A Mixed-method Study Exploring the Practice of Mathematics Education, with a Focus on the Integration of Online Gamified Mathematics Practice Activities in Primary Classroom Settings in Saudi Arabia.

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of PhD is entirely my own work, and that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abbreviations

ACER	Australian Council for Educational Research
BPDP	Blended Professional Development Program- Saudi Arabia.
BYOD	Bring Your Own Devices
CCSS	Common Core State Standards (U.S.)
DCENR	Department of Communications, Energy and Natural Resources-Ireland
DCU	Dublin City University (Ireland)
DES	Department of Education and Science/ Department of Education and Skills (Ireland)
DfE	Department for Education (United Kingdom)
EC	European Commission
ERCSME	Excellent Research Centre of Science and Mathematics Education-Saudi Arabia
GPCD	General Project for Curriculum Development (Saudi Arabia)
ICT	Information and Communication Technology
KSA	Kingdom of Saudi Arabia
MoE	Ministry of Education (Saudi Arabia)
MoEP	Ministry of Economic and Planning (Saudi Arabia)
NCS	National Center for Assessment (Saudi Arabia)
GAS	General Authority for Statistic (Saudi Arabia)
NCTE	National Center for Technology in Education (Ireland)
NCTM	National Council of Teachers of Mathematics (United States)
NTP	National Transformation Program 2020 (Saudi Arabia)
PEEC	Public Education Evaluation Commission (Saudi Arabia)
RCSME	Excellence Research Centre of Science and Mathematics Education (Saudi Arabia)
T4edu	Tatweer Company for Educational Services (Saudi Arabia)
TEHC	Tatweer Education Holding Company (Saudi Arabia)
TIMSS	Trends in International Mathematics and Science Study
TSDP	Teaching Strategies Development Project (Saudi Arabia)
US	United States
UK	United Kingdom

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Title: A mixed-method study exploring the practice of mathematics education, with a focus on the integration of online gamified mathematics activities, in primary classroom settings in Saudi Arabia.

Jawaher Al-Ghamdi

Abstract

This multi-phase mixed methods research study set-out to explore the integration of online gamified activities, within the context of mathematics education, specifically focusing on lower primary grade levels in an International private school and Tatweer public school in the eastern area of Saudi Arabia. The study examined the performance of mathematics education in traditional settings, the integration of online gamified activities for mathematics practice, as well the readiness of teachers with respect to technology integration in the Saudi primary education system. The results indicated that mathematics was being taught in somewhat traditional ways in both settings, albeit with evidence of collaboration and peer assessment, but limited innovative integration of technology by teachers in classroom practice. The findings further showed that the integration of online gamified learning activities to practice mathematics contributed positively to learners' motivation and dispositions towards mathematics, and to their academic performance. Moreover, it further found that gamification elements, including the award of points and certificates, along with provision of facilities that enabled learners to engage competitively, receive feedback and publicly share their achievements, had a direct effect on increasing engagement and motivation of learners in mathematics education. The results also indicated that teachers overall felt positively disposed towards the integration of technology in education but needed better technology infrastructure and professional development training to progress the infusion of ICT in their practice. The recommendations of the study included: the provision of training for teachers on ICT skills development and pedagogies for technology integration, the need for the Saudi Ministry of Education to consider increased technological resourcing for schools, the communication of findings relating to inadequate or redundancy in the aesthetic design of online mathematics practice activities to game designers and educational technologists, and further research to ascertain whether the 'bolt-on' online Mathematics Practice model used in this study could be up-scaled to increase transitions towards technology integration in mathematics education across Saudi Arabia.

Chapter 1: Introduction

1.1 Introduction

Saudi Arabia is consistently a global leader in oil production and still has significant oil reserves (Li, 2018). However, as noted by Zaki Yamani, Saudi Arabia's energy minister in the 1970s*: "The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil," (Kimberley, 2016),* a prescient observation in the context of recent advancements in renewable sources of energy, particularly solar power and wind power, which are predicted to achieve parity with (or exceed) non-renewable forms of energy (especially oil) in countries such as China, Spain and the United Arab Emirates in the next five years (Scott, 2018). Furthermore*,* oil reserves are diminishing across the globe, and there is recognition that peak oil production has or will likely pass in most countries between 2010 and 2030 (Li, 2018). Therefore, within oil-dependent nations like Saudi Arabia, there is *now* broad acceptance of the urgent need to re-orient economies and indeed societies towards new ways of living and being. In this regard, the Saudi 2030 Vision (رؤية **2030** السعودية) launched in 2016, plans to reduce the country's dependence on oil as the main income generator, and instead has chosen to diversify into economic sectors including: health, education, recreation and tourism. The Saudi 2030 Vision articulates a series of goals and accompanying programmes that aim to bring about reforms across a broad range of systems (including education) to enable Saudi citizens to come to terms culturally with the new plans while also enabling them to become active participants in the necessary societal and economic transformations in a post-oil economy.

The genesis of this thesis came from consideration of the need to enable Saudi citizens to develop competencies to engage in post-oil economies (such as the digital skills required to engage in the knowledge economy). Within the various plans contributing to the Saudi 2030 agenda (including: the National Transformation Programme, 2016-2020), technology is frequently cited as a key agent in facilitating change and education is targeted as a means of enabling Saudi citizens to develop a broad range of new competencies, including digital skills, that align with the new vision/s for Saudi Arabia. Many children within and beyond Saudi Arabia have grown up with digital media, computers, videogames and mobile technologies, and are reputedly very comfortable using these technologies. According to

Prensky (2001), education systems need to be reformed to address the needs of the so-called *digital natives* as these types of learners are thought to be more technologically savvy and to process information (or learn) differently to previous generations, and furthermore are said to become disengaged or disenchanted when technology is not meaningfully integrated within their learning environments. The Saudi education system has moved through periods of reform that considered the affordances of technology integration within educational contexts from the 1990s, and this has continued up to and including the active 10th National Development Plan (2015-2019). In line with the Saudi 2030 Vision, governmental initiatives in the 10th National Development Plan are targeting teacher professional development and infrastructure in schools, seeking to specifically address the persistent issue of low level technology integration within teaching and learning contexts across the Saudi compulsory education system. These initiatives seek to improve the technological competence of teachers and learners, to enhance teachers' understanding of how to meaningfully integrate technology in learning contexts, and furthermore to improve the technological infrastructure in schools.

It is within this context that the researcher chose to explore the integration of online gamified learning in primary education. The study broadly sought to identify way/s in which technology could be mainstreamed within education to enable meaningful transitions towards the Saudi 2030 Vision. The potential of gamified learning in the practice of mathematics education at lower primary levels was primarily explored in this study, with a secondary focus on the readiness of Saudi teachers for technology integration in education. In the initial section of this chapter the rationale for the research study is presented, followed by an overview of the research study and methodology, and a summary of the contributions of the research. This chapter closes with a summary of the thesis structure.

1.2 Rationale

This multi-phase mixed methods research study set-out to explore the integration of online gamified activities, within the context of mathematics education, specifically focusing on lower primary grade levels in an International private school and Tatweer public school in the eastern area of Saudi Arabia. In this regard, the study examined the performance of mathematics education in traditional settings, the integration of online gamified activities for mathematics practice, as well the readiness of teachers with respect to technology integration in the Saudi primary education system.

The reason for examining how mathematics education was being performed was that there was a dearth of research on how mathematics was being taught within the Saudi context at that time, and of learners' experiences therein, particularly at the lower grade levels. Therefore, there was a real need to examine how Saudi teachers were teaching mathematics - the performance of mathematics education - in traditional settings, in parallel to exploring the implications of integrating technology-enabled learning interventions (such as gamified learning) in such settings. The context for exploring online gamified learning was evidence from other jurisdictions of its success in motivating learners to engage within and beyond the classroom, and the sense that it had the potential to similarly motivate learners in the Saudi context (Su and Chengt, 2014). In order to prosper within dynamic social, cultural and economic environments of the 21st century, learners need to develop and/ or enhance skills such as critical thinking, teamwork, digital literacy, problem solving, collaboration and cooperation. In the last 30 years, a range of pedagogic approaches have been developed to foster these skills. One such approach involves the gamification of learning, which has been shown by Lee & Hammer (2011) to be particularly important in supporting learners to interact, communicate and collaborate with each other, and thus can help facilitate types of learning required for 21st century living. From the initial review of the literature in 2015-2016, there was limited research at national and global levels on the behaviour of children aged between 6 and 9 within online gamified learning environments (as explained in the literature review chapter, only 17 papers/ studies were identified that specifically examined gamified learning with this age-group of learners). Therefore, this study hoped to add to the body of research by exploring learners' engagement and motivation in a particular type of gamified learning (which was geared towards enabling the practice of mathematics) in an attempt to shed light on how the use of these types of activities can support learning in mathematics education at the aforementioned grade levels. Moreover, this study aimed to respond to calls for improvements in the enhancement of digital literacy of learners, while recognising that the wider context of ICT integration is impacted by many and varied factors such as teachers' and learners' dispositions and skills, and the technological infrastructure. In doing so, the researcher also recognised that the evidence base for the generalizations underpinning the concept of digital natives has been contested by researchers including, Helsper and Eynon (2008) and Bennett et al. (2008), and accepted that digital natives are perhaps better identified across a broader range of factors which move beyond the narrow generational concept, to include other impacts such as the degree of immersion in the technology and breadth of exposure to online engagement for learning purposes, as well as socio-demographic factors (gender dimensions or educational levels).

The Saudi education system is undergoing significant changes in terms of supporting the integration of technology at all levels of education. In this regard, the study further explored the readiness of Saudi teachers with respect to technology integration in primary education. Therefore, teachers' access to, dispositions towards, skills and professional development in technology enabled learning were explored so as to better understand the context and illuminate existing or likely future disjoints in the translation of policy into practice within the Saudi education system. This study is particularly timely as to date there have been limited reviews of the effectiveness, or otherwise, of the translation of national policies and strategies into educational practice at primary levels in Saudi Arabia.

1.3 Overview of Research Methodology

This multi-phase mixed methods research study set-out to explore the integration of online gamified practice activities, within the context of mathematics education, specifically focusing on primary grade levels 1 to 3 in an International school and a Tatweer school in the eastern area of Saudi Arabia. The Tatweer public school was chosen as these types of schools were already committed to a reform programme for integrating ICT in education in Saudi Arabia, and thus the expectation at the out-set of the study was that the Tatweer school would have the technological infrastructure to support the online intervention, and moreover, that teachers in these schools would be more knowledgeable and experienced in integration ICT in their practice. Furthermore, the International school was chosen on the basis that education being performed at these types of schools was perceived to be more progressive, and technological integration in the practice of teaching and learning was expected to be common-place. It should be noted here that the Saudi education system is single-sex in terms of segregation of pupils, and importantly also of teachers. As a female researcher, my access therefore was limited to engaging in research in girls-only schools.

The research took place across three phases from 2015-2018, with the first two phases of research undertaken with learners at various lower grade levels. In phases one and two, the first level of research sought to gain insights into how mathematics education was being performed by teachers (and corresponding learner engagement) within traditional primary grade levels 1 to 3 classroom contexts, and the second level of active research involved exploring the impact of integrating online gamified mathematics practice activities (using an online platform called Mathletics) within mathematics education across these primary grade levels. In phase 3, the focus was on uncovering Saudi teachers' dispositions, level of experience in using technology, and professional learning in ICT, with a view to ascertaining their overall level of readiness for integration of technology in the practice of mathematics education.

There were three overarching research questions for this research study, the first of which was: *How is mathematics education presently being performed by teachers and learners in Grades 1 to 3 in two Saudi primary school contexts?;* the second question being, *What impact, if any, does the integration of online gamified mathematics 'practice activities' have on learning* in Grades 1 to 3 *in these Saudi schools?*, and finally: *What is the state of readiness of Saudi teachers for technology integration in their practice of mathematics education at primary level in this district of Saudi Arabia?*

This led to an investigation of the following sub-questions in phases one, two, and three:

- What teaching and learning approaches and strategies are currently used by Saudi teachers to teach conceptual knowledge and to practice mathematics concepts in Grade 1, Grade 2, and/or Grade 3 contexts? How do primary learners interact and perform within these traditional spaces?
- Does the integration of online gamified mathematics practice activities affect learners' disposition, engagement, motivation and/ or academic performance in Grade 1, 2 and/ or 3 contexts in International and Tatweer primary school contexts? Why, why not?
- What levels of ICT experience, access to technology, professional development and confidence do primary teachers have in Saudi Arabia? What are teachers' attitudes towards ICT integration in education?

The research data across the first two phases of this study included researcher field-notes recording observations of whole-class interactions across the sessions, and furthermore was complemented with data from interviews with learners and teachers about their experiences in the session, alongside data collected from auto-tracking learner engagement within

Mathletics, from using eye-tracker software and/ or from parents. Furthermore, in phase 2 a number of surveys were deployed, to ascertain if there were significant differences in learners' levels of satisfaction, confidence, anxiety and interest, and academic performance in mathematics pre-and post-intervention. Finally, a teacher survey was deployed in phase 3 to ascertain Saudi teachers' readiness to integrate technology in education. The qualitative data was coded using thematic analysis, and the quantitative data was analysed using descriptive statistics along with t-tests and Mann-Whitney U test, where appropriate.

1.4 Contributions of this Research

This thesis makes the following contributions to knowledge and research:

1.4.1 The study engaged in a review and analysis of the performance of mathematics education by teachers in two different types of primary schools (public and private) at lower grade levels (Grade 1/2/3) in the eastern area of Saudi Arabia. As such, it has provided really important insights into how mathematics was taught by these teachers, and the implications of this for learners, across these two school settings. The findings showed that although opportunities were regularly presented for learners to engage in paired and/ or group work, and in peer assessment within the mathematics education classes, the main practice was pre-dominantly teacher-led, with sessions uniformly structured around the course textbook and workbook. This was further supported by evidence from a survey of other teachers across the eastern region of Saudi Arabia, which showed reliance on more didactic approaches in their general practice. Moreover, an examination of learners' dispositions towards mathematics in the public school showed that Grade 2 and Grade 3 learners became negatively disposed towards certain aspects of mathematics in traditional mathematic classes. Therefore, the study highlights the need to revise or re-orient Saudi teachers' professional development on general pedagogies, with a focus on enabling teachers to foster learner-centred approaches and learner autonomy, including the affordances of more motivating pedagogic approaches such as: active learning methodologies, project-based, and/ or discovery learning.

1.4.2 This study further engaged in an exploration of the impact of integrating gamified learning activities for practising mathematical concepts, within what has been termed a 'Bolt-on' Mathematics Education model. This bolt-on model was structured in a way that allowed for teacher explanation of mathematical concepts and processes using traditional approaches, with the learners further engaging within an online gamified platform called Mathletics to practice the mathematics. The model thus respected the expertise of the teacher and their important role in fostering conceptual knowledge building within mathematics education, whilst scaffolding the practice dimension of mathematics learning using online gamified mathematics activities instead of more traditional text-book/ worksheet activities, within a traditional classroom setting. The findings showed that learners were highly engaged and motivated when interacting within Mathletics within and beyond school settings, and furthermore their performance improved overall in mathematics. This Bolt-on Mathematics Education model does not require high levels of teachers' technological ability or know-how, and thus could be used to fast track technology adoption in mathematics education by teachers, and, in this regard, has the potential to contribute to broader transitions towards deeper integration of technology in education, a key objective of Saudi Arabia's Vision 2030.

1.4.3 This study further contributed to new knowledge within the domain of human-computer interface design. In this regard, a comprehensive exploration of the interaction of six learners (two from each grade levels 1, 2 and 3) within Mathletics was undertaken using eye-tracking software, which showed that there existed some redundancy in the aesthetic design of the Mathletics interface (the avatar, and assistance facilities were unused by learners) and in the pedagogic framing of activities in multiple formats (learners typically ignored the textual question in favour of numerical or visual question on-screen). These findings will be of particular interest to educators, learning technologists and instructional designers engaged in design of educational tools for mathematics education and other domains.

1.4.4 Finally, this study explored teachers' readiness for technology integration in education across the eastern area of Saudi Arabia. In this regard, the findings showed the need for support to improve the technological infrastructure in schools, as well as the need for review of professional development of teachers. In terms of the latter, Saudi teachers need to be introduced to a broader range of pedagogies (including those that offer opportunities for sustained, self-directed learning as already mentioned) and also need more training on ways in which technology can be integrated in teaching and learning practices. This is of particular significance in the context of current plans for education outlined within the Saudi National Development Plan and the National Transformation Programme, and thus, will be of particular interest to policy makers and governmental departments tasked with progressing reforms within the education system that focus on developing specific teacher and learner competencies that enable new directions for economy and society outlined in the Saudi 2030 Vision.

1.5 The Thesis Structure

The thesis is divided into seven chapters, as outlined below:

Chapter One is an introduction to the thesis, with an overview of the study, the research methodology, the rationale for engaging in this type of research, and a summary of the main contributions of the thesis. **Chapter Two** comprises the literature review and includes an overview of the Saudi education system and mathematics education, a comparative analysis of ICT policies and programmes in Saudi Arabia and Ireland, and a critical review of gamified/ game-based learning within primary education contexts. **Chapter Three** details the research methodology, including the rationale and philosophical underpinning of the research and methodologies employed. It further describes the data collection and data analysis processes, and the limitations of the study. **Chapter Four** presents the analysis of data about mathematics education and gamified learning gathered in the International (private) school during the first phase of this study. **Chapter Five** presents the analysis of data about mathematics education and gamified learning gathered in the Tatweer public school during the second phase of this study. **Chapter Six** presents the analysis of data gathered from teachers in the third phase of this study regarding their readiness to integrate technology in teaching and learning. **Chapter Seven** details the conclusions from the overall study of mathematics education and gamified learning, including a summary of the recommendations and future research work.

Chapter 2: Literature Review

2.1 Introduction

This chapter opens with an overview of the education system in the Kingdom of Saudi Arabia (KSA). The review of literature includes a comparative analysis of Information and Communication Technology (ICT) policies and programmes in Saudi Arabia, followed by a detailed review of mathematics education, and ends with a critical review of gamified/ game-based learning within primary education contexts. A number of different methodologies were used across the literature review, which are detailed separately within the relevant section.

2.2 The System of Education in Saudi Arabia

The Education system in Saudi Arabia will soon reach its centenary, with development of the Saudi education system mapped in three stages from 1923 to 2023 (see Figure 2.1). The first stage called 'Establishment' (initiated in 1920s) focused on educating Saudi citizens about the importance of education, and on the development of education policies and plans, primarily focused on the male population (education of boys). The second stage called 'Expansion' started in 1950s, and focused on the availability of education for everyone, equal learning opportunities for both genders, and increasing literacy levels across the population. The third stage entitled 'Quality' was initiated in the late 1980s and focused on enhancing processes for knowledge-building, improving learning outcomes, enhancing evaluation by using performance indicators and ensuring the education system contributed to sustained economic development (Ministry of Education, 2012).

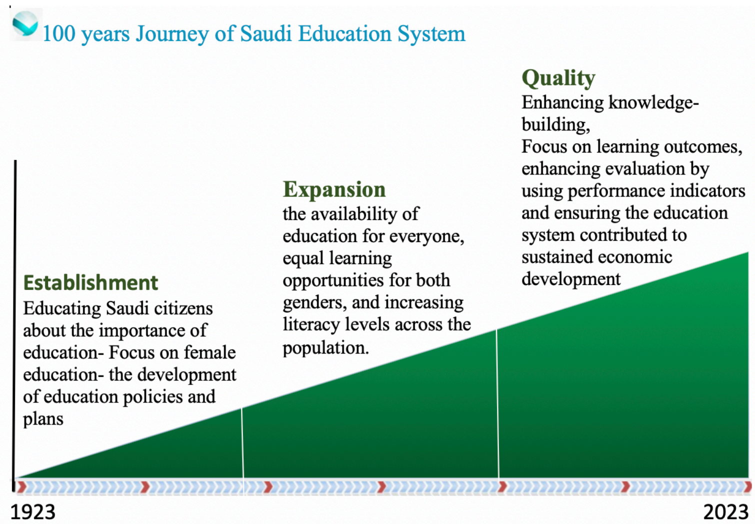


Figure 2.1: 100 years Journey of Saudi Education System, Ministry of Education, 2012.

According to Ministry of Education (MoE), the primary focus of the Saudi system when it was first established in 1923 was to put structures in place for the provision of education for boys only. In 1951 the Ministry of Knowledge was established to take responsibility for the education of boys. In the 1960s, the General Presidency for girls was established, which opened the pathway for the education of girls at least in theory. In 2002, the General Presidency for girls was re-housed under the Ministry of Knowledge, to bring together the general education of boys and girls in Saudi Arabia. A year later the Ministry of Knowledge was re-named as the Ministry of Education, with responsibility for the general education of all school-aged learners (aged 6-18). In 2015, the Ministries of Education and the Ministry of Higher Education were merged into one entity “the Ministry of Education”, which encompassed education at all levels within the Saudi education system (MoE, 2019b).

The Ministry of Education has responsibility for the development of the national educational policy and furthermore has oversight of development of ‘boys’ and girls’ schooling, junior colleges, teacher training, special needs, and adult education’ (Oyaid, 2009, p.18). It also has responsibility for the provision, maintenance and construction of educational institutions, as well as the provision of equipment, materials and resources such as textbooks to schools.

The compulsory element of the Saudi education system is structured into three levels: Primary/ Elementary level (for learners aged 6-12), Intermediate level (for learners aged 12-15) and Secondary level (for learners aged 16-18), with a total of circa 6 million learners (Statista, 2017). The pre-school system (including kindergarten) is not part of the official education system and thus not a prerequisite for enrolment within primary education but many children aged 3-5 years of age do attend pre-school settings. The pre-school curriculum is articulated within seven books, issued under the title “The Self-Learning Curriculum for Kindergarten” (Al-Jadid, 2012), which are used to develop reading and writing skills for pre-school children.

In the context of mainstream primary education (as illustrated in Figure 2.2) *Elementary* education is the first stage in the Saudi education ladder, which is six years in duration and divided into lower level and upper level. Children at the age of six enter this elementary stage of their schooling and generally complete the stage aged 12. In the lower level of elementary education, learners of both genders typically aged 6-9 are introduced to a total of eight subjects: Religion Study (3 subjects), Arabic Language, Mathematics, Science, Art, Home Economics (for girls only) and Physical Education (for boys only). In the upper level, the same subjects are continued with learners aged 9-12, and in addition three new subjects are added to the curriculum, namely, Social and National Studies, and English Language, thus a total of eleven subjects are covered in upper elementary level (MoE, 2015a). The middle stage in the education ladder is *Intermediate* education. Learners aged 12-15 who successfully completed primary education can engage at this level. The duration for Intermediate studies is three years. A total of 13 subjects need to be completed by the learners at this level, which include the 11 subjects covered at upper elementary level as well as Computer Science and an additional Religious Education subject (MoE, 2015b). *Secondary* education is the final three years in the general education ladder, and at this level learners aged 16-18, who successfully completed Intermediate level, can progress to advanced levels in a range of subject areas (total of 25 subjects), in areas including: language (Arabic and English), Religious Studies, Social Studies, History, Geography, Science, Mathematics, Computer Science, Physics, Chemistry, Biology (MoE, 2016).

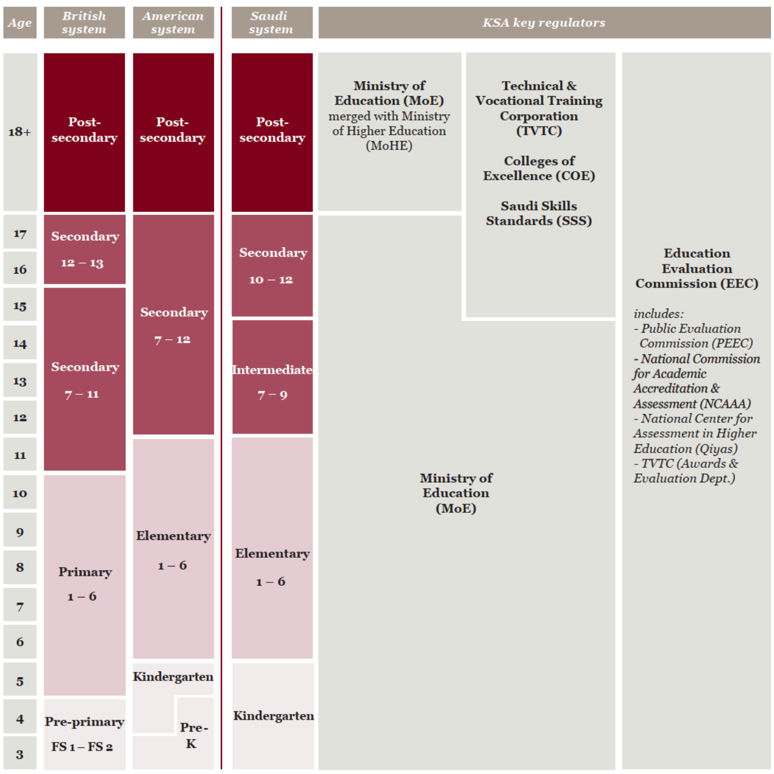


Figure 2.2: Saudi Arabia National Education profile (Price Waterhouse Cooper, 2017)

The academic year consists of two terms at all levels of education, each from 15 to 18 weeks in duration. Learners usually study for 25 to 36 hours each week, in classes of 40-45 minutes in duration. In terms of assessment at primary level, continuous assessment is the dominant mode of assessment, with a requirement of a 75% pass rate for learner progression through each level of this stage. In terms of assessment at Intermediate and Secondary stages, a number of modes are used including: formative assessment, mid-term examination and summative examinations to assess learners progress, with successful completion of all assessments at each level necessary for progression to next stage (MoE, 2015c).

It is very important here to note that the Saudi school system is not a co-educational system. Therefore, the learners (and their teachers) at all levels are separated by gender, with girls taught solely by female teachers and boys by male teachers, with the exception of the pre-school setting, where learners of both genders are taught by female teachers. Learners of each gender are covered by the same policy and are offered/ undertake almost the same suite of courses and curriculum (Doumato, 2003) – with an exception being for example that only girls can take Home Economics and only boys can take Physical Education.

2.3 Review of ICT Policies and Programmes in Education.

This section presents a comparative review of national policies and programmes with regards to the integration of Information and Communications Technologies (ICT) in education in Saudi Arabia, with those implemented at national levels across a western country, namely Republic of Ireland. Saudi Arabia is a relative newcomer to prioritising the integration of technology in education, and this has had benefits in that there were many opportunities to learn from what has worked well (and/ or avoid the pitfalls) in terms of technology integration in western countries with a longer history of doing so. In the context of this literature review, a comparative review involving Ireland was conducted as it was felt that it would be useful to benchmark the policy, action plans and/ or programme developments in Saudi with those from a western country that had actively attempted (with some success) to integrate ICT policy and programmes within the education system. Kozma's (2008) framework for comparative analysis of ICT was chosen to guide this review, which examined active ICT policy in these countries, with a particular focus on critiquing the associated programmes implemented for education, in 2017 (which was the year in which the comparative analysis was conducted)

The methodology for comparative analysis is further explained in the next section. This is followed by brief histories and reviews of the national plans, agencies and initiatives to infuse ICTs within education in the selected countries in the past 30 years. Finally, the comparative analysis of active Saudi Arabia's national policy and programmes in ICT with those implemented at a national level in Ireland in 2017, is presented.

2.3.1 Methodology for Comparative Analysis of ICT Policy

This dimension of the literature review utilized Kozma (2008) *Framework for Comparative Analysis of ICT Policy* as a methodology to critically review ICT developments with respect to education in the two settings, Saudi Arabia and Ireland. In terms of a framework for comparative analysis, Kozma (2008) suggested four policy rationales that facilitate an analysis of the vision or purpose of ICT policy, and a further five operational elements that that could be used for analysis of ICT programme/s, at a national level. The four high-level policy rationales can be viewed as visions embedded within the 'strategic policy', and include: *Support Economic Growth*, *Promote Social Development, Advance Education Reform* and *Support Education Management*. Kozma (2008) acknowledged that some policies can combine two or more of these rationales, and thus a fifth element 'Multiple Rationales' component could be added to capture this. In terms of the operational elements that could be compared and contrasted across ICT programmes in education, Kozma (ibid) includes: Infrastructure Development, Teacher Training, Technical Support, Pedagogical and Curricular Change, and Content Development. Kozma (ibid) further recommends some other components that can be used in the analysis of ICT action plan and/or programmes and these include: Policy Alignment, Distributed Policies, Private-Public Partnerships and Evaluation of Strategic Level.

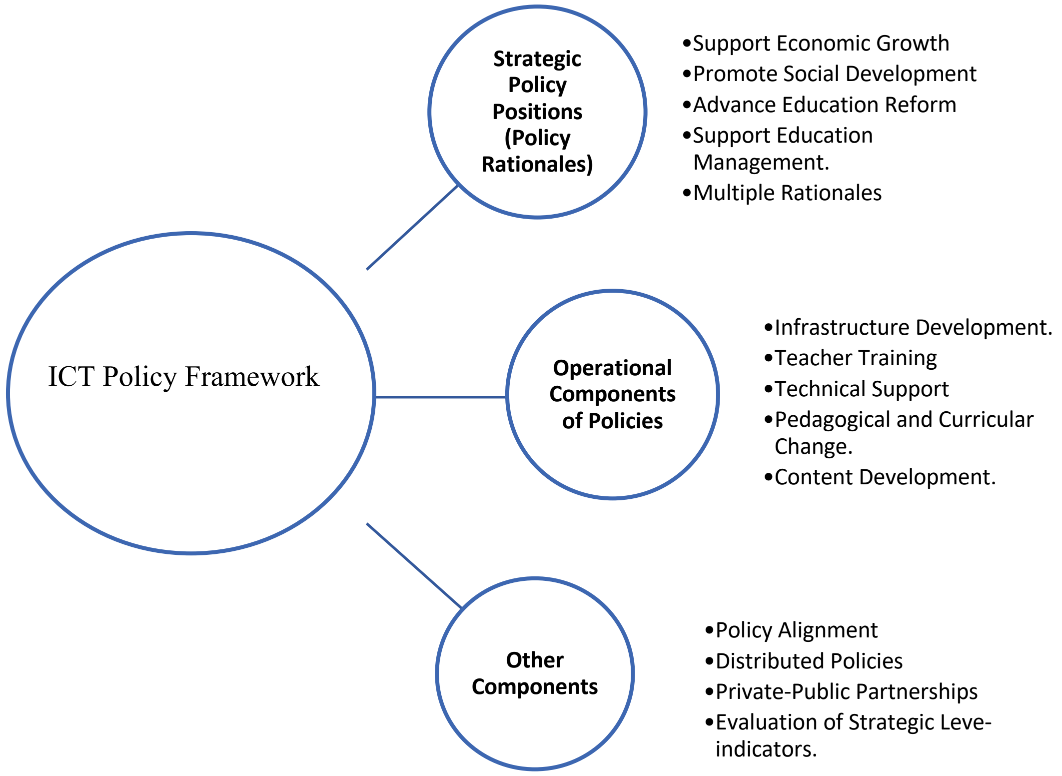


Figure 2.3: Kozma's Framework for Comparative Analysis of ICT integration (in Education)

Kozma's (2008) framework thus provided the units of comparative analysis (as illustrated in Figure 2.3) for this critical review of those ICT policy, programme and/ or action plans in education in the Saudi and Irish contexts that were active in 2017. The brief histories of national policies and plans in both jurisdictions are outlined in the next section, and this is followed by an analysis of policy and programmatic development using Kozma's (2008) framework for comparative analysis of policy developments in the Saudi and Irish contexts.

2.3.2 Brief History of ICT National Policies and Plans: Saudi Arabia

The Ministry of Education in Saudi Arabia has made comprehensive reforms and created cohesive plans to redevelop the educational system and to improve student learning and educational outcomes by integrating ICTs into curriculum and into learning and teaching process. The 2nd National Development Plan (1975-1980) and the 3rd National Development Plan (1980-1985) both emphasized the importance of introducing new learning resources, but there was limited integration of ICT-enabled learning resources during these periods. In its 4th National Development Plan (1985-1990), the Ministry of Economic and Planning placed a new emphasis on the quality of education outcomes, but again the integration of ICT in education practice was extremely limited. It wasn't until the policies from the 5th and 6th National Development Plans (1990-1995, 1996-2000) were actioned that ICT integration became more visible within the Saudi education system, with for example the introduction of computer science as an elective course in primary education and as a compulsory course in secondary education (Ministry of Economic and Planning, MoEP, 2018e). The Watani project, the Saudi schools` net (Internet) project, also was launched in 2000, with a focus on integrating technology to further objectives including: to develop learners' ICT skills, to enhance teachers' ICT skills, to create ICT-enabled learning environments that were responsive to the needs of learners and teachers, to improve educational processes to support effective ICT skills development, and to prepare learners to engage in the knowledge economy (Watani, 2000). During the 7th, 8th and 9th Saudi National Development Plans (2000-2015), further actions to provide ICT skills training to teachers and learners, and to promote ICT integration in the classroom were launched.

Table 2.1 Active Policies and Programmes referring to ICT in Education in Saudi Arabia in 2017.

Kingdom of Saudi Arabia - *Policies and Programmes referring to ICT in Education, 2017, that were included for purposes of this literature review.*
• General Project for Curriculum Development (1998-current), specifically the Report of the General Project for Curriculum Development (2010). • The National Strategy for the Development of Education (NSDE), King Abdullah Project for General Education Development (known widely as the Tatweer project), 2007-2023. • 10th National Development Plan (2015-2019). • National Transformation Programme, NTP, 2020 (to achieve the Saudi Vision 2030) (2016-2020)

When this literature review was initially conducted in 2017, there were four active policies and/ or programmes in Saudi Arabia referring to ICT integration in education, as illustrated in Table 2.1. The first of these was the General Project for Curriculum Development (GPCD) which was a national project organised by the Ministry of Education in 1998, that aimed to develop education through ICT integration across a range of aspects, including:

curricula, teachers' skills, teaching strategies and teaching and learning environment. The most recent report available on its progress (during the literature review in 2017) was the Report of the General Project for Curriculum Development (2010). Secondly, King Abdullah established a country-wide project for general education in 2007 known as *King Abdullah bin Abdulaziz Project for Development Public Education* which resulted in the implementation of the Tatweer project (2007-2023), which aimed to reform educational outcomes through a greater integration of technology in public school contexts. The Ministry of Education established the Tatweer Education Holding Company (TEHC) in 2008 to implement Tatweer programmes. The Tatweer strategy had ten main goals including the goal 'to increase the use of ICT to improve the quality of education' (MoE, 2007). The Tatweer project implemented a range of development programmes focused on integration of ICT to: develop teachers' skills, develop curricula, enhance schools' activities and improve the school environment. Thirdly, within the 24 objectives listed within the 10th National Development Plan (2015-2019), developed by the Saudi Ministry of Economic and Planning, there was reference to the need to upskill teachers and learners in ICT. The 10th National Development Plan thus supported actions that promoted ICT skills development and integration in education. Finally, the National Transformation Programme for Education 2020 (as shown in Appendix A) was developed by the Saudi Ministry of Economic and Planning at the beginning of 2016 to appropriately respond to the Saudi Vision 2030 programme. The programme had some general objectives underpinned by technological skills development and integration of technology within education systems, such as: '*improving the recruitment, training and development of teachers, improving the learning environment to stimulate creativity and innovation, and improving curricula and teaching methods'* (MoEP, 2016).

2.3.3 Brief History of ICT National Policies and Plans: Republic of Ireland

In context of Republic of Ireland, the Department of Education and Science (DES) has been mainly responsible for ICT policy implementation across education. The DES launched its first ICT policy document in 1997, entitled "Schools I.T. 2000" which covered the period from 1997 to 2000, where the basis for the development of ICT across the education system was established. The Schools I.T. 2000 targeted actions for increasing (technology-enabled) classroom resources and infrastructure, as well as teacher skills development and support. In order to implement I.T. 2000, the National Center for Technology in Education (NCTE) was set up in 1998. The NCTE set out a framework for achieving the integration of ICT into education in Irish primary and post-primary settings. The National Center for Technology in Education in Ireland was responsible to provide Irish schools with ICT support and training and engaged in tracking of technology infrastructure in education through a series of national census exploring the availability of ICT infrastructure in schools (NCTE Census reports, 1998; 2000; 2002; 2005, as cited in the Inspectors Report from the DES, 2008b). In 2001, the DES released a policy document entitled "Blueprint for the future of ICT in Irish education", with the main thrust of policy and associated programmes therein being to continue the main initiatives under I.T. 2000 through to 2007. These included: expansion of ICT to schools, increase of access to the Internet, further integration of ICT in teaching and learning and enhancement of professional development for teachers. The Inspectors Report for the Department of Education & Science (DES, 2008b), further presented an analysis of the availability of ICT in schools with data collected from a range of sources including a national survey completed by principals and teachers, a questionnaire completed by learners, and school case studies undertaken during visits by inspectors. The main recommendations for policy–makers from this Inspectorate Report (2008) were to seek ways to improve ICT capacity and training for teachers in using ICT in teaching and learning, and the second recommendation for schools, highlighted that schools be shown how to use existing ICT infrastructure to further the integration of ICT in teaching and learning. In 2009, the "Smart Schools = Smart Economy" (SSSE) report was published by the DES to further support primary and post-primary schools with the integration of ICT. Five core recommendations were made in this report relating to: '*Classroom and student infrastructure, technical support and the virtual learning environment (VLE), Teacher Professional Development, ICT planning and multi-annual budgeting, Digital content growth and Enhancement broadband for schools'* (DES, 2009, p. 6).

Table 2.2 *Policies and Programmes referring to ICT in Education active in 2017 in Ireland.*

Republic of Ireland
• ICT Skills Action Plan, 2014-2018 – Irish Department of Education and Skills. • Action Plan for Education, 2016-2019 – Irish Department of Education and Skills. • Digital Strategy for Schools, 2015-2020 – Irish Department of

Education and Skills.

- Framework for Junior Certificate 2015 – Irish Department of Education and Skills.

In the Irish context, there were four active policies and programmes referring to ICT integration in education in 2017 (as shown in Table 2.2). Firstly, the "ICT Skills Action Plan 2014-2018", a collaboration that included representation from a number of government bodies including the *Department of Education and Skills*, *Department of Jobs, Enterprise and Innovation and industry*, as well as *state agencies* and industry stakeholders, and sought to improve ICT skills to support economic development. The ICT Action Plan had 22 actions including: improvement of school infrastructure, teacher professional development, and re-development of curriculum. Secondly, the "Action Plan for Education 2016-2019" was developed by Department of Education and Skills, and provided a strategic overview of the education and training reform programme. The plan had five main objectives:

> *1)improve the learning experience and the success of learners, 2) improve the progress of learners at risk of educational disadvantage or learners with special educational needs, 3) help those delivering education services to continuously improve, 4) build stronger bridges between education and the wider community, and, 5) improve national planning and support services* (DES, 2016, p. 2).

Thirdly, the "Digital Strategy for Schools 2015-2020" was a five-year digital strategy aimed at enhancing the use of ICT in teaching, learning and assessment within primary and post-primary education contexts. This strategy had four key themes: '*Teaching, learning and assessment using ICT, Teacher professional learning, Leadership, research and policy, and ICT Infrastructure*' (DES, 2015, p.6), which were underpinned by financial resourcing and training supports as drivers towards effecting positive changes in education infrastructure, and practices. Finally, the "Framework for Junior Certificate 2015" developed by the DES, further set out to improve teaching, learning and assessment practices to support the delivery of a quality, inclusive and relevant education of students in the first three years of their post-primary education. With this document, the role of technology in enabling diversity in teaching approaches and assessment, whilst also enabling digital skills development among learners, is highlighted.

2.3.4 Comparative Analysis of Strategic Policy or Programme Rationale/s

As identified by Kozma (2008), the rationale for many strategic policies pitched to drive agendas for ICT integration in education tend to fall within one or a combination of the following – 1) to support economic growth, 2) social development, 3) advance education reform and/or 4) support education management. This section compares and contrast the underpinning rationale/s for strategic policies in Ireland and Saudi Arabia that were active in 2017.

2.3.4.1 Support Economic Growth

In the Saudi context, all of the aforementioned policies and plans made some reference to the need to integrate technology in education as a means to prepare learners for the labour force and thus contribute to economic growth. In terms of the General Project for Curriculum Development (1998), the strategy aimed to integrate ICT in ways that enabled promotion of the type of learning and performance that meets the needs and requirements of the labour market, whilst supporting economic growth. Similarly, the focus of the Tatweer project initiated in 2007 was to enhance *'... the quality of education to ensure that all students are equipped with the necessary skills to develop their country and achieve sustainable knowledge economy'* (p. 26). Furthermore, the focus of the 10th National Development Plan (2015-2019) was to promote the knowledge-based economy by enhancing '... *the main determinants of productivity and economic growth through focusing on information technology and education to achieve distinct economy'* (p. 38). In addition, the National Transformation Programme 2020 aimed to prepare young Saudis with general and basic skills to enable them to live and work in a global economy.

Likewise, in the Irish context, within the aforementioned policies and plans relating to ICT integration in education, reference was made to the need to prepare learners for the labour force and contribute to economic growth. The ICT Skills 2014-2018 Action Plan was very much focused on promoting economic growth within the ICT sector through among other things the reform of education. This plan was developed to *'increase the supply of highly skilled ICT professionals from abroad to complement the increase in the domestic supply of high level ICT graduates from the education system*' (DES, 2014, p. 5). Moreover, the Digital Strategy for Schools, 2015-2020, also was developed to '*take account of the recent economic challenges and looking to the future and the anticipation of economic growth'* (p.10). Similarly, within the rationale for changes to the Junior Certificate curriculum as outlined within the Framework for Junior Certificate 2015, the need to prepare learners for knowledge economy and to prepare them for labour force is called out.

2.3.4.2 Promote Social Development

In the Saudi context, three of the aforementioned policies and plans made some reference to the need to integrate technology in education to promote social development. A key aim of the General Project for Curriculum Development (1998) was to help prepare Saudi learners to cope with the rapid changes in Saudi society in terms of culture, daily life and expansion of cities/ towns (population movements from rural to urban settings). These changes had impacts on the development of social relationships, and it was hoped that curricular reforms such as including ICT to support quality learning experiences would ultimately support smoother cultural and societal transitions within Saudi context. The Tatweer project (2007) recognised the importance of ICT in enhancing and supporting social development among learners. The 10th National Development Plan (2015-2019) outlined the importance of ICT in increasing parental participation in learning and also in developing learners' personal and inter-personal dispositions and skills such as: morals, values, communication, teamwork, leadership.

In the Irish context, three of the policies and plans made some reference to the need to integrate technology in education to promote social development of learners. The Digital Strategy for Schools 2015-2020 supported the use of ICT as a tool to transform teaching, learning and assessment, in ways that enabled learners to develop 21st century skills such as collaboration with peers, as well as higher order thinking skills, self-directed skill-sets, and to encourage them to take ownership of own learning. Furthermore, within the Action Plan for Education 2016-2020, the need to improve students' values and core skills through social development was highlighted. The significance of ICT integration from a social perspective was highlighted within the learning statements of the Framework for Junior Certificate, 2015. For example, two of these learning statements (19 and 24 as shown below) highlighted that the integration of technology in education was highly valued, in terms of its role in supporting the development of life-skills (such as communication, lifelong learning, collaboration, creative thinking, translation of knowledge into practice).

> *19. values the role and contribution of science and technology to society, and their personal, social and global importance*
> *24. uses technology and digital media tools to learn, communicate, work and think*

collaboratively and creatively in a responsible and ethical manner (DES, 2015b, pg. 57-58).

2.3.4.3 Advance Education Reform.

In the Saudi context, three of the aforementioned policies and plans made some reference to the need to integrate technology in education to advance education reforms. In the context of Saudi Arabia, the General Project for Curriculum Development (1998) involved a major reform of the curriculum with the primary aim to prepare learners for the knowledge economy through enhancement of skill-sets such as thinking skills, problem-solving skills, self-learning skills, collaborative learning, and communication, recognising that ICT can play important part in supporting the development of these skills-sets. In terms of the Tatweer project (2007), it was developed to reform the education system through supply and support of the much needed technology infrastructure in public settings and through provision of teacher ICT training. Likewise, the 10th National Development Plan**, 2015-2019** contained a programme for education that sought to enhance economic growth through reform of education systems, specifically "*improve the learning environment to stimulate creativity and innovation and provide citizens with knowledge and skills to meet the future needs of the labor market*". (MoE, 2015i, p.60).

In the Irish context, two of the aforementioned Irish ICT policies and/ or plans made some reference to the need to integrate technology in education to advance education reform. The strategies focused on greater improvements in teaching, learning and assessment. **The Digital Strategy for Schools 2015-2020** in itself could be considered an education reform programme developed to support the notion of integrating ICTs to enhance the progression of education reform and support the development of active and informed citizenry. It thus advanced educational reform through use of digital technologies *'enhance teaching, learning and assessment so that Ireland's young people become engaged thinkers, active learners, knowledge constructors and global citizens to participate fully in society and the economy*' (DES, 2015, p. 5). Furthermore, within the Action Plan for Education **2016-2019**, a whole-systems reform approach was applied centred on reforms based on the key principles of access, excellence, transparency and innovation, with an aim '*to deliver high quality education and training experiences that equip learners with the knowledge and skills* *that they need to achieve their potential and to participate fully in society and the economy*' (DES, 2016, p. 6).

2.3.4.4 Support Education Management

In the Saudi context, there was limited explicit reference within the policies and plans (active in 2017) to the need to integrate technology in education to support education management. In fact, the Tatweer project brief was the only one of those reviewed to specify a technology-enabled system that could manage educational process i.e. the "Noor e-system" which includes facilities to track and report on students' attendance and performance, and teacher's attendance, as well as timetabling facilities to structure organisation of classes.

Similarly, in the Irish context, there was very limited reference within the policies and plans (active in 2017) to the need to integrate technology in education to support education management. The **Digital Strategy for Schools 2015-2020** did mention the potential of technology to provide feedback on learner performance to teachers and parents. In this regard, teachers could review learner performance through data gleaned from learner interactions within online simulations, digital games, virtual worlds, and/ or virtual labs for example.

2.3.5 Comparative Analysis of Operational Components of Policies/Programmes

The operational components were made visible within programmes, action plans, and/ or projects in the descriptions of how the strategic vision was to be realized. The operational components as outlined by Kozma (2008) included the presence of one or more from the following components: 1) Infrastructure development, 2) Teacher Training, 3)Technical Support, 4) Pedagogical and Curricular Change, and 5) Content Development.

2.3.5.1 Infrastructure development

In the Saudi context, there was considerable articulation of infrastructure development within the Tatweer project plan (2007) which sought to invest in and expand the use of appropriate technologies across Saudi schools. The Tatweer plan stated as its aim that it set-out to ensure that all schools have good ICT infrastructure (MoE, 2007), and further detailed that some of these supports would include supplying computers and other ICT equipment along with high speed Internet connectivity to schools in Saudi Arabia. Furthermore, the 10th National Development plan (2015-2019) also re-iterated its plan to provide schools with the necessary ICT infrastructure.

In the Irish context, there was explicit reference, within the Digital Strategy for Schools policy 2016-2020 and Action Plan for Education 2016-2019, to the need for supports in ICT infrastructure development. The Digital Strategy for Schools 2015-2020 recognising the need for schools to upgrade their ICT facilities, reported that investment in national ICT infrastructure (specifically improved connectivity through broadband services, and grants for schools to purchase ICT equipment) would be extended to include all post-primary schools and a number of special schools with post-primary students, and primary school settings. The strategy documents further pointed to trends regarding the role of cloud computing in education, and learners being encouraged to bring their own devices (BYOD) to schools. With respect to the latter, they noted the potential of engaging in BYOD practices in terms of progressing ICT integration in schools, but pointed to the need for the provision of advice and support for schools with regards to potential issues in doing so, and in enabling schools to make informed decisions at local levels regarding infrastructural requirements. The Action Plan for Education (2016-2019) included the implementation of the Digital Strategy for Schools (including investment in infrastructure such as high-speed broadband for primary schools) within its pathway.

2.3.5.2 Teacher Training

In the Saudi context, there was recognition of the need for teacher training to develop ICT competency within the Tatweer project brief (2007-2023). The Tatweer project plan included an overview of an ICT competency framework, with a focus on building teachers' skills in infusing ICT in their teaching and learning practices. Furthermore, the role of technology in enabling communities of practice was recognised within the Tatweer project, with opportunities for teachers to connect and exchange best practice in using technology for learning and teaching purposes. Moreover, the Tatweer plan referred to the forging of partnership with educational colleges that would enable the development of teacher training programmes focused on the usage of ICTs across the curriculum. The National Transformation Program for Education (2020) also mentioned the need for teacher professional development and the inclusion of ICT within '*the comprehensive framework for continuing professional development for teachers and educational leaders*' (MoE, 2016, p. 100).

In the Irish context, there was recognition of the need for teacher training to develop ICT competency within the Digital Strategy for Schools 2015-2020, and that advice and guidance would need to be provided for teachers and schools with respect to the effective, critical, and ethical integration of ICT, along with examples of authentic and good practices in teaching learning and assessment using ICT. Within the Digital Strategy for Schools 2015-2020, there was further confirmation of the need for adaptation and localisation of the UNESCO ICT Competency Framework (2018) for teachers working in Irish school contexts, in order to enable schools to "*have greater clarity around the concept of ICT integration*" (DES, 2015a. p. 6).

2.3.5.3 Technical Support.

In the Irish context, there was recognition in Digital Strategy for Schools 2015-2020 that schools faced challenges in acquiring appropriate technical support, and commitment to engage in a review of "*technical support options with a view to providing guidance on the best technical support solution for schools*" (DES, 2015a, p. 7). During the formulation of this Digital Strategy for Schools, '*schools identified the challenge of attaining reliable and timely technical support as a major issue. In addition, schools had very diverse needs in terms of technical support, which would require technical providers to have a high level of technical knowledge and expertise that is relevant to different school settings or contexts'* (DES, 2015a, p.43). There was just one reference to the need for technical support within the Saudi policies or programmes that were active in 2017, and this was within the Tatweer report (2007).

2.3.5.4 Pedagogical and Curricular Change

In the Saudi context, as already mentioned, the Tatweer project plan pointed to improving the quality of learning by connecting teachers with peers to exchange best practice on integrating ICT in their relevant discipline/s. However, the Tatweer project brief lacked detail on how ICT would be used to support assessment.

In the Irish context, as already mentioned the Digital Strategy for Schools 2015-2020 committed to providing guidance and examples of good practice on the integration of ICT in teaching, learning and assessment, which would contribute to enhancement of pedagogical and curricular practices. Furthermore, within this strategy, the DES committed to the articulation of the necessary digital skills and related learning outcomes in the new curricula throughout the lifetime of the Digital Strategy and beyond. A possible criticism of the strategy was that there was not enough detailing within the strategy on what should be included in terms of learners' digital competencies and how technology should or could support assessment, pedagogical and/ or curricular change - its focus instead appeared to mainly focus on identifying teacher competencies vis-à-vis technology integration. It was noted within the Digital Strategy for Schools that there were calls for the development of learners' levels of digital literacy by including coding and programming in the Irish primary and post-primary curriculum, whereby learners would learn core problem-solving and life-skills such as computational thinking, logic, critical thinking and strategic thinking.

2.3.5.5 Content Development

In the Saudi context, there was recognition within the 2010 report of General Project for Curriculum Development of the need to integrate ICT into the curriculum and provide learners with digital content and other resources related to the curriculum such as educational video, multimedia, e-book and website/s. Moreover, the Tatweer project brief committed to upgrading the educational portal to provide educational content that facilitated sharing of experiences by teachers and learners. Furthermore, it committed to engagement in Interactive Digital Content curriculum development, thus enabling the transformation of all curriculum into online and off-line 'interactive' experiences, supported by multimedia content on smart phones, tablets and iPads and a central education portal. Furthermore, it committed to providing high quality digital learning experiences for all students through the establishment of an e-school, built by a team of specialists to lead and manage it. The National Transformation Programme 2020, further made commitments to improving curriculum, teaching and assessment methods through '*shifting to digital education to support teacher and student progress'* (MoE, 2016, p. 100).

In the Irish context, there was recognition of the need for content development within the eight key skills within the Framework for Junior Certificate (2015), which also directly referenced digital competencies that enhance the learning and life-skills of learners. In this regard, the DES noted specialist short courses in coding and digital media literacy were to be offered within the revised Junior Certificate Framework. Teachers were also to be offered continuing professional development to transition to the new framework, and additional resources and online support were to be made available to support teachers in enhancing the learning environment through use of ICT. Furthermore, the Digital Strategy for Schools 2015-2020 included a commitment to support all learners with high-quality digital content, whilst also supporting national educational portals, such as 'Scoilnet' and the 'Arts in

Education' portal. The plan also indicated it would support alternative means of assisting schools to access digital content, such as the purchase of digital resources relevant to the curriculum.

2.3.6 Comparative Analysis of Other Components Impacting Policy

The comparative review concluded by exploring policy/ programme alignment and embedded evaluation strategies, where relevant, within both the Saudi and Irish contexts.

2.3.6.1 Policy Alignment

In the context of Saudi Arabia, the Tatweer project aligned with other national plans including the 9th and 10th National Development Plans, the Saudi Employment Strategy (2009) and the National Transformation Programme 2016-2020, all of which involved close coordination and collaboration across a range of governmental departments, including the Ministries of Education, Communications, and Information Technology.

In the Irish context, the Digital Strategy 2015-2020 aligned with, and supported the ICT Skills 2014-2018 Action Plan, which aimed to '*ensure young people have the necessary knowledge and skills to contribute to and participate in modern society'* (p.10). The rollout of broadband to primary and post-primary schools programme was jointly funded by the Department of Communications, Energy and Natural Resources (DCENR) and the Department of Education and Skills, showing alignment and collaboration across two different governmental departments in the implementation of the policy to improve Internet access to all primary and post primary schools. The Action Plan for Education (2016-2019), was closely aligned to a number of ICT integration strategies and included cooperation across a number of other Departments, including the Department of Education & Skills, and their agencies. For example, it aligned with the Digital Strategy for Schools 2015-2020 which aimed to invest in infrastructure such as high-speed broadband for primary schools.

2.3.6.2 Evaluation at Strategic Level – Indicators.

In the Irish context, within the DES Digital Strategy 2015-2020, there was a separate theme titled: *Leadership, Research and Policy*, under which the need for distributed leadership in order to truly integrate ICT across the education system was highlighted. The Strategy recognised the important role of the DES and associated agencies in providing "*strong leadership in supporting schools to effectively integrate ICT into teaching, learning and* *assessment*" (p.7), while also strongly advocating for school management and key stakeholders to also provide leadership and ownership in this process, so that "*we achieve ICT integration and equip learners with the digital competencies that we value*" (p.7). In addition, the DES recognised the need for evaluation to monitor the meaningful integration of ICTs in education, and in assessment of progress in this regard. The DES further recognised the importance of researching and sharing of good practices in integration of ICT in Education within the wider teaching community to enhance the overall educational experiences of young people across the system. Finally, the DES cautioned of the dangers of mis-use of ICTs in education and committed to providing guidance and supports to ensure the effective, safe and ethical use of ICTs is embedded within school policies and practices.

In the Saudi context, the MoE recognised the importance of measuring the outcomes from the implementation of their action plans and projects progressing integration of ICT in education. Therefore, the final phase of each action/ project had an evaluation section to annually measure the strategies' outcomes.

2.3.7 Conclusions: Comparative Analysis of ICT in Education Policy/ Programme

In terms of both the Saudi and Irish contexts, the review of rationale/s underpinning policies and/ or programmes focusing on ICT integration in education, found evidence of multiple rationales, with a primary focus on using ICT integration to progress the type of educational reform that would lead to better preparation of a work-force for the knowledge economy (thus, enhance economic growth) across both countries and a lesser focus on its value in terms of enabling or enhancing social development/ cohesion in Saudi Arabia.

In terms of operational components, the comparative review of policies and programmes showed that infrastructure development, teacher training in ICT, content development and needs for pedagogical support were articulated within action plans, projects and/ or programmes focused on ICT integration across both jurisdictions, and furthermore the need for technical support was made explicit in the Saudi Tatweer report and the reports reviewed from the Irish context.

In terms of policy alignment and explicit reference to evaluation of plans/ programmes, there was considerable alignment of the plans and projects with national policies, and robust measures within both contexts to assess the effectiveness of ICT integration in education.

The detailing of evaluation strategies within the Irish policies and programmes was extensive and sought at its core to critically evaluate and be responsive to the learning from the process of integrating ICT in education.

2.4 Mathematics Education.

The context for this study is mathematics education, and therefore, this section presents a brief history of the development of mathematics education internationally, including an overview of what are considered core principles and good pedagogic practices in mathematics education internationally.

2.4.1 Brief History of the Development of Mathematics Education.

The study of mathematics as a discipline began in the 6th century AD with Pythagoras who coined the term ‘mathematics’ from Greek, meaning ‘subject of instruction’ (Heath, 1921). Before the modern age, mathematics was primarily used for trade and commerce. By the twentieth century, mathematics had become an independent curriculum in developed countries. The first mathematics curriculum mainly focused on teaching and learning of basic arithmetic (addition, subtraction, multiplication, and division). Therefore, the focus in mathematics was on processing mainly arithmetic operations, to support mental arithmetic skills and basic accounting. In the 1950s and 1960s, the focus of ‘new mathematics’ moved towards enabling learners to understand concepts within mathematics and to develop computational skills. Later, in the 1980s and 1990s, there was a shift towards what was called ‘mathematical power’, which promoted the development of: reasoning, solving problems, connecting mathematical ideas, and communicating mathematics to others (Kilpatrick, Swafford, & Findell, 2001; Devlin, 2011). In the early 21st century, ‘mathematical proficiency’ became a key focus in many countries. In a report titled “Adding it Up: Helping Children Learn Mathematics”, Kilpatrick et al., (2001) described mathematical proficiency as having five strands which attempt to codify mathematics skills according to what is needed to function in society of today which involve specific processes as follows:

- Conceptual Understanding: Comprehension of mathematical concepts, operations, and relations
- Procedural Fluency: Skill to carry out procedures flexibly, accurately, efficiently, and appropriately
- Strategic Competence: Ability to formulate, represent, and solve mathematical problems

• Adaptive Reasoning: Capacity for logical thought, reflection, explanation, and justification
• Productive Disposition: Habitual inclination to view mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy (p.5).

In most countries, the mathematics curriculum is organised into distinct domains to engage learners in mathematical process/skills such as reasoning, argumentation, justification, generalisation, representation, problem solving, communicating and connecting, which Dunphy, Dooley & Shiel, (2014) argue need to be tied to the content that students are learning. Learners, therefore, need to be able to make connections across mathematical concepts and furthermore to develop fluency, reasoning, and competency in problem solving. For younger learners, numeracy is the heart of mathematics school curricular content. Nowadays, it is broadly recognised that Mathematics content should not be limited to solely the topic of numbers; it should be comprehensive, drawing on many domains. Thus, in some countries such as the United Kingdom (UK) and the United States (US), the mathematics curriculum facilitates inter-disciplinary connections. In many countries, mathematics textbooks are effectively organized to focus on the major mathematical concepts at each level of education. For example, at primary level, the domains in the US Common Core State Standards (CCSS) for mathematics for Grade 1 to Grade 3 include: operations and algebraic thinking, number and operations in base ten, measurement and data, and geometry (Common Core State Standards, 2010). Similarly, the study programmes for year 1 and 2 in the United Kingdom are organised into five domains: number, measurement, geometry, statistics, and algebra (Department for Education, DfE, 2013). Moreover, the Irish curriculum for primary learners aged 5–8 includes number, measurement, geometry and spatial thinking, algebraic thinking, and data and chance (Dunphy et al., 2014).

The focus of mathematics education in general is not just to engage learners in mathematics thinking but rather to enable them to view mathematics as way of thinking (Pratt, 2002) and a subject of growth in which their role is to learn and think about new ideas (Boaler, 2016). Therefore, all learners should be taught within a culture that values their ability to think, engages them in the breadth of mathematics, and encourages them to achieve more (Boaler, 2016). Learners must be taught to be power thinkers who make connections, think logically, and use numbers creatively.

2.4.2 Approaches/ Models for Mathematics Education

There are diverse ways of fostering the development of mathematical proficiency over time. More traditional pedagogic approaches applied within mathematics education would have very much followed linear pathways, such as those outlined by Good, Grouws, and Ebmeier in 1983 (as explained in Sullivan, 2011) as follows:

> After correcting homework, the teacher poses some old examples to check student facility with prerequisite skills. The teacher then presents some new examples and asks students to complete some illustrative tasks. Next, further questions are posed [by the teacher] in sets of similar complexity. Then the students' responses to set exercises are corrected. Some further examples are posed [by the teacher] to the class to check both the students' accuracy and their capacity to explain the process they used. Further examples are set for homework.

This sequential lesson structure would traditionally have been promoted to regulate the approach to teaching and learning across a range of disciplinary areas, but in the context of mathematics education would in reality have only been beneficial in development of basic procedural knowledge rather than learners' conceptual, analytical or adaptive type reasoning. Since the turn of the millennium, there have been attempts to clarify the characteristics of good mathematics education. According to the National Council of Teacher of Mathematics (NCTM) in the United States, there are five essential characteristics of an effective mathematics lesson**,** namely, having a distinct introduction to the lesson, through engagement of learners in the development of mathematics concept/skills, guided practice from teacher, summarising of key learning, and/ or facilitation of independent learning, as noted by Larson (2002). The characteristics are further described below.

1) **Distinct Lesson Introduction:** The first effective element in mathematics learning is a 'distinct beginning'. Teachers can use a variety of ways to start a mathematics lesson with a clear focus on the mathematical goal. Thus, teachers at the beginning of a mathematics class can help learners to focus on the main objective of the lesson, what they will learn, and why this objective is important. Secondly, the class can be started by connecting learners to prior knowledge. Thus, teachers can design initial activities to access learners' prior knowledge; these activities could include discussing homework or a 'problem of the day'.

2) **Development of Concept/Skills:** Teachers can choose activities and instructional strategies to support the learning objective. Therefore, they can choose an activity that actively engages learners in exploration of the topic at hand and make sense of it. They can engage learners in worthwhile activities and use physical models before enabling learners to abstract from physical to conceptual. Furthermore, teachers can also enable learners to make connections between mathematical ideas in differing ways, thus broadening their understanding of the concept/s.

3) **Guided Practice:** Learners can move from practising learning themselves to practising under the teacher's guidance. Learners can be provided with activities that allows them to choose different methods to solve a problem. The teacher will help them to understand the strategies that they used to solve a problem and why this strategy worked. Learners can work in groups or individually on the activity.

4) **Summarising:** Learners are asked to connect the results of mathematical activities with the learning objectives. Teachers can check on learners' understanding through questioning and discussion. Interactions of learners with the teacher or their peers have a powerful influence on their learning.

5) **Independent Practice:** Learners should be allowed to practice independently to facilitate their conceptual understanding and to help them master mathematical skills. Learners are given space to practice what they've learned and are engaged in activities that reinforce mathematical concepts and skills. This helps them to develop a deeper understanding of the new concepts learned. These activities can be in the form of written activities, carefully designed games, or digital activities.

At first glance, these effective characteristics look similar to key aspects of the aforementioned traditional lesson structures for mathematics education. However, the approach differs greatly with respect to firstly, level of learner autonomy within the setting, and secondly, the level of learner engagement. The expectation within a mathematics education model that actively tries to integrate these 5 characteristics of effective learning is that learners will be more self-directed, and also more engaged within the learning process. Conversely, teachers will act more as facilitators, and subject matter guides on the side, helping to keep learners focused on-task throughout the learning cycle.

In terms of pedagogic models that effectively integrate some or all of the aforementioned characteristics of effective mathematics education, two sample pedagogic models are presented here simply as examples of how these elements can manifest in teaching and learning practice. These two models, namely, the Alternative Challenging model (Wigley, 1992) and the 5E Model (Bybee, 1987), are discussed in the following sub-sections.

2.4.2.1 Pedagogic Model: The Alternative Challenging Model

The 'Alternative Challenging Model' of mathematics education presented here was developed by Wigley in 1992. The main feature of this model is to challenge the learner. Therefore, the teacher initially presents a challenge and then supports the class work. The essential support elements in this model are encouraging collaborative work, setting more open tasks, and providing learners opportunities to reflect on their learning. Learners can work in small groups, and each group can use their own strategy to solve a common problem. The teacher can work extensively with groups, encourage discussion, and share ideas, so that learners can help and support each other. Individual work, however, still occurs to meet individual needs. The 'Alternative Challenging Model' can be summarised as follows:

1- The teacher provides learners with challenging activities and gives them time to work on the activities. At the right level of challenging, learners can progress towards solving the problem using a variety of approaches. It is important here to give sufficient time for learners to understand the problem.
2- The teacher's role is to enable learners' present their ideas and share them within groups or with the whole class.
3- A variety of strategies can be applied to different mathematics problems to test special cases, examine related problems, and develop some fluency in the process.
4- Using variety of techniques, learners can review their work, identify what they have learnt, and understand how it is all connected.

The other essential feature of this model according to Wigley (1992) is in enabling the learner to review own work, or what can be described 'reflective activities'. Reflective activities help learners to consider what they have learnt, and this will inform future learning activity. Reflective activities can be in the form of talking or writing activities. Therefore, learners can draw a concept map of the selected topic, make a poster, or write a report.

2.4.2.2 Pedagogic Model: 5E Model

The 5E Model was developed by a team led by Roger Bybee in 1987 in a Biological Science Curriculum study. However, this model equally can be used within mathematics classrooms. The 5E Model is an instructional model that consists of five phases: engage, explore, explain, elaborate, and evaluate. The five phases are explained further as follows:

- *Engagement:* The purpose of this phase is to gain an understanding of the learners' prior knowledge. It is also important to foster learners' interest in the upcoming concepts so that they will be ready to learn. The teacher can assess learners' prior knowledge and help them to engage in the new mathematical concepts through the use of short activities. The teacher's role is to identify the instructional task and set the rules and procedures for the task. In this phase, mental activities and/or physical activities can be used.
- *Exploration:* The purpose of this phase is to get learners involved in exploring activities. Exploring activities are designed such that learners and teachers can discus concepts, processes, and skills. This is a hands-on and concrete phase. The teacher's role is that of a facilitator. Thus, the teacher allows time and opportunity for learners to explore objects. During mental and physical activities, learners establish relationships, observe patterns, identify variables, and question events.
- *Explanation:* In this phase, learners generate an explanation of a phenomenon. The teacher can ask questions and provide learners an opportunity to explain and demonstrate their understanding. This phase also provides the teacher to introduce new concepts and skills, and this can guide learners towards a deeper understanding. The teacher can use a variety of techniques and strategies, such as verbal explanation and videos.
- *Elaboration:* In this phase, learners extend their understanding, concepts, and skills according to a new situation. Learners who struggle are provided more time and experience. In this phase, learners can work in small cooperative groups to discuss, present their approach, gather more information when needed, and receive feedback from others. This phase provides learners with the opportunity to get involved in new experiences through which they develop deeper understanding, gather more information, and acquire adequate skills. Learners show their understanding of the concept by completing additional activities.

- *Evaluate:* This is the final phase of the model, and it encourages learners to assess their understanding. Therefore, learners should be given feedback. This phase allows teachers to assess learners' progress towards achieving the learning objectives and to determine each student's level of understanding.

The 5E Model goes further than earlier characteristics of effective mathematics education by not just fostering engagement by learners in discovery type approaches, but by also helping the learners produce more polished products through cycles of explanation, elaboration and evaluation. The 5E model is underpinned by constructivist/ socio-constructivist theories of learning, promoted by Dewey (1933), Vygotsky (1934), with influences from Bruner (1960), that aim to facilitate deep and meaningful learning through learners' collaboration and active engagement within the learning process. The constructivist theory originated by Piaget in 1936 asserted that children's learning is age and stage related, and this overall constructivist sensibility "maintains that learning is a process of constructing meaning; it is how people make sense of their experience" (Caffarella and Merriam, 1999, p. 260). Contrary to Piaget, Vygotsky (1978) asserts that learning is a 'social process', whereby learners construct new concepts and knowledge based on their current and / or previous knowledge through interaction with the other. Bruner's initial work in the 1960s was within the realm of cognitivism, which perceived learning in terms of cognitive processes within the mind. In later years, he recognised the significance of social interaction and culture on learning, a form of socio-cultural constructivism, which prompted further thinking and debate on how learning occurs, which is captured in his 1996 book 'The Culture of Education'. Thus, this research study draws on Bybee's (1987) 5E Model, and underpinning (socio) constructivist theories promoted by Vygotsky and Bruner, as this model is commonly used within mathematics education.

2.5 Mathematics Education in Saudi Arabia.

The Saudi education system has, and is still, undergoing significant changes in terms of supporting the improvement of mathematics education at all levels in education. This improvement will continue under the Saudi National Transformation Programme 2020, which will further the goal of having high levels of skills and competency development among both teachers and learners, in line with the overall Saudi National Vision for 2030. This section outlines key developments with respect to the mathematics in primary education in Saudi Arabia.

2.5.1 Review of Saudi Mathematics Curriculum

The contemporary Saudi mathematics curriculum was articulated within the General Project for Curriculum Development (GPCD) which was introduced in 1998 and implemented in mathematics education from 2011. The General Project for Curriculum Development was a comprehensive national development plan that aimed to enhance mathematics education (and other subject areas such as science) through the development of content (including textbooks, teacher guides, activity books, and CDs), leadership and professional development of teachers, material development (including integrating technology in teaching and learning processes), and improvement in learning outcomes. The project was based on several principles, some of which included learner-centred approaches, exchange of knowledge and communication, active learning based on exploration, development of higher-order thinking skills, development of decision-making skills, development of learners' ability to deliver initiatives and plans, and connection of learning with real-life contexts (Shaya & Abdul-Hamid, 2011).

The Saudi mathematics textbooks were expected to align with the standards outlined by external bodies such as the National Council of Teachers of Mathematics (NCTM) (of the United States) in terms of the *content standards* and *process standards* (exemplified within McGraw-Hill mathematics textbooks). The NCTM *content standards* included five main areas that students needed to focus on from Grade 1 to Grade 12: numbers and operations, algebra, geometry and measurement, data analysis, and probability. The five *process standards* further required that mathematics teachers should aim to foster: problem solving, reasoning and proof, communication, connection, and representation (Shaya & Abdul-Hamid, 2011). In the years following the introduction in 2011 of the new mathematics curriculum within the General Project for Curriculum Development, a series of studies were conducted by the Excellent Research Centre of Science and Mathematics Education (ERCSME) in Saudi Arabia. The ERCSME studies involved comparative analyses of learners' outcomes using two groups, the first of which was taught using the old version of the Saudi mathematics textbook while the second group was taught using the new Saudi curriculum. The findings from this study showed that there were statistical differences between the groups, with the group taught using the new curriculum achieving slightly better scores than the one which was taught using the old version of the mathematics curriculum (ERCSME, 2015). The first participation by Saudi Arabia in the mathematics component of the Trend of International Mathematics and Science Study (TIMSS) was in 2003 (MoE, 2018a). Saudi Arabia achieved significantly below the average in mathematics (with a mark of 416) in the TIMSS test administered to fourth grade learners in 2007 (Al-Shamrani, 2009), and its overall ranking dipped from 45th in 2011, to 46th in 2015 (Al-Shamrani, Al-Shamrani, Al-Burzan, & Al-Durani, 2016). Furthermore, in 2016, a report was written by members from the ERCSME comparing the average performance of fourth grade students in mathematics in Saudi Arabia with the top five countries in TIMSS, 2015, focusing on mathematics content areas and cognitive processes. This study found that performance of Saudi learners was below the average (383) for all mathematical content areas (Numeracy, Geometry and Measurement, Data Representation). Moreover, Saudi learners achieved below average in all cognitive processes when compared to the top five top countries (Al-Shamrani et al., 2016). The authors reasoned that the below average performance may have been caused by differences within the 'depth' of the mathematics content taught to the learners in Saudi Arabia (when compared to curriculum coverage in the top five countries) or it may have been as a result of pedagogic approaches used by teachers in Saudi Arabia. A key aim of the Saudi Ministry of Education (as articulated in the National Transformation Programme 2020) in terms of international performance, became to enable the average fourth grade Saudi student to achieve 460 in mathematics within the TIMSS test by 2020.

A further study by ERCSME (2015) explored the alignment of the content of the Saudi textbook to the content of the original series textbooks from the publisher, McGraw-Hill. They found that the Saudi Grade 2 & Grade 3 textbooks had moderate coverage of curricular areas, and furthermore that Grade 1 textbook alignment was below average, when compared with the curriculum coverage for these grade levels within the McGraw-Hill standard textbook. Similarly, another study by Al-Blewi (2016) to analysis Saudi mathematics textbook in terms of the alignment with curricular areas within the TIMSS 2011 Study, including: Content Domains and Cognitive Processes, indicated that the Saudi mathematics textbook somewhat aligned with content covered within TIMSS 2011 standard. In this regard the level of numeracy skills development/content exceeded by about 14% that which was required to engage with TIMSS Study (2011), while the Geometry and Data Representation areas were covered to a lesser extent than the requirements by TIMSS 2011 Study (9%, 5.7% respectively). In terms of Cognitive Processes (Knowing, Applying, Reasoning), the findings showed that the Saudi mathematics textbook somewhat met the curricular requirements for the TIMSS 2011 Study, with the thematic area of 'Knowing' exceeding the curricular requirement by about 16.5% and the curricular coverage of the thematic area of 'Applying' being 9.3% less the TIMSS 2011 Study requirements.

Finally, a number of assessment projects have raised concerns about performance among children. The Educational Performance Improvement Project, entitled Hssen (improvement in English language) was the first national assessment since the introduction of the new curriculum to assess mathematics in both lower and upper levels in primary education. The assessment was first implemented in 2013 and targeted all primary students in both public and private schools. The tests take are held twice a year (MoE, 2013). Furthermore, in 2015, a collaborative assessment project involving the Australian Council for Educational Research (ACER) and Saudi Arabia's Public Education Evaluation Commission (PEEC) was introduced to evaluate the development of assessment framework and explore the mathematics and science curriculum taught in Saudi Arabia for students at each level. The project included a survey of students, teachers, and parents to gather information about students' family resources, attitude to schooling, and learning and experience of schooling. PEEC plans to introduce computer-based assessments to enable interactive and multimedia-rich assessments. The first assessment was undertaken in 2015 and it involved grade 3 and grade 6 students in mathematics and science. The plan is to expand the assessment each year in terms of the number of grade levels and subjects to be assessed. The results of either of the aforementioned assessments are not publicly available, so no further analysis can be made within this literature review.

2.5.3 Saudi Teacher Preparation and Professional Development for Mathematics Education

The process of mathematics education requires appropriate content knowledge and pedagogical knowledge across the disciplinary area/s. In terms of formal training, teachers in Saudi Arabia are required to have a bachelor's degree from a college of education in subjects related to the subject matter. Such a teacher preparation college programme is typically of four to five years in duration and can be accessed through two types of teacher training colleges. The first type is an education college which prepare Intermediate and second-level teachers. These colleges focus mainly on specific subjects such as: mathematics, physics, and chemistry. The other type of teacher education college is focused on preparing primary teachers and tends to integrate general courses in science and mathematics. Both types of colleges provided teachers with field experience and supervised teaching practice.

The Teaching Strategies Development Project (TSDP - 'Teach me how to learn' project) was developed by the Saudi Ministry of Education in 2000. The overall objective of this project was to develop classroom teaching practices that could help achieve good educational outcomes. The project was based on an active learning pedagogic approach that aimed to place learners at the centre of learning processes. It aimed to encourage learners to discover and construct knowledge by engaging them with direct experiences and open-ended activities to support their thinking and exploration. It also encouraged learners to ask questions and work independently or within co-operative groups (MoE, 2008). To achieve this, the MoE recommended the use within mathematics education of particular teaching strategies such as collaborative learning, communication, critical thinking, creative thinking, and solving problems. There is no evaluation available publicly on the broader success or otherwise of this programme. The new mathematics curriculum was intended to encourage teachers to use continuous assessment, including diagnostic assessment, formative assessment, and final assessment. At the beginning of the academic year, teachers were to evaluate learners' performance to determine their individual strengths, weaknesses, and knowledge. Furthermore, at the beginning of each chapter, teachers were asked to evaluate learners' prior knowledge through the use of different resources such as textbooks, teacher's guide, or any other relevant resource. Formative assessment was to be used in every lesson to evaluate learners' understanding. In addition, final assessment could be given to the learners at the end of each chapter to assess their knowledge of the topics covered in that chapter (Shaya & Abdul-Hamid, 2011).

According to the Saudi Ministry of Education two main challenges relating to teacher education remained in the implementation of the new curriculum: (1) primary mathematics teachers were not specialists in mathematics teaching, and, (2) the Saudi educational system suffered from a lack of teacher professional development (Shaya & Abdul-Hamid, 2011). In order to develop mathematical proficiency, mathematics teachers needed to have a deep understanding of mathematics knowledge, be well skilled in teaching, and really have a good understanding of how learners learn. In more recent times in Saudi Arabia, there had been some attempts to develop working frameworks to develop pedagogical knowledge within pre-service and in-service mathematics training programmes. For example, a study by Almaliki, 2010 explored the effectiveness of a proposed training program to provide mathematics in-service teachers with some active learning skills, as well as its impact on learners' dispositions towards mathematics and their academic achievement. The study found that the training programme was effective in fostering the integration of active learning skills. Another study was by Hamdi, 2017 develops a training programme based on some of new active learning strategies to improve in-service primary mathematics teachers. He found that the programme was effective in fostering the integration of active learning strategies. Following the introduction of the new mathematics curriculum across Saudi Arabia in 2011 a series of studies were conducted by the ERCSME. One of the ERCSME studies in 2011 sought to assess the professional development needs of mathematics teachers, including content and pedagogy knowledge. The findings showed the need for primary teachers to gain content knowledge, especially in new areas added to the new curriculum (such as statistics) and also in mathematics skills (such as problem- solving strategies). Furthermore, the results showed that primary teachers needed additional training on mathematical pedagogies, particularly how to integrate technology in their daily teaching practices (Al-Balawi & Saeed, 2011).

A study by ERCSME in 2012 explored the effects of teachers' qualifications, practices, and perceptions on student achievement in TIMSS 2011. According to Dodeen, Dunphy, Shumrani & Hilal, 2012, Saudi mathematics teachers were inadequately prepared for teaching mathematics. In terms of their professional development, most of the Saudi mathematics teachers did not participate in any professional development programme that would develop subject knowledge in areas such as critical thinking, problem-solving skills, and integration of technology in mathematics education. Moreover, a study by Albalawi & Alrajeh, 2012 explored mathematics topics and pedagogy covered in professional development programmers in Saudi Arabia. Most of the teachers highlighted that ‘Numbers and Operation’ was the most topic covered in their professional development programs. In terms of pedagogy covered in their professional development programmes, they found that lesson planning, class discussion and connecting learners with real life problem were the dominant pedagogies covered in professional development programmes. Conversely, inquiry-based teaching, problem-based learning, concept mapping and learning cycles were generally less well covered within in professional development programmes. Therefore, the diversity of pedagogies was limited within professional development programmes in the Saudi context. This has been supported by findings from studies across the years which have showed that Saudi teachers consistently lack the ability to implement active learning strategies in mathematics classroom practice, especially problem-solving strategies (Al-Amri, 2012; Al-Badr, 2006), exploring strategies (Al-Badr, 2006), and implementation of higher-order thinking skills (Al-Zaharni, 2009; Al-Khozaim, 2012; Al-Rashidi, 2014; Al-Shadee, 2016; Alrwais, Alshalhoub, Abdulhameed & Albdour, 2016).

The MoE thus sought higher standards for teachers’ knowledge of their subject matter, and appropriate pedagogies therein. In this regard, since 2013 pre-service Saudi teachers were further required to pass assessments to determine whether they met the teaching standards. The assessment was prepared by the National Centre for Assessment (NCA). The assessment included two parts: the first part was general assessment, which covered teaching pedagogy involving all subjects, and the second part was a specific assessment of a teacher’s subject matter knowledge and grade level (MoE, 2018a). However, a further study by ERCSME in 2015 exploring the effect of professional development on teachers’ practice, found that while professional development did result in improvement with respect to curricular integration in mathematics education, it had little effect on the integration of ICT in teaching, learner-centered education and/or learner-evaluation, and teachers reported that they still needed more training in these areas. Al-Shamrani et al. (2016) in their report about factors effecting learners’ achievement in TIMSS (2015) reported that one of the factors is ineffective teachers’ professional development. They found that Saudi teachers were receiving professional development in many areas including: mathematics content, teaching mathematic, integrated technology in mathematics, improving learners’ critical thinking and solving problem strategies, assessment, and addressing individual needs, but the content of these courses was not effective in promoting quality learning experiences.

In 2016, the MoE sought to further enhance continuous professional development for in-service teachers, by developing standards for teacher professional development for all teachers (pre-service teachers, novice teachers, advance teachers, and expertise teachers) at all levels of education. The standard had three domains, including: teacher professional values, teachers' professional knowledge, and teachers' professional practices (PEEC, 2016). In addition, in an effort to further encourage teachers to engage in on-going professional development, a national programme 'Tmkeen' was introduced by Tatweer Company for Educational Services (T4edu) in 2016 and aimed to develop mathematics and science teachers' subject knowledge and associated pedagogies. Tmkeen was a blended professional development program (BPDP) for mathematics and science teachers of all grades. It included direct training courses, online training courses, and self-learning tools (T4edu, 2016). Further, the programme included 33 training packages with a total of 2640 hours of professional development. Each package contains 80 training hours-worth of content, including direct training, e-training, self-learning, and classroom projects. Each package was divided to include professional mathematics training for primary grades (grade 1–3), upper grades (grade 4–6), intermediate grade (level 1–3), and secondary grade (level 1–3). The programme offered three levels - basic, intermediate, and advanced - which was based on the flipped classroom model learning (using ICT), and furthermore, took into account the characteristics of adult learning as well as the characteristics of effective continuous professional development (T4edu, 2016a).

More recently, in 2017, the t4edu launched a new programme 'Khebrat'. The aim of the programme was to develop professional practices for teachers and school leadership in the practice of teaching (including ICT integration) through international partnerships. Nine countries were chosen to implement new programmes in specialist areas, including: Ireland, U.S., UK, Australia, Canada, Finland, Singapore, New Zealand, and Sweden. Furthermore, in 2018, the National Centre for Professional Development launched a summer training programme in partnership with a group of Saudi universities, which included: Tatweer for educational services, Tatweer for educational technology, Saudi private centres, and specialized companies, all of which provided opportunities for teachers to increase the efficacy of educational practices (T4edu, 2016b).

2.5.4 Instructional Materials and Technology.

Since schools opened, textbook and workbooks have remained the main resources in the mathematics classroom, and in the Saudi context are provided by the Ministry of Education. In addition, supplemental materials, such as: geometric figures, base-ten blocks, connecting cubes, and wooden geometric shapes have been provided for primary-level mathematics classes (MoE, 2016a). Furthermore, teachers were to be supplied with specific resources such as guidebooks, teacher's manuals, flash cards, posters, and computer software (CDs with textbook and related materials) specifically prepared for them, by mathematics and science project managers and the MoE (TIMSS, 2015).

However, in terms of technology integration, studies suggest that in Saudi schools there has been an ongoing issue with the availability of technology that is impacting on teacher and learner use of ICT in classroom practice. Al-Shmrani study in 2008 exploring the effect of school equipment' on learners achievement in TIMSS in 2007 found that only 8% of Saudi learners had adequate access to technology in schools. Similarly, the issue of lack of technology and related educational materials re-appeared as one the challenges reported by the MoE facing the implementation of the new mathematics curriculum and other curricula in 2011 (Shaya & Abdul-Hamid, 2011). This finding was re-confirmed by Dodeen et al., 2012, who found that the Saudi school environment was the main obstacle affecting the integration of technology in teaching and learning practices, particularly the shortage of computer software and hardware. However, in a literature review in 2014, Al-Mulhim found that the lack of access to ICT was still one of the main factors that affecting the integration of technology in teaching and learning in Saudi Arabia, specifically an insufficient number of computers, internet access, and the lack of software, especially those that have Arabic content. Other studies by Al-Bugami & Ahmed (2015) and Al-Harbi (2017) found that the lack of ICT resources remained one of the main barriers that hinder ICT implementation in Saudi schools. The MoE has retained a focus on promoting the use of digital resources, with companies such as iEN commissioned to provide learners with rich e-learning resources such as interactive content, self-learning tools, and self-evaluation activities to help learners look beyond the limitation of textbooks (MoE, 2019a). In 2018, the MoE further provided each learner with a free textbook with links to each lesson in digital workbooks. Learners with the new textbook can use their own devices to scan the barcode in each lesson to access the digital copy of the workbook on the iEN website.

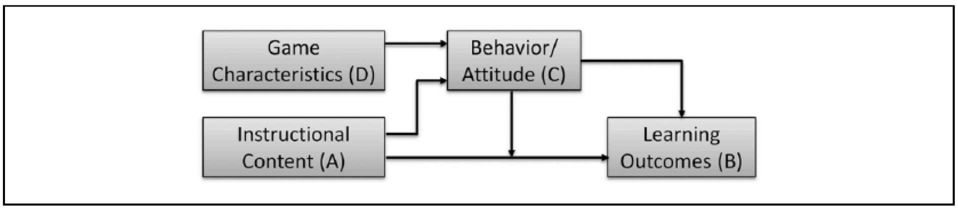
2.6 Online Gamified Learning.

As this doctoral research study intended to use an online gamified platform for practicing mathematics (i.e. the Mathletics platform), it was deemed important to conduct a review of literature and studies that had explored the impact of online gamified learning and game-based learning on learners' dispositions, cognitive abilities and behaviours, specifically at the primary level of education. The discussion opens with an introduction to the concept of gamification of learning, which is followed by an explanation of the methodology for this section of the literature review, and in the latter section, the findings and conclusions from the meta-analysis of the review are presented. It is important to note here that some content in this section has been re-cast from material presented within a chapter on gamification/ game-based learning that was published by Springer in 2017 (Alghamdi & Holland, 2017), which can be accessed from Apppendix J.

2.6.1 Gamification of Learning

The gamification of learning involves the use of game features in a non-game context (Deterding, Sicart, Nacke, O'Hara & Dixon, 2011), and focuses on developing skills, changing behaviours and driving innovation (Burke, 2014). In fact, "*gamification is about engaging people on an emotional level and motivating them to achieve their goals*" (Burke, 2014, p.16). The use of gamification has been increasingly applied to different fields, including politics, health and marketing. Gamification of learning involves the application of individual game elements or combinations of those elements within a learning context (Landers, 2015). Numerous scholars have attempted to create a gamification element framework. For example, Werbach, and Hunter, 2012, proposed a framework of gamification in which the gamification elements form a pyramid with three main groupings as follows: *components* (i.e., achievements, levels, avatars, points, badges, leaderboards, virtual goods, content, and gifting); *mechanics* (i.e., challenge, competition, cooperation, feedback, resources, rewards, and chances); and, *dynamics* (i.e., constraints, emotions, narrative, progression, and relationships). In addition, Bunchball (2010) presented a list of common game mechanics that could be applied to gamification: points, levels, challenges, virtual goods, rewards, status, accomplishments, self-expression and competition. In educational contexts, Kapp (2012) further added to that list, with: "*goals, rules, conflict, competition, cooperation, time, reward structures, feedback, levels, storytelling, interest level and aesthetics*" (pg. 28) as elements that can be applied within a learning context. Moreover, in a systematic mapping study to investigate the gamification elements that can be applied in education, Dicheva, Dichev, Agre & Angelova (2015) acknowledged that the most popular game mechanics were: points, badges and leaderboards, and further identified gamification principles, including: visual status, social engagement (competition), freedom of choice, freedom to fail, and rapid feedback. More specifically, in primary education, Simões, Díaz Redondo and Fernández Vilas (2013) constructed a framework of gamification elements that could be applied to an online social learning environment for primary education learners (aged 6 to 12), which included: feedback; rewards (e.g., badges and points); levels; a progress bar; student participation; and, performance.

Landers (2015) tried to develop a theoretical model to explain how gamification affected learning. He used nine game attributes to define game elements including: action language, assessment, conflict/challenge, control, environment, game fiction, human interaction, immersion and rules/ goals that can apply outside of game context to increase engagement and improve learning. Landers (ibid) defined gamification as the use of these game elements to facilitate learning and related outcomes (p.757). In his theory, he stated that game elements will affect learners' behaviour and by default their learning. In this regard, Landers articulated two main processes by which game elements can affect learning (see Figure 2.4), which form the foundation of the theory of gamified learning.



Note. D → C → B and A → C → B are mediating processes. The influence of C on A → B is a moderating process. Directional arrows indicate theorized path of causality.

Figure 2.4: Theory of gamified learning adapted from Landers, 2014.

The first process is a more direct 'mediating process' and the second process is a less direct 'moderating process'. Gamification can affect learning via the mediating process, i.e. when game characteristics affect behaviour and/or attitude and the behaviour and/or attitude affects learnings. The important implication in this process is that a game element must cause positive changes in the behaviour/ attitude of a learner, with the corollary that the change in behaviour will lead to improvement in learning. For example, the integration of a game element (e.g. points, credits) might encourage learners to visit the activities more regularly, which would likely lead to improvement in their learning. In terms of a moderating process, the learner engagement with the instructional content and experience of interacting in game (i.e. achieving or not achieving the learning outcome/s), is impacted by the learner disposition.

2.6.2 Methodology

The focus of this part of the literature review was to identify recent studies on gamified/ game-based learning undertaken within the context of primary education. The electronic databases searched in this dimension of the literature review were Science direct, IEEE (Institute of Electrical and Electronics Engineers), Springer, Scholar and Wiley. The scope of the search was narrowed using terms including “online game–based learning” “online digital game-based learning”, “gamified learning” and “gamification” and more specific terms were also included such as “primary education” and “younger learner”, and over 1000 papers were initially identified. Studies were then selected with the following inclusion criteria; 1) have been published from 2005 to 2015, 2) have focused on primary education, and 3) have been written in English language. It also should be noted that only those games employing an Internet or wifi connection were considered ‘online’, and, consequently, papers presenting research on topics, such as digital based-learning without use of internet connection, were not included in this paper.

To enable the implementation of the selection criteria, and given the diversity of online games, two steps were taken in the selection process. First, during abstract screening, records reporting the same study were clustered together. Second, during full-text vetting, the references were reviewed, which resulted in the delivery of several papers relevant for the review but not covered in the databases. The literature review uncovered seventeen papers reporting on studies exploring the impact of online gamified/ game-based learning. The questions that guided the review of each of the selected papers were as follows:

- What does this study reveal about dispositions, cognitive abilities and/ or behaviours of learners within online game-based/ gamified learning environments?

- What factors contribute to changes in learners' dispositions, cognitive abilities and/ or behaviours within online game-based/ gamified learning environments?

For the purpose of the review, *Dispositions* were understood as learners' attitudes or feelings towards engagement within the disciplinary area; *Abilities* were understood as development of learners' cognitive abilities within the disciplinary area; and, *Behaviours* were understood as the nature, types and degree of engagement in the disciplinary area within and beyond the classroom.

The findings from the selected papers were initially coded according to whether an increase, decrease or no change was recorded in the dispositions, abilities and/ or behaviours of learners. The age-group, disciplinary area and size of study were also recorded. In addition, factors that contributed to changes in dispositions, abilities and/ or behaviours of learners were noted. The outcomes from the coding process were then cross-tabulated to ascertain common outcomes and corresponding themes, and these were then presented within the frame of discussion under the headings of 'Dispositions', 'Abilities' and 'Behaviours' in game-based/ gamified learning contexts.

2.6.3 Nature of studies under review

Seventeen studies were identified focused on online games-based learning/ gamification across a range of disciplinary areas. Overall, the studies mainly adopted research approaches that utilised solely quantitative or else mixed methods, with solely qualitative approaches being less common. Furthermore, studies measuring cognitive abilities (academic achievement) tended to use pre-testing and post-testing of abilities, whereas the studies of behaviours and dispositions tended to use direct observation as their research tool of choice.

A variety of different online game-based learning contexts have been used: a cooperative educational online computer game as outlined in a study by Ke & Grabowski, (2007); collaborative educational online computer games as outlined in studies by Dourda, Bratitsis, Griva1 & Papadopoulou, (2014), and Su & Chengt, (2014); a computer game design outlined within a study by Meluso, Zheng, Spires, & Lester 2012; mini games reviewed by Hwang, Wu, & Chen (2012) and Bakker et al. (2015); and 3D online game environments outlined in studies by Tüzün, Yilmaz-Soylu, Karakus, Inal, & Kizilkaya (2009) and, Filsecker & Hickey (2014).

In terms of using game-based learning or gamified learning, four studies used game-based learning, namely, Tüzün et al. (2009); Kuo (2007); Filsecker & Hickey (2014); and Sung & Hwang (2013) and only one study used gamified learning -Chang & Chen (2009). Moreover, almost all studies used some form of gamified web–based learning, including: Ke & Grabowski (2007); Costu, Aydın, & Filiz (2009); Serin (2011); Hwang et al. (2012); Chuang & Chen (2009); Garcia & Pacheco (2013) & Ronimus, Kujala, Tolvanen, & Lyytinen, (2014), while mobile learning was used in just two studies - Dourda et al. (2014), and Sandberg, Maris, & De Geus (2011).

The most common disciplinary areas for the studies under review were mathematics education and science education. Six studies implemented online games in mathematics courses (Ke & Grabowski, 2007; Costu et al. 2009; Chang *et al.*, 2012; Garcia & Pacheco, 2013; Ke, 2014; Bakker *et al.*, 2015) and another six studies were in the disciplinary area of science (Kuo, 2007; Serin, 2011; Hwang *et al.*, 2012; Sung & Hwang, 2013; Su & Chengt, 2014; Filsecker & Hickey, 2014). The remainder focused on other disciplinary areas, such as Geography (Tüzün *et al.*, 2009, Dourda *et al.*, 2014) English (Dourda *et al.*, 2014) and Literacy skills-Reading (Ronimus *et al*., 2014).

Most of the studies sought to explore the effect of engagement in online games on learners' dispositions. A number of studies explored the impact of engagement in online games on the learners' cognitive abilities such as problem solving, multiplicative reasoning ability and academic achievement. While a few studies examined the effect of engagement in online games on learners' behaviour, this review found that only three studies had implemented gamification elements. Two of these studies integrated gamification elements within 3D virtual worlds (Tüzün *et al.*, 2009; Filsecker & Hickey, 2014). The other study implemented gamification elements in a mobile learning environment (Su & Chengt, 2014).

2.6.4 Impact of online game-based learning /gamification on dispositions

Eleven studies focused on the effect of online games on learners' dispositions and attitudes (Ke, 2007; Hwang, Wu& Chen, 2012; Tuzun, Yilmaz-Soylu, Karakus, Inal, & Kizilkaya, 2009; Filsecker & Hickey, 2014; Kuo, 2007; Sung & Hwang, 2013; Ronimus, Kujala, Tolvanen & Lyytinen, 2014; Vos, Van Der Meijden, & Denessen, 2011). A variety of types of online gaming products, including 3D immersed games (Tuzun et al , 2009; Filsecker & Hickey, 2014) and mini games (Hwang et al., 2012; Bakker, Van Den Heuvel-Panhuizen, & Robitzsch, 2015) which support social interaction (cooperation, collaboration) and competition were shown to have positively enhanced primary learners' dispositions toward learning across a range of different disciplinary areas (Hwang et al, 2012; Bakker et al., 2015; Tuzun et al., 2009; Filsecker & Hickey, 2014).

Game-based learning was also shown to promote an increase in positive attitudes towards disciplinary areas (Ke & Grabowski, 2007; Dourda, Bratitsis, Griva1 & Papadopoulou, 2014; Kuo, 2007; Sung& Hwang, 2013; Costu, Aydin & Filiz, 2009; Sandberg, Sandberg & De Geus, 2011) to make the learning experience more enjoyable (Su and Changt, 2015) and to promote engagement beyond the classroom (Sandberg et al., 2011). This led in some cases to learners exhibiting independent behaviours (becoming more self-directed, autonomous) and a positive shift in their interest towards the process of learning, as opposed to focusing on academic grades (Tuzun et al., 2009). Game-based learning supported this through the inclusion of motivational gaming features such as fantasy and relevance (Kuo, 2007) collaboration and team-based type activities (Dourda et al., 2014) and appropriately designed aesthetic interfaces with attractive illustrations for example (Dourda et al., 2014). Immersive gaming environments that supported 3D virtual engagement among multiple players were further shown by Tüzün et al. (2009) to increase motivation through use of exploration, interaction, collaboration and through activation of player presence. The act of constructing games was also shown to increase positive attitudes and motivational levels of learners (Vos et al., 2011), particularly if it involved experimentation and sharing of ideas – learners liked 'messing around with scripts' (Vos et al., 2011), Ronimus et al. (2014) further found that the presence of reward systems had an initial significant positive effect on concentration levels. Su and Chengt (2015) found that leaderboards, badges and missions increase learner engagement. Kuo (2007) found that game and non–game learning environments should be more fun to motivate learners and keep them on task.

Other studies evaluated the impacts of specific game elements on learner engagement. For example, Kingsley & Grabner-Hagen (2015) and Seixas et al. (2016) evaluated the gamification mechanics (for example, badges) on learners' engagement. They found that badges can create a fun learning environment and have a positive effect on learners' motivation and interests.

There were some cautionary notes about use of game-based learning in some of these studies. A study by Ronimus et al. (2014) reported that when the novelty of using reward system within games wore off, the learners' engagement decreased. Furthermore, Ke & Grabowski (2007) found that cooperative game-playing encouraged more positive dispositions than competitive game-playing towards the disciplinary area of mathematics. Also gaming environments without a sufficient degree of learning challenge – such as those involving just the gathering of information – were sometimes perceived as boring as shown in a study by Tüzün et al. (2009) and thus led to decreased levels of motivation, engagement or interest in the disciplinary area.

2.6.5 Impact of online game-based learning/gamification on cognitive abilities

Nine of the studies specifically explored the impact of online games on learners' academic achievement (Ke & Grabowski, 2007; Dourda et al., 2014; Su & Cheng, 2015; Meluso et al., 2012; Hwang et al., 2015; Tuzun et al., 2009; Kuo, 2007; Sung & Hwang, 2013; Serin, 2011). Some of these and other studies further examined the effect of online game-based/gamified learning on specific abilities such as problem-solving skills, multiplicative reasoning ability, and self-efficacy (Ke & Grabowski, 2007; Dourda et al., 2014; Su & Cheng, 2015; Meluso, 2012; Hwang et al., 2015; Tuzun et al., 2009; Filsecker & Hickey, 2014; Kuo, 2007; Sung & Hwang, 2013; Serin, 2011). In terms of academic achievement, the results of these studies found game-based/ gamified learning in general led to improvement in learners' academic achievement. This improvement resulted from learners' enjoyment, involvement and satisfaction within the online gaming process (Ke & Grabowski, 2007; Dourda et al., 2014; Su & Cheng, 2015; Hwang et al., 2012; Bakker et al., 2015; Su & Cheng, 2015). Overall these studies of online game-based learning/gamified learning further reported improvements in learners' cognitive abilities such as: problem-solving skills (Filsecker & Hickey, 2014; Serin, 2011; Garcia, 2013; Bakker et al, 2015), factual knowledge (Dourda et al., 2014), self-efficacy and confidence (Su & Cheng, 2015; Meluso, 2012; Serin, 2011) and in learners' academic performance (Ke & Grabowski, 2007; Dourda et al., 2014; Su & Cheng, 2015; Meluso et al., 2012; Hwang et al., 2012; Tuzun et al., 2009; Kuo, 2007; Serin, 2011).

Online game-based learning/gamified learning was shown to enable improvements in learning performance, knowledge and/ or skills-sets through the use of the constructivist platforms and communication interfaces that promote collaboration, increase players enjoyment and/ or value the ownership and personal expression (Garcia, 2013). In terms of academic achievement, Hwang et al. (2012) found that competition and challenge of the online game resulted in an increase in learners' interest, with fuller involvement, concentration and enjoyment, and improved performance. In a study by Filsecker et al. (2014) players interacting with each other through the 3D virtual space were shown to have a greater understanding of key concepts and increased interest in solving problems. Sung & Hwang (2013) found that collaborative computer games enhances learners' confidence and self-efficacy. Participants in a study of a mathematics educational game by Costu, Aydın & Filiz (2014) highlighted the need for enjoyment in educational games, but also cautioned about the need to keep a balance between entertainment and knowledge dimensions of game-based learning environments, recommending that the game be well-connected to the lesson learning outcomes. They further recommended that a competition-type use of the game would likely increase the level of engagement in the game. A study exploring the potential of mobile gamified learning by Su & Cheng (2015) highlighted the positive correlation between intrinsic motivation and learning achievement. In this case, the use of gamification features such as leaderboard, badges and mission resulted in an increase in learners' interest and satisfaction, and thus, positively impacted on their intrinsic motivation, which in turn is reflected in an increase in their academic performance. A study by Vos et al. (2011) concluded that game-makers demonstrated more cognitive competence (in deep learning strategies) than those who just played existing games. This indicates that the process of game creation is of more value from a cognitive perspective than that of game-playing. Interestingly, a study into 3-D immersive learning environments by Tüzün et al. (2009) showed significant learning gains among participants but highlighted the importance of the promotion of cooperative game play (with peer support) as opposed to competitive game-play (with no peer support). They concluded that co-operative game-play led to positive increases in both the participants' dispositions and academic performance, whereas competitive game-play only resulted in improved academic performance.

A study by Ronimus et al. (2014) on web-based game learning further reported improvement in academic performance but cautioned that activities which are perceived by learners to have too high a degree of learning challenge can result in decreased interest of learners in that activity. In a study of a web-based (geography) game by Dourda et al. (2014), learners showed considerable improvement in content knowledge and highlighted the need for cooperation with peers in achieving the learning outcomes. Dourda et al. (ibid) also found that teamwork, communication and collaboration inherent in game-playing enhanced learners' satisfaction and enjoyment. A number of cognitive strategies were recorded, including increased abilities of learners in skimming, scanning and translating web texts. Furthermore, it was noted that face-to-face compensation strategies (including gestures and facial expressions) were used to overcome limitations in understanding the English language (their second-language) within the web-based content. A study by Garcia & Pacheco (2013) further found that online game-based learning can improve understanding of key concepts and improve cognitive skills, through the use of collaborative elements in problem solving and by helping learners to build their own knowledge, and by providing direct contact with real problems.

In contrast, according to Kuo (2007) learners' academic achievement can be improved by game and non-game learning environments. He found no significant difference for learning outcomes between online game-based learning and non–game-based learning. The author concludes that design for both learning environment should be more fun to motivate learners.

2.6.6 Impact of online game-based learning/gamification on behaviours

Eight of the studies explored the impact of online games on learners' behaviour (Dourda et al., 2014; Bakker et al., 2015; Tuzun et al., 2009; Filsecker et al., 2014; Kuo, 2007; Garcia & Pacheco, 2013; Ronimus et al., 2014; Sandberg et al., 2011). The results generally were positive with respect to learner' behaviours. For instance, Kuo (2007) found that learners visited online game environment after school time where no homework was required. Furthermore, the learners enjoyed teamwork in the collaborative learning environment (Dourda et al., 2014; Tuzun et al., 2009). Sandberg et al. (2011) reported that learners spent more time within the online learning environment. Ronimus et al. (2014) found the level of learning challenge increased playing time. Online games provided direct contact with real problems and provide better opportunities for promoting the participation by children (Garcia, 2013). On the other hand, Filsecker et al. (2014) noted that gamification elements such as external rewards did not have any effect on learners' levels of engagement and playing time.

From a review of these studies, it was clear that online game-based learning/ gamified learning could have positive impacts on learners' behavior, specifically in terms of increasing the level of engagement in learning activities within and beyond the classroom (Dourda et al., 2014; , Bakker et al., 2015; Tuzun et al., 2009; Kuo, 2007; Garcia & Pacheco, 2013; Ronimus et al., 2014; Sandberg et al, 2011) but had the potential to negatively impact on engagement (Filsecker et al., 2014; Garcia & Pacheco, 2013). The level of engagement of participants can be increased in online gaming through raising intrinsic motivation (Kuo, 2007) through inclusion of activities incorporating competition (Costu et al. 2009) through the inclusion of group and through self-directed activities that promote ownership and agency (Dourda et al., 2014). Participants in a study by Tüzün et al. (2009) were so motivated by engagement in game-based learning that they had to be ejected on occasion from the computer room, and furthermore expressed the desire to play the game outside school time. In a study by Sandberg et al, 2011, participants were motivated to engage in game-based learning in their own time by the use of smart-phone technologies platform. A study by Garcia & Pacheco, 2013 showed that the interactive platform provided direct contact with real problems and provides better opportunities for promoting participation of learners.

A study by Costu, Aydın & Filiz (2009) recommended the inclusion of competition features to increase levels of engagement by participants within game-based learning contexts. In a study by Hwang et al. (2012) participants were found to be highly engaged in game-related activities that promoted intrinsic motivation. The level of intrinsic motivation was examined through flow-experiences. In the flow experience, participants fully engaged with and were fully focused on the activity, and thus become intrinsically motivated to remain engaged in the activity (Csikszentmihalyi, 1975, as cited by Hwang et al., 2012). The degree of learning challenge, control and enjoyment were core factors impacting on the flow-experience, and thus, the levels of intrinsic motivation. In the study by Hwang et al., the flow experience in the experimental group was shown to have significantly improved through the inclusion of 'instant interactions', 'explicit objectives' and 'dynamic challenges' within the game. A study by Ronimus et al. (2014) further showed high level of [learning] challenge led to increased playing time and concentration by learners. In other reviewed studies, it was noted that the process of gaming promoted team-work and collaboration (Dourda et al., 2014), and could further result in increased desire to engage in learning at home (Tuzun et al., 2009).

However, some of the reviewed studies highlighted how particular features of online gaming/ gamified learning environments could reduce levels of engagement. A study by Garcia & Pacheco (2013) found that engagement was negatively impacted by differing levels of abilities among group of participants (particularly when gaming occurs in the absence of supervision/ outside of class-time). Moreover, Garcia & Pacheco (ibid) found that differing levels of computer skills resulted in participants preferring to collaborate face-to-face rather than within virtual contexts. Furthermore, a study by Ronimus et al. (2014) found that while the presence of a reward might initially increase engagement, the effects of rewards as a motivating factor for engagement decreased over-time. Furthermore, this study found that shortcomings in the design of control, goal setting and feedback features in an online game may have contributed to lower participation levels within the online game. Finally, a study by Filsecker and Hickey (2014) found no link between external rewards and disciplinary engagement.

2.6.7 Conclusions Gamified Learning

In the context of mathematics education, the literature review revealed some interesting benefits of integrating online games within mathematics activities. In their research study of mathematics with Grade 5 learners, Ke & Grabowski (2007) noted engagement in online games showed positive increases in learner attitudes and academic performance. A similar study, by Costu, Aydın, and Filiz (2009) with learners from grades 6 to 8, also noted that learners developed more positive attitudes towards mathematics education and found engagement in online games enjoyable. In their study of the behaviour of Grade 3 learners, Garcia & Pacheco (2013), found that the learners were motivated by engagement in online activities in mathematics class. A study undertaken by Chang *et al.* (2012) with Grade 5 learners found that engagement in online games promoted problem solving skills in mathematics classes. Bakker *et al.* (2015) in their study with learners from Grades 2 and 3 similarly found particular online mathematics games to be effective in enhancing learners' multiplicative reasoning ability.

The literature review of online game-based learning /gamified learning on learners' dispositions, cognitive abilities and behaviours, showed that online game-based learning/ gamified learning has mainly positive effects on learners' dispositions, cognitive abilities and behaviours. In the current review, the factors contributing to the successful implementation of game-based learning/ gamified learning in enhancing young learners' dispositions included: motivational gaming features, social interaction (collaboration), immersive gaming environments, enjoyment elements, and some gamification elements (such as: feedback, leaderboards, and badges). Furthermore, the application of constructivist principles in game-design, inclusion of opportunities for social interaction (collaborative, cooperative) and integration of competitive features within game design were shown to have positive impacts on learners' cognitive abilities and academic performance. However, studies also highlighted factors reducing levels of learners' engagement and motivation, and thus impacting negatively on learners' dispositions, within games-based/ gamified learning contexts. These included games with low levels of challenge and, conversely, games that promoted competition between players, which were shown in some cases to result in decreased levels of motivation, engagement or interest in disciplinary area; thus, impacting learners' dispositions. Interestingly, studies of games-based learning with too high a degree of (learning) challenge were shown to decrease learner interest and to negatively impact on their cognitive abilities and academic performance. Finally, game-designers need to be mindful that gamified reward system (whether attempting to motivate intrinsically or extrinsically) can positively, or negatively, impact on motivation levels of learners.

2.7 Conclusions

This chapter has provided an overview of the education system and mathematics education in Saudi Arabia, alongside a comparative analysis of ICT policies and programmes (with those in Ireland). The review shows that while Saudi Arabia is a relative newcomer to education, and more specifically the integration of ICT in education, it has been responsive in enhancing the quality of education through a range of initiatives, including: reform of the curriculum, provision of teacher professional development, and supply of computer technologies and infrastructure to support the transition of Saudi learners (citizens) towards the knowledge economy, which underpins the Saudi 2030 Vision. However, as in Western contexts, there are challenges in terms of increasing teacher's ICT skills and in providing appropriate learning resources for the Saudi context. The critical review of gamified/ game-based learning indicated that the integration of this form of learning within primary education contexts has the potential to enhance learner motivation and engagement, with possibility of improving learning outcomes, but conversely can detrimentally affect learning if not designed properly.

Chapter 3: Research Methodology

3.1 Overview of Research

This multi-phase mixed methods research study set-out to explore the integration of online gamified practice exercises, within the context of mathematics education in primary settings within the Saudi context. In this regard, the study examined the performance of mathematics education in traditional settings, the integration of online gamified activities for mathematics practice, as well the readiness of teachers with respect to technology integration in the Saudi primary education system. In the initial section of this chapter, the nature of the research study and research questions are outlined, followed by a justification in underpinning this research with the paradigm of pragmatism. This is followed by an overview of the Multiphase Mixed Methods research model utilised for this research, the phases of research and the data collection tools. In the final parts of the chapter, there is explanation of how rigour in the research process has been ensured, followed by an overview of the key ethical considerations of the research.

3.2 Nature of Study & Research Questions

This multi-phase mixed methods research study set-out to explore the integration of online gamified practice activities, within the context of mathematics education, specifically focusing on primary grade levels 1 to 3 in an International school and a Tatweer school in the eastern area of Saudi Arabia. The research took place across three phases from 2015-2018, with the first two phases structured into a number of levels of research. In phases one and two, the first level of research sought to gain insights into how mathematics education was being performed by teachers (and corresponding learner engagement) within traditional primary grade levels 1 to 3 classroom contexts, and the second level of active research involved exploring the impact of integrating online gamified mathematics practice activities within mathematics education across these primary grade levels. In phase 3, the focus was on uncovering Saudi teachers' dispositions, level of experience in using technology, and professional learning in ICT, with a view to ascertaining their overall level of readiness for integration of technology in the practice of mathematics education.

There were three overarching research questions for this research study, the first of which was: *How is mathematics education presently being performed by teachers and learners in Grades 1 to 3 in two Saudi primary school contexts?;* the second question being, *What* *impact, if any, does the integration of online gamified mathematics 'practice activities' have on learning* in Grades 1 to 3 *in these Saudi schools?*, and finally: *What is the state of readiness of Saudi teachers for technology integration in their practice of mathematics education at primary level in this district of Saudi Arabia?*

This led to an investigation of the following sub-questions in phases one, two, and three:

- What teaching and learning approaches and strategies are currently used by Saudi teachers to teach conceptual knowledge and to practice mathematics concepts in Grade 1, Grade 2, and Grade 3 contexts? How do primary learners interact and perform within these traditional spaces?
- Does the integration of online gamified mathematics practice activities affect learners' disposition, engagement, motivation and/ or academic performance in Grade 1, 2 and/ or 3 contexts in International and Tatweer primary school contexts? Why, why not?
- What levels of ICT experience, access to technology, professional development and confidence do primary teachers have in Saudi Arabia? What are Saudi teachers' attitudes towards ICT integration in education?

3.3 Philosophical Underpinnings of the Research

In choosing a research paradigm to underpin this research, consideration was given to a range of paradigms beginning with the positivist paradigm, moving to the post-positivist and social constructivism paradigms, before finally deciding on the pragmatic paradigm.

The positivist paradigm (which leans on an objectivist worldview) was not considered appropriate to underpin this research because the ontological positioning of positivist research is that there exists one reality – one truth – that can be proved or disproved, and this can only be done objectively. As a researcher, I rejected this deterministic view of the world that underpins positivist research. Furthermore, I would argue that framing research using hypothesis constructed using laws of cause and effect, and, utilising quantitative approaches (that foreground observation and measurement through experimentation) are not appropriate for all forms of research.

In terms of the post-positivist paradigm, this researcher valued the recognition of multiple realities within the post-positivist frame of thinking. However, in the debate about the research paradigms, some writers argued that post-positivist paradigm could be more aligned with quantitative methods of research (Reichardt & Rallis, 1994) because post-positivist '*do not believe in strict cause and effect, but rather recognize that all cause and effect is a probability that may or may not occur'* (Creswell, 2012, p. 23). They reduce the ideas into small set of ideas to test the theory (e.g. variables) (Creswell, 2014). Within the post-positivist paradigm, researchers view inquiry as '*a series of logically related steps, believe in multiple perspectives from participants rather than a single reality and espouse rigorous methods of qualitative data collection and analysis'* (Creswell, 2012, p.24). However, I felt that from epistemological and axiological perspectives, the post-positivist paradigm is still somewhat wedded to notions of objectivity and while it does allow for qualitative research, it is to some extent still deductive in its approach, and does not fully recognise the potential of the unexpected findings that can emerge from research.

Social constructivists try to understand the world in which the research participants live and work, and this paradigm of social constructivism aligns with qualitative methods of research (Reichardt & Rallis, 1994). Social constructivist researchers do not begin with a theory; rather they '*generate or inductively develop a theory or pattern of meaning'* (Creswell, 2007, p. 21). Therefore, their interpretation is shaped by their own experiences and background (Creswell, 2013). Constructivists understand all phenomena from an individual's perspective (Creswell, 2009). In practice, constructivists use the qualitative method to collect and analyse data. In terms of my own worldview, I believe that there is no single reality, in other words multiple realities exists, and these are constructed through interactions with people, places and things. In terms of research, I value the different kinds of data that can emerge from explorations, and recognise that these may answer or respond to questions that haven't directly been posed, and all data collected are of value. However, the social constructivism paradigm creates a dilemma in that it can be quite open-ended in its approaches, which may result in the research moving out of field – in other words, I may as a researcher fail to adequately respond to intended focus of research, if it is followed in its purest sense. Therefore, the social constructivist paradigm was not chosen to underpin this research.

Pragmatism as a worldview '*arises out of actions, situations, and consequences rather than antecedent conditions (as in post-positivism)*' (Creswell, 2009, p.10). It is based on the work of Peirce, James, Mead and Dewey in the 19th century, along with other more recent writers such as Murphy (1990), Patton (1990) and Rorty (1990). Pragmatism is not committed to any philosophy or paradigm, its '*inquirers draw from both quantitative and qualitative assumptions when they engage in their research'* (Creswell, 2009, p.10). According to Patton (1990), pragmatism focuses on 'what works' and find solutions to problems. It draws on valuing both objective and subjective (Cherryholmes, 1992). Pragmatists do not see the world as absolute unity. Researchers using this paradigm have freedom to choose methods and procedures that meet their needs, and as such pragmatism can provide a philosophical basis for mixed methods research (Creswell, 2009; Hanson et al., 2005). For this study, pragmatism was therefore chosen as the underpinning philosophy and worldview. The pragmatic paradigms underpin my research as I believe that exploring the research problem is the primary focus, and that consideration of the research methods (while important) is secondary to consideration of whether the data collected through the process of research responds to the research questions. Pragmatism as a paradigm thus allows practical considerations to change or re-orient the research process so as to respond as fully as possible to the research questions. An overview of the conceptual framework for this study is presented in Appendix I.

3.4 Model of Research

The model of research used for this research was Mixed Methods research. Mixed methods research involves '*both quantitative and qualitative data collection and analysis in a single study or program of inquiry'* (Creswell et al., 2004, p. 7). This approach has many different terms such as *integrating*, *multimethod* and *mixed methodology* but most writers recently use the term *Mixed Methods (*Tashakkori& Teddlie, 2010).

Hanson et al. (2005) summarized the rationale for combining methods of research as follows: "*a) combining numeric trends and specific details from qualitative data to best address the research problem, b) identify variables from existing tool or develop a new one, c) obtain statistical results and use them to identify individual*." (p.226). Greene, Caracelli, & Graham (1989) identified a number of reasons for utilising mixed methods in research, from the most constrained which would be to use it for *triangulation*, to the least constrained which is for *expansion*. Instead of using mixed methods solely for the traditional purpose of triangulation, it has been used in this research study to allow for greater exploration and explanation of how mathematics education is being performed, the potential of gamified learning, and the readiness of teachers to integrate technology in their practice.

For mixed methods research, Creswell et al. (2003) identified six mixed-methods approaches that can be used as a framework to collect and analysis data, and discussed how the paradigms or theoretical lenses can be different based on the type of the design. Hanson et al. (2005) argued that mixed method research can be viewed a 'method' that allows a researcher to use any numbers of worldviews. The mixed methods designs can be chosen based on the research problem/s and reason for mixing research methods. Creswell (2013) mixed methods designs include: *Convergent Parallel Design* where the qualitative and quantitative data can be collected and analysed during the same phase and then the results are mixed during the overall interpretation. The *Explanatory Sequential Design* starts with the collection and analysis of quantitative data and this is followed by collecting and analysis of qualitative data. The *Exploratory Sequential Design* starts by the collection and analysis of qualitative data and the second 'quantitative phase' will be built based on the results from initial phase. The *Embedded Design* is to collect and analyse both qualitative and quantitative data within a tradition qualitative and quantitative design. The *Transformative Design* is when the researcher utilises both qualitative and quantitative data-sets within a transformative theoretical framework. The aforementioned mixed methods designs were not considered appropriate for this research study, as they did not adequately reflect the intended research pathway and purpose. However, Creswell's sixth approach, the *Multiphase Mixed Method* design did align with the proposed research pathway, and thus became the method of choice for this research, and this is further explained in the next scetion.

3.4.1 Multiphase Mixed Method Design.

This research study utilized multiphase mixed method design. The basic idea of the Multiphase Mixed Methods approach according to Creswell & Plano Clark (2011) is combining sequential and concurrent approaches over time to address the overall programme objective based on what was learned previously (see Figure 3.1).

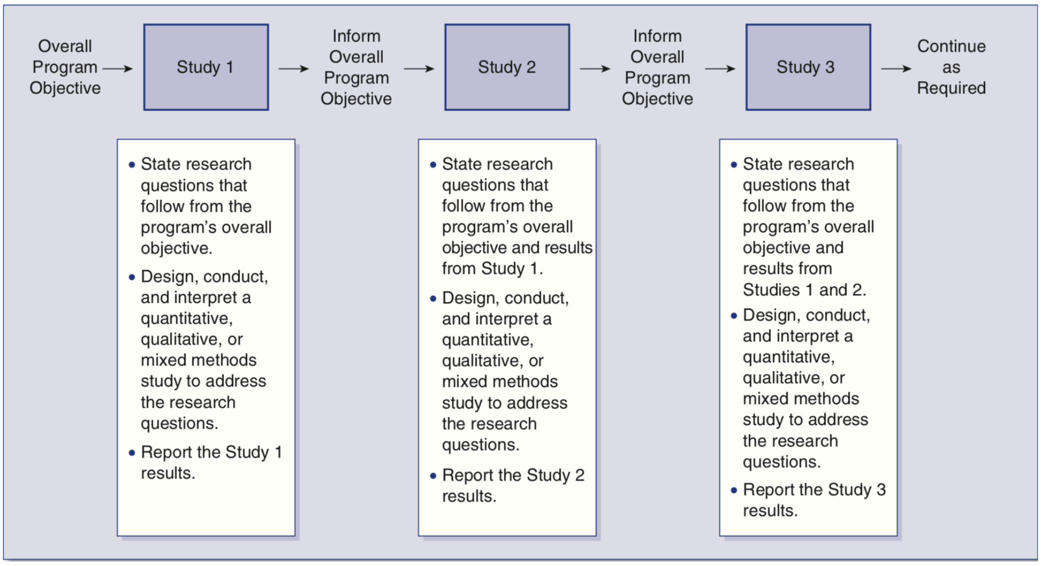


Figure 3.1: Multiphase Mixed Methods Research Designs based on Creswell & Plano Clark (2011).

The rationale for using Multiphase Mixed Methods research for this study was that the overall research objective could not be addressed in a single mixed method study. The research consisted of three sequential phases: the first phase was qualitative, followed by concurrent mixed method, and the final phase involved quantitative approach (see Figure 3.2). In phases one and two, as mentioned earlier the first level of research sought to gain insights into how mathematics education was being performed by teachers (and corresponding learner engagement) within traditional primary grade levels 1 to 3 classroom contexts, and the second level of active research involved exploring the impact of integrating online gamified mathematics practice activities within mathematics education across these primary grade levels.

With respect to phase 1, the entire research was based within an International primary school context, and was qualitative in nature involving direct observation by the researcher of teachers and learners engaged in a series of traditional mathematics sessions, each of which were immediately followed by 'bolt-on' sessions integrating online gamified mathematics practice activities. The research data included researcher field-notes of observations of whole-class interactions across the sessions, and furthermore was complemented with data from interviews with learners and teachers about their experiences in the session, alongside data collected from auto-tracking learner engagement within Mathletics using eye-tracker software. Each of the data collection tools was uniquely designed to explore specific dimensions of the research. For example, interactive classroom observations provided information related to the subject of the study i.e. the learner in primary school. It allowed the researcher to observe '*classroom interactions and events, as they actually occur'* (Burns, 1999, p. 80). The researcher holds the belief that class observations can help to understand of behaviour and explain actions of the participants – in this case, what kinds of activity was taking place and how were learners responding within the traditional and technology-enabled learning activities. Interviews on the other hand, provide a direct way to collect data and gain information that cannot normally be observed, such as feeling and thinking (Patton, 1990). Individual interviews '*yield significant amounts of information from an individual's perspective'* (Hancock & Algozzine, 2006). Hence, individual interviews were used to tap into learners' perspectives of learning using the online platform, Mathletics. The data from the Mathletics software provided information about when learners accessed the mathematics practice activities and their performance therein. In addition, eye tracking software was used with six individual learners (2 from each grade level) with resultant data-sets on learner's interaction within the Human Computer Interface (HCI). The data from the eye-tracking software was coded and combined with researcher field-notes during the interactive observations of the six learners to analyse specific aesthetic design aspects of the Mathletics software that impacted on learner's experience in this study. This phase provided the first vignettes into: a) how mathematics education traditionally was being performed in this International school in Saudi Arabia, and b) the impact of online gamified learning activities on learners' engagement and motivation.

In phase 2, the entire research was based within a Tatweer public primary school. The research approach was similar to the previous stage in that qualitative research methods were used in direct observation by the researcher of teachers and learners engaged in a series of traditional mathematics sessions, each of which were immediately followed by 'bolt-on' sessions integrating online gamified mathematics practice activities. In this regard, direct observations, and interviews with teachers and focus groups with learners were utilised. However, the research approach differed to the previous phase in that it also utilised quantitative methods to assess differences in pre- and post-study dispositions (satisfaction, interest, anxiety, confidence) and academic performance. Thus phase 2 is characterised as a concurrent mixed methods research approach, with tools deployed at this stage to investigate both qualitative and quantitative dimensions of the research. For this phase of the study, the researcher believed that a mixed methods research approach was necessary in order to better articulate the impact of online gamified mathematics practice activities on learners' motivation, engagement, and disposition toward mathematics. Additionally, in order to measure learners' academic achievement, pre- and post- tests were developed and deployed, as a form of direct evaluation tools to measure student learning before and after the Mathletics intervention.

In phase 3, the focus was on uncovering Saudi teachers' dispositions, level of experience in using technology, and professional learning in ICT, with a view to ascertaining their overall level of readiness for integration of technology in the practice of mathematics education. It is important to note that there was some qualitative capture of teachers' readiness to integrate technology from interviews in phases one and two, which were blended with discussion of findings in phase 3. However, phase 3 was predominantly a quantitative study, where data was collated and analysed from a survey deployed to teachers in International and Tatweer schools in the Eastern area of Saudi Arabia. This final phase aimed to explore teachers' access to, experience of and professional development needs in ICT within the context of teaching and learning, with a view to ascertaining the current state-of-play with respect to technology integration/ infusion in Saudi primary schools. The findings from this phase are presented in the form of discussion of descriptive statistics and the outcome from statistical tests (t-test and Mann Whitney U test).

Research Phase 1

Data Collection Time - Sept-Dec 2015

Research Approach: Qualitative Research

Focus of Research -

- Critiquing teaching and learning approaches used, and learner engagement, in traditional mathematics education sessions

- Exploring learners engagement and interaction within online gamified mathematics practice (Mathletics) sessions (individually and in whole class settings)

Cohort - Learners and the teachers in Grade 1/2/3 in International School in Saudi Arabia.

Particpants' Numbers: Grade 1 (n=21)

Grade 2 (n=16), Grade 3 (n=19) and three teachers.

Number of Sessions: Grade 1 (18), Grade 2 (18) and Grade 3 (18), and 6 Individual cases (2 at each Grade level).

Data Collection Tools - Class observation notes, Learner Interviews, Teacher Interviews, Eye-tracking tools, Interactive Observation.

Data Analysis: Thematic coding

Other Minor Focus:

Qualitative data on Teachers' ICT skills, use and training. (n=3)

Research Phase 2

Data Collection Time- Jan-May 2016

Research Approach: Qualitative & Quantitative Research

Focus of Research -

- Critiquing teaching and learning approaches used, and learner engagement, in traditional mathematics education sessions

- Compare and contrast experiences of learners across two groups, one of whom uses Mathletics to practice mathematics and the other uses traditional teaching approaches to practice mathematics exercises.

Cohort - Grade 2 and 3 learners, teachers and parents in Public School in Saudi Arabia.

Particpants' Numbers- Grade 2 CG (n=19)

MG (n=10), Grade 3 CG (n=20), MG (n=19), Three Teachers and Five Parents (Mothers).

Number of Sessions: Grade 2 (8) and Grade 3 (8)

Data Collection Tools - Survey instrument, Mathematics Performance test, class observation notes, interviews with teachers, parents and learners.

Data analysis: Paired t-tests, Thematic coding

Other Minor Focus: Qualitative data on Teachers' ICT skills, use and training. (n=3)

[NOTE: CG=Control Group; MG=Mathletics Group]

Research Phase 3

Data Collection Time - Dec 2017-April 2018

Research Approach: Quantitative Research

Focus of Research - Build a profile of teachers' access to, skills in, professional learning opportunities and dispositions towards using technology in education in primary settings in Saudi Arabia

Cohort - Teachers in 20 Public Primary Schools & 3 private schools

Particpants' Numbers- 24 Tatweer's Teachers and 17 International schools' Teachers.

Data Collection Tools - Survey instrument

Data Analysis: Descriptive statistics, t-test & Mann Whitney U test

Figure 3.2: Multi-phase Mixed Methods Research Model

3.5 Overview of Data Collection Processes

3.5.1 Data Collection for Phase One

Multiple qualitative data tools were used during phase one including; direct class observations, face to face interviews with learners and teachers, interactive observations, Mathletics progress report and visual records (eye-tracker data). It was hoped that analysis of the data at this phase would enable better understanding of the teaching and learning approaches used in traditional settings, as well as the learners' engagement within traditional mathematics settings and online gamified practice learning sessions. The participants in this phase were from three different groups: grade one (n=21), grade two (n=16) and grade three (n=19). The age of the students ranged from 6 to 9 years. It should be noted that all students participated in this phase were Arabic native speakers, although English was the language of instruction within the International school.

Table 3.1*:* Data collection for Phase One

What was examined?	Data collection tools	Analysis
Teaching and learning approaches used, and learner engagement, in traditional mathematics education sessions	• Direct class observation with the whole class. • Teachers' interviews.	Pedagogic approaches were used to explain and practice mathematics concept. Quality of learner interaction/engagement.
Learners' engagement in online gamified mathematics practice activities and motivation factors at individual and whole class setting using Mathletics.	• Direct class observation with the whole class. • Mathletics report (from software) for all students. • Teachers' interviews.	Quality of learner interaction/ engagement. Model of Integrating technology in mathematics education.
	• Eye tracking data-sets • Mathletics Report • Learner interviews.	Learner Motivation/ engagement. HCI interface – Mathletics.
Teachers' use, access and professional development in ICT.	• Teachers interview	Teachers' use, access and training in using ICT in teaching - To be discussed along with data from Phase 3

The direct class observations were utilised at all three grades. Direct classroom observations were performed during normal class sessions, which were typically of 45 minutes duration. All groups were taught the mathematics concepts in traditional classrooms, and during the final 20 minutes, the learners practised the mathematics concepts during the class using the Mathletics platform. Teachers and learners' interactions were observed for the full 45 mins, during approximately 18 separate sessions of classroom lessons to record their behaviour and understand their 'expressed dispositions' and their progression in both traditional mathematics sessions and in bolt-on sessions using Mathletics to practice mathematics. Field-notes from the observed sessions were manually recorded in the researcher' diary, capturing the teacher and learners' engagement in the classroom within the traditional and Mathletics enabled sessions.

The face to face semi-structured interviews were conducted with six students from each grade (see Appendix C). The interviews were audio-taped and hand notes were taken. The learners' interview questions started by warm-up questions to help relax the learners. The first three questions asked about their free time at home, their favourite game and their favourite devise. The purpose of this was to create a positive atmosphere for the learner. The rest of the questions were much focused on the factors that motivate learners' in the online gamified mathematics platform. Each interview lasted between fifteen and twenty-five minutes. The purpose of using these tools was to understand the factors that appeared to influence the learners' disposition towards online mathematics education.

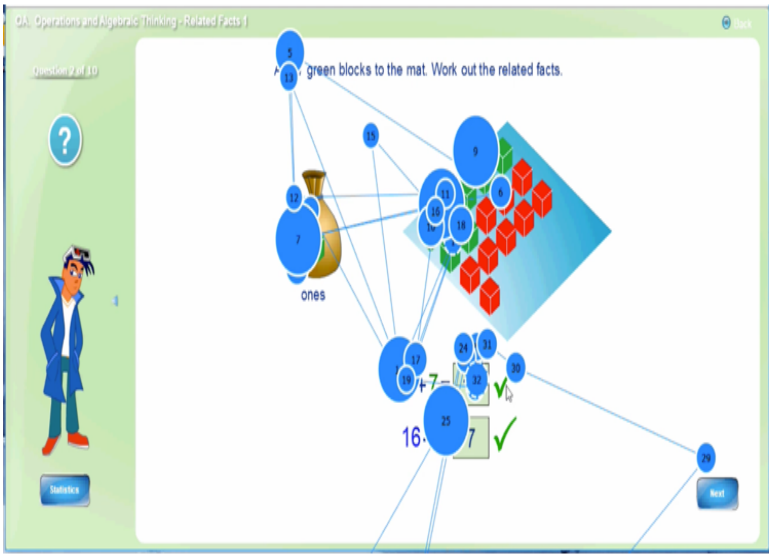
Semi-structured interviews were conducted with the three teachers participating in this research, to capture teachers' viewpoints regarding the use of technology for students in classrooms and an understanding of their level of using technology in classroom. The face to face semi-structured interviews were also conducted with the teachers (see Appendix C), each lasting between twenty and twenty-five minutes. All interviews were audio-taped and hand notes were also taken. The teacher interview had seventeen questions, including questions about the use of technology in their daily classrooms, their experience using ICT in teaching, their level of using technology, and the training courses attended by them. The first four questions asked about the background information of the teachers. Question five and six asked about teachers' ICT skills and training. Questions from seven to ten asked about the teachers' integration of ICT in teaching. The rest of questions asked about the teachers' opinions about integrating online gamified learning technology into the classroom. The teachers were interviewed before and after the intervention, each interview taking from 15-20 minutes.

At the individual learner level, interactive observation and the eye-tracker software were used with two students from each of the groups (Grade 1, 2 and 3) – thus, tracking a total of six learners interacting with the online Mathletics platform. These learners were each observed for three to five sessions. During the observation, the learners were asked questions regarding their approach to solving the mathematics practice problems, and where and why they looked (or not) at various aspects on the Mathletics screen while they were completing the mathematics practice activity. This method helped to ascertain the decisions learners made when interacting with the online interface (e.g. do they read the whole question or only the keyword/s?) All observations and verbalisations were written in the researchers' diaries during the sessions (see Appendix C).

The Mathletics platform was the online mathematics practice forum used in this research study. This platform was chosen as it was an example of an online gamified learning environment which supported some elements of gamification while allowing for the practice of mathematics. Mathletics was also selected as the platform of choice as it was the only online software that aligned with both the Common Core Standard for mathematics curricula (the standard for the International school system) and the Saudi Mathematics curriculum being delivered within the public school system in Saudi Arabia.

The Mathletics was solely focused on enabling learners to practise mathematics, so did not include facilities to explain concepts to learners. Each participant had their own account. The Mathletics platform generated a tracking report that provided information about learners' achievements, improvements, points awarded, certificates earned, and engagement with others globally in a separate facility called "Live Mathletics". It presented the percentage of activities completed within school hours and outside school time for each learner. The Mathletics tracker reports were used to further evaluate learners' engagement with Mathletics within and beyond the classroom intervention.

Finally, eye-tracker software was used in an attempt to better understand learners' interaction within the Mathletics software and to gain insight into underlying choices in their interactions within the online mathematics practice activities. The software records eye movement of learners on-screen, thus generating data-sets that can be used to track the elements of the screen (interface) that learners interact with during the process of solving mathematics problems. Eye-tracking research is conducted using sensor technology that enables a device to know exactly where the eyes are focused when participants are for example using a technology-enabled platform, or within real-world settings (such as monitoring classroom engagement). It can determine learners' presence, attention, focus, drowsiness, consciousness or other mental states. This information can be used to gain deep insights into learner behaviour and/or to design new user interfaces for education and other settings. In the context of this study, the Mathletics platform only allowed learners to practice mathematics, so it didn't facilitate conceptual development, and thus the eye-tracking software was solely used for analysing learners' interaction in the human computer interface (not to analysis their cognitive or affective states).



- Small Circle=Short Fixation or Gaze
- Larger Circle – Longer Fixation or Gaze
- Number in Circle indicates the pathway of learner's gaze on the interface
- Position of Circle indicates what (or where) the learner looks at on-screen (or doesn't look at).

Figure. 3.3: Screenshot of the full interaction of the learner with the Related Fact 1 activity. [The screenshot shows that the learner never looked at the avatar, the statistic icon or the question mark icon. It also shows that the learner's eyes frequently looked down off the screen.]

In the context of this study, the Tobii eye-tracker X2-30 was used to collect data on where the learners looked on-screen when using the Mathletics platform. This eye-tracking information was used to provide insights into learners' attention and interaction on-screen when completing mathematics practice activities. The data from the eye-tracking system is presented in the form of gaze plots as shown in Figure 3.3 above, which are data visualisations that can communicate important aspects of visual behaviour clearly and with great power. Fixation or visual fixation shows where the learners' visual gaze lands at a point in time. The duration of visual fixation relates to length of time the learner's gaze is fixed on a particular point on the screen. Gaze plots essentially track the focus and deliberation of the eyes as the learner progresses through an activity. It ultimately results in the identification of the course of the track/s taken by the learner, along with any stopping points within the activity. Gaze plots show the locations, sequence, and time spent looking at locations on the stimulus. For example, in Figure 3.3 the learner initially looks at the visual objects and attempts to solve the problem with a minor glance at one word in the question, and without seeking assistance from the Avatar, or Hint box on left hand side. The primary function of gaze plots is to reveal the time sequence of looking or where the eye looks at a particular point in time. The time spent looking, most commonly expressed as fixation duration, is shown by the diameter of the fixation circles. The circles indicate fixations, thus the diameter of the circle is directly proportional to the amount of time the eye is fixated on a certain point. The longer the gaze, the larger the circle becomes, and a shorter time spent looking at a point results in a smaller circle. The lines indicate saccades or saccadic eye movement. Gaze plots is usually the sum of all fixation durations within a prescribed area.

3.5.2 Phase Two.

One significant difference between phase one and two was in the formation of an experimental grouping that could be used to compare and contrast dispositions and/or performance of learners. Therefore, a Control Group and an Integrated Group were formed at Grade 2 and Grade 3 levels (Grade 1 learners were not available to participate in this phase of the study). The Control Group undertook the traditional mathematics session, and thus were taught the traditional way and used workbooks for practising mathematics. The Integrated Group was a bit more complex – it included two cohorts of learners in one classroom all of whom were taught the traditional way, however, one cohort had access to ipads or laptops and thus could engage with Mathletics in the mathematics practice part of the class, the remainder had to undertake practice activities within the workbook – these cohorts became known as the Workbook Group (WG) and Mathletics Group (MG). In answer to the question on most people's mind at this point is why the laptops could not be shared to allow everyone in the Integrated Group to participate in Mathletics, or why wasn't the Mathletics Group taught separately from the Workgroup Group. The answer is two-fold – the first being that the Mathletics software is linked to individual profiles and thus if learners had been sharing laptops in groups of two or three, then they would have had to login/ out of their accounts and there wasn't enough time to facilitate this within the time-frame for practising mathematics. In terms of being taught separately, the Saudi system demands that the assigned teacher must teach her full cohort, and within the constraints of the curriculum there wasn't the time for the teacher to deliver 8 separate sessions to facilitate the use of Mathletics in this research study. Thus, the Integrated Group represented the only way to explore the use of Mathletics in phase two.

The participants in this phase were from two different grades (two and three) in a Tatweer public school setting. The students ranged from 7 to 9 years of age. Grade two Control Group had 19 students (n=19). The Integrated Group had a total of 29 learners, with 19 in the WG and a further 10 of them were in the MG. Meanwhile, grade three Control Group had 20 students (n=20). The Integrated Group had a total of 30 learners, with 11 in the WG and a further and a further19 participants in the MG. It should be noted that all students participated in this phase were Arabic native speakers, as Arabic was the language of instruction within the Tatweer school.

Mathematics performance tests were prepared to measure the impact on individual learner performance within the Control Groups and Mathletics Groups at each grade level. The participants completed the mathematics test twice, with approximately six weeks between the sessions (pre- and post- Mathematics Performance Test). The mathematics tests included questions from a mathematics book that has questions similar to those being undertaken in the Mathletics platform (see Appendix E).

This study also adapted an existing "Mathematics Disposition Survey" MDS (see Appendix E) to investigate the pre- and post- disposition levels of learners completing mathematics practice exercises. The participants completed the MDS test twice, with approximately six weeks between the sessions (pre- and post- MDS survey). The survey used in this study was adapted from a German instrument, namely, the Math Anxiety Questionnaire (MAQ) designed by *Fragebogen für Rechenangst* to assess anxiety levels in primary school learners aged between 6 and 9 and engaged in mathematics education (Thomas & Dowker, 2000 as discussed in Krinzinger et al., 2007). The original survey included four different types of questions addressing the following seven categories: *mathematics in general* (MG), *written mathematics problems* (WM), *mental mathematics* (MM), *easy mathematical tasks* (EM), *difficult mathematical tasks* (DM), *mathematics homework* (MH) and *listening and understanding* (LU) in mathematics class. Each category included the following four scales based on the original MAQ scale: 'How good are you at…?', 'How much do you/have you…?', 'What do you feel when…?', and 'How worried are you when…?'. Since the purpose of this study was to explore satisfaction levels with math endeavours, the following element was added to each category: 'How satisfied do you feel when…'.

The hybrid survey developed for this study thus required learners to answer five different types of questions. They were asked to choose their answers using 5-point Likert scale with one symbol representing each type of response. All statements included pictorial ratings aligned to items ranging from '4' to '0', with 4 indicating the most positive answer (e.g. very happy) and '0' indicating the most negative possible answer (e.g. very unhappy). The factors were interpreted as follows: the first factor, i.e. 'How good are you at…?', reflected the level of confidence; the second aspect, i.e. 'How much do you/have you…?', reflected the level of interest; the third factor, i.e. 'How happy or unhappy are you if you have a problem with…?', reflected the level of sadness; the fourth aspect, i.e. 'How worried are you when…?', reflected the level of worry; and the fifth factor, i.e. 'How satisfied do you feel when…', reflected the level of satisfaction. The third and fourth factors could be considered as negative emotions, and thus these categories were combined and interpreted as the level of anxiety.

Table 3.2*:* Data collection for Phase Two

What was examined?	Data collection tools	Analysis
Teaching and learning approaches used, and learner engagement, in traditional mathematics education sessions	• Direct class observation with the whole class in Control Group. • Teachers' interviews. • Learner Interviews • Mathematics Performance Test • Mathematics Dispositions Survey	Pedagogic approaches were used to explain and practice mathematics concept. Quality of learner interaction/engagement. Learner Performance Learner Dispositions
Learners' engagement in online gamified mathematics practice activities and motivation	• Direct class observation with the whole class in Mathletics.	Quality of learner interaction/ engagement.

factors at individual and whole class setting using Mathletics.	• Mathematics report for all students. • Teachers' interviews. • Mathematics Performance Test • Mathematics Dispositions Survey	Model of Integrating technology in mathematics education. Learner Performance Learner Dispositions
	• Learner interviews. • Parental Interviews	Learner Motivation/ engagement. Learner Dispositions
Teachers' use, access and professional development in ICT.	• Teachers interview	Teachers' use, access and training in using ICT in teaching - To be discussed along with data from Phase 3

In Phase 2, many of the same qualitative data tools from the first phase were re-used including; direct class observations, face to face focus groups with learners and interviews with teachers, and classroom observations. The direct class observations were conducted across eight Grade 2 and Grade 3 mathematics sessions (each circa 45mins in length) - the direct observation process was the same as in phase one, therefore it is not detailed here. The interviews conducted with a total of 3 teachers followed a similar format as the phase one teacher interviews, with a few additional questions gathering information on teachers' opinion on learners' engagement in mathematics class after the integration of Mathletics. The teachers in the MG sessions were further asked about their opinions to gamified mathematics practice activities.

As it was challenging to generate discussion in interviews with this age group, the learner interviews were changed to focus groups (using the same questions as in interviews) and one focus groups were held with four learners from Grade 2 and Grade 3. Furthermore, interviews were 5 parents (mothers) were added here in order to gain some insight into learner engagement with Mathletics beyond the school door – see Appendix E. The interviews with parents were unstructured and focused on ascertaining from parents their child's interest in using the Mathletics platform at home and factors that motivated them to engage with platform's activities. Each interview lasted between twenty and twenty-five minutes. The interviews were audio-taped and hand notes were also taken.

The eye-tracker software was not used in phase 2 because of the prohibitive cost of leasing the software and also because it was felt that additional data from this sphere would not offer any more in-depth insights into the broader research focus in the context of mathematics education. The focus in phase two was similar to phase one in that the intent was to reach a better understanding of the teaching and learning approaches used in traditional settings, as well as gaining insights into what motivates and sustains learners' engagement within traditional mathematics settings and online gamified practice learning sessions.

3.5.3 Phase Three

The purpose of this research at this phase was to investigate teachers' access to, experience of and professional development needs in ICT within the context of teaching and learning, with a view to ascertaining the current state-of-play with respect to teachers' readiness to engage with technology integration/ infusion in Saudi primary schools. This phase gathered data from teachers teaching in all girls and all boys schools in both Tatweer and International schools. As required, direct contact was made with the Department of Education in the eastern area in Saudi Arabia to ascertain the actual number of schools, and primary teachers in both types of schools, and to seek their assistance in the deployment of the survey. The total numbers of primary Tatweer schools were 10 girls schools and 10 boys schools, with a total of 130 teachers across 20 schools. There were 90 teachers employed across 3 International Schools in the same region.

Table 3.3: Data collection for Phase Three

What was examined?	Data collection tools	Analysis
Teachers' use, access and professional development in ICT.	• Teachers Survey • Teacher Interviews in Phase 1 and 2	Readiness of teachers' to integrate technology in their practice

During the period from November 2017 to December 2017 a literature review was conducted to find a standardised survey to assess teachers' ICT skills, access, confidence and professional development. A survey was adapted from an instrument developed by the European Commission (EC) (Directorate General Communications Networks, Content and Technology) in 2011 to benchmark professional teachers' development and confidence in using ICT in schools across 31 countries across Europe (EC, 2017). The original survey consisted of 29 questions divided into ten categories: the first part contained four questions about ‘Information about the target class’. The second part contained three questions about ‘Experience with ICT for teaching’. The third part contained five questions about “ICT for teaching’. The fourth part contained five questions about ‘Support to teachers for ICT use’. The fifth part contained two questions about ‘ICT based activities and material used for teaching’. The sixth part contained one question about ‘Obstacles to using ICT in teaching and learning’. The seventh part contained one question about ‘Learning activities with the target class’. The eight part contained one question about ‘Teacher Skills’. The ninth part contained two questions about ‘Teacher opinions and attitudes’ and finally, the last part contained five questions about ‘Personal background information’. All questions on this survey had sub-questions. The types of questions included; Multiple-choice, Yes or No, and Likert scale-type - Strongly agree to Strongly disagree. The teachers were to respond to several prompts on a Likert scale ranging from 1 to 4 (e.g. 1 refers to ‘a lot’ and 4 refers to ‘not at all’). In the case of teachers not integrating technology in classroom practice, they were re-directed to a sub-set of questions ascertaining why not.

For the purpose of this study, a number of modifications were made, including adding two questions to the first category one on the gender of learners, and the other asking for the grade level the teacher taught at, and three other questions were modified to change the names of subjects, and hours worked per week. Also, two sub-items were added to the fifth category (about the nature of learning materials, and types of online games) and other two items were added to the sixth category on safe usage and e-safety.

The survey was initially piloted at the end of December 2017 with teachers that worked in primary Tatweer schools. The purpose of the pilot was to ascertain whether the survey needed to be modified based on Saudi teachers’ experience in completing the survey. The survey was launched using the Survey Monkey website and the link of the survey was sent to 8 teachers known to the researcher. Seven teachers returned their responses with some qualitative feedback on their experience of completing the survey (collected via phone calls). Also, the researcher presented the survey to some specialist reviewers from one Saudi University to identify the appropriate structure of the survey needed to achieve the objectives of the study. The feedback forms were returned to the researcher who reviewed their suggested corrections and remarks. In a total, feedback from nine participants were returned from the pilot phase. Based on the feedback from the pilot phase, small changes were made to the survey; four questions were deleted to reduce the numbers of questions which had been noted as a cause of concern, and the two questions were added – the final version of the survey can be viewed in Appendix G.

The final version of the survey contained 27 closed questions, and was deployed using the Survey Monkey website in two languages (Arabic and English). The Department of Planning and Development in Saudi Arabia was responsible for sending the survey links to teachers at the target schools, as is normal practice in Saudi Arabia. During the period January 2018 to March 2018, a total of 24 primary teachers (12 male/12 female) from Tatweer primary schools and 17 primary teachers (4 male/13 female) from 3 International schools completed the survey.

3.6 Data Analysis

3.6.1 Qualitative Data Analysis

In terms of data gathering and general processing, the data collected through class observations and interviews were prepared for analyses by weekly transcribing and translation of data-sets. In the first phase, all interviews and observation data were transcribed from field notes and audio transcripts into word documents. In the second phase, where the data was collected from the Arabic school, all interviews were transcribed into word documents in the original Arabic language and then were translated to English. The rationale for the translation, which was very challenging for a non-native English language speaker, was that the process of analysis in one language - 'English' - would be much more efficient and time-saving.

The analysis of qualitative data-sets is the process that makes sense out of the data, and according to Creswell (2009), it '*includes logical steps to convey a sense of the overall activities of qualitative data analysis'* (p. 184). Creswell (2007) identified a simple process to analyse qualitative data as follows: '*preparing and organizing the data for analysis, reducing the data into themes through a process of coding* and finally, *representing the data'* (p.148). One of the most common processes for analysing qualitative data sets is thematic analysis, a method to identify, analysis and report patterns within data (Braun & Clarke, 2006). According to Braun & Clarke (ibid), thematic analysis is a method that '*can produce insightful analysis to answer the research questions*' (p. 97). Thematic analysis was considered for this research as that it has been proven to be an effective method of identifying themes in qualitative data-sets, that '*capture the key idea about the data in relation to the research questions and represent some level of patterned response within the data set'* (Braun& Clarke, 2006, p. 82). Braun & Clarke (2006) further explain that the theme/s can be identified either in an inductive 'bottom up' or deductive 'theoretical or top down' approach. This research study followed the inductive approach which allowed *'research findings to emerge from the frequent, dominant or significant themes inherent in raw data, without the restraints imposed by structured methodologies'* (Thomas, 2006, p.238). In this regard, the researcher read and re-read to code the data and determined theme/s without using a pre-conceived framework. The specific analysis steps were adapted in this study from Braun & Clarke (20060, who present six different phases of analysis process (see Figure 3.4).

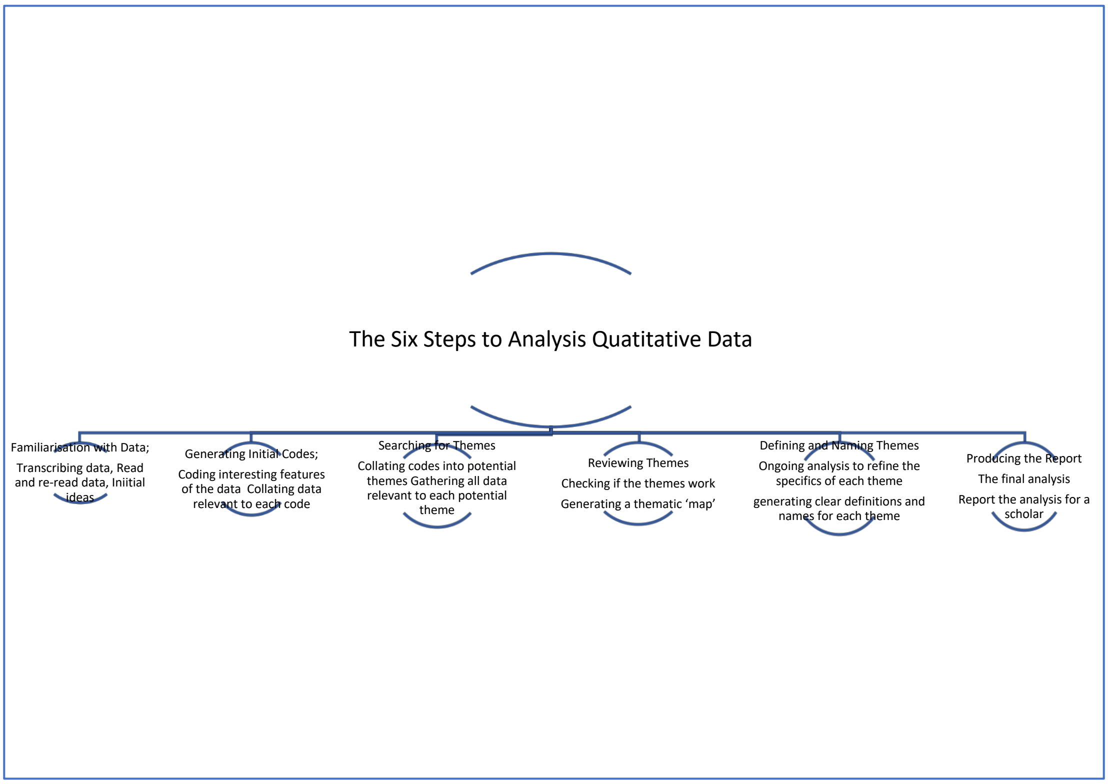


Figure 3.4: Thematic analysis approach adapted from Braun & Clarke, 2006

These steps were used as follows; firstly, the dataset was read multiple times before being coded. At this time memos were made to generate ideas for coding. According to Boyatzis (1998), codes are '*the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon'* (p. 63). Therefore, at the second phase of analysis of the data, a list of initial codes from the data were developed. The data was then organized and the data codes and themes displayed in tabular form using Microsoft Word. The codes were further highlighted to indicate potential themes/ patterns. These codes were then grouped into categories. The third phase focused on the meta level of themes. Mind maps were used to sort the codes into potential themes. The themes then were reviewed and reduced to a number of main themes. Thomas (2003) stated that '*Most inductive studies report a model that has between three and eight main categories in the findings'*. In the case of this study, four to five themes were identified across the grade levels.

The report generated by Mathletics was used to ascertain learners' interaction in activities in and / or out of school time, as shown in Figure 3.5. It was further used to gauge their engagement in the online competition environment 'Live Mathematics', as shown in Figure 3.6

Student Year-Grade	Student Name	Class Year-Grade	Class Name	Group Name	Activity	Attempts	First Score	Recent Score	Improvem	High Score	Recent Attempt
2		2	2D	2D	Adding in Any Order	2	100	100		100	Nov-03-2015
2		2	2D	2D	Add Three digit numbers	3	100	100	0%	100	Nov-04-2015
2		2	2D	2D	Make Number Counts	1	90	90	-	90	Nov-09-2015
2		2	2D	2D	Place Value 1	2	90	90		90	Nov-16-2015
2		2	2D	2D	Repartition Two Digit Numbers	1	90	90	-	60	Nov-17-2015
2		2	2D	2D	Which is Bigger?	1	100	100		100	Nov-23-2015
2		2	2D	2D	Which is Smaller?	1	100	100		100	Nov-23-2015
2		2	2D	2D	Are You Ready?	1	100	100		100	Nov-30-2015

Figure 3.5: Student's attempts and improvement- Mathletics report.

					1			2			3			4			5		
Student Year-Grad	Student Name	Class Year-Grad	Class Nam	Group Name	Total Correct	Top Score	Accuracy %	Total Correct	Top Score	Accuracy %	Total Correct	Top Score	Accuracy %	Total Correct	Top Score	Accuracy %	Total Correct	Top Score	Accuracy %
2		2	2D	2D	4,192	35	98	84	10	79	-	-	-	0	0	0	-	-	-
2		2	2D	2D	933	41	98	2	2	100	4	4	100	-	-	-	-	-	-
2		2	2D	2D	480	36	94	3	3	50	0	0	0	-	-	-	-	-	-
2		2	2D	2D	49	18	92	3	3	50	-	-	-	-	-	-	-	-	-
2		2	2D	2D	650	27	95	4	4	57	1	1	50	-	-	-	-	-	-
2		2	2D	2D	611	35	96	4	2	40	0	0	0	-	-	-	-	-	-
2		2	2D	2D	945	27	95	24	8	69	-	-	-	-	-	-	-	-	-
2		2	2D	2D	621	25	92	7	5	47	0	0	0	-	-	-	0	0	0

Figure 3.6*:* Students' engagement in 'Live Mathletics'- Mathletics report.

3.6.1.1 Analysis of Eye-tracker data-sets

The data gathered from the Tobii eye-tracker were also used within the analysis process. The scan-path visualisations provided valuable information about the on-screen interactions of individual learners and provided important information of human-computer interaction using Mathletics. In this context, poorly or inadequately designed interfaces for example resulted in learners not understanding the question, or in not making use of help facilities for example in this study.

The process of coding the eye-tracking data-sets from the Tobii eye-tracker is summarised in Figure 3.7 overleaf. The process was complex as the engagement of a learner in a single mathematics practice activity generated a video of circa 30 seconds in length with many on-screen interactions, so it was necessary to devise a process for selecting, refining, analysing and coding eye-tracking data-sets, which has been outlined in Figure 3.7. To facilitate a deep review of learner interactions within the Mathletics interfaces, a number of frameworks were developed.

Analysis and Coding Process
Eye tracking Data-sets

Process in Analysis and Coding of eye-tracking data-sets can be summarised as follows:

- Collate data-sets for individual case studies – data was exported as a video recording for each set of questions completed by each of the six case study participants.
- Each video recording was reviewed to ascertain which questions sets would be selected for analysis. The process of selection focused on ensuring representation of learner interaction across different thematic areas (question types) as well as examining cases where unusual or different behaviour in terms of interface engagement was evident.
- This resulted in decision of suitable number of questions to be reviewed per candidate.
- For each case study participant, the next steps involved capturing what was being viewed on screen in writing. In this regard, a number of templates were created in order to ensure as full a capture as possible of all on-screen/ off-screen activity. The first template describes the pedagogic and aesthetic design of mathematics activity as manifested in the on-screen Mathletics platform. The second template describes actual user on-screen/off-screen interaction across the activity. The third template provides a summative description of learner interaction across a set of activities within a mathematics theme and includes data collected through interactive observation by researcher. It should be noted that, in this table, the blue words are what the learner said during the observation and the green words are what the researcher observed.
- This stage involved thematic coding of data-sets for analysis purpose.
- The last table for each of the activity was used for coding and develop themes/ categories. Two columns have been added to the table, the first column to write the first cycle of coding and the second column was used to write the theme/ the categories.
- The data in the first column in the table was read multiple times and a number of codes were developed. These codes then were combined to a number of categories.

Figure 3.7: Analysis and Coding Process - Eye tracking Data-sets

The example in the appendix shows one such screen, and its accompanying templates for Grade 1, Case 1, Learner A. The first review would have explored the aesthetic and pedagogic layout of the interface, as shown on Figure 3.8, and recorded it in Template A (see Appendix D). The second template would have reviewed the movement displayed in Figures 3.9 and 3.10 and recorded this movement within Template B (see Appendix D). The final template was the Coding Matrix (Template C) and this matrix brought together findings from the review of the eye-tracking data-sets with data gleaned in interactive observations when researcher present with individual learners using Mathletics. The final summary was blended with analyses of other data-sets using the wider frame of thematic analysis and to report the final learner's interaction with the activity.

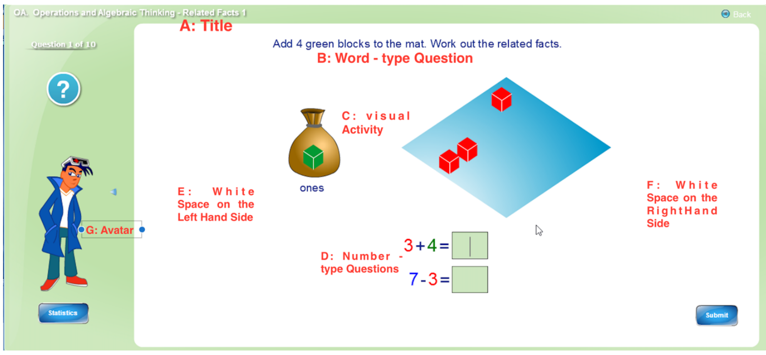


Figure 3.8: Screenshot of the initial screen of related facts 1 activity.

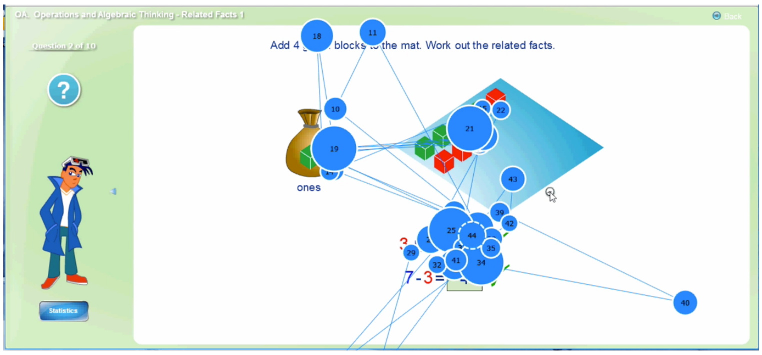


Figure 3.9: Screenshot of the learner's eye movements (Plots 1- 41).

Figure 3.10 : Screenshot of the heat map showing more focus on the numerical question than the visual activity.

Some sample data codes and emergent themes are illustrated in Table 3.4.

Table 3.4: Sample Themes & Codes in Phases 1 & 2

Sample Themes & Codes in Phases 1 & 2

(whole-class observation, interviews, Mathletics report & eye-tracker)
Theme: Pedagogy
Teacher uses didactic approach to explain mathematics concepts; Teacher fosters whole-class discussion; Teacher facilitates group-work for collaboration/ co-operation; Teacher using Question & Answer technique; Teacher engages active learning approach; Teacher facilitates a high degree of self-directed/ independent learning among learners; Teacher encourages playing; Teacher initiates peer assessment technique; etc.
Theme: Instructional Resources
Teacher deploys physical resources (blocks, balls); Teacher deploying online/ offline digital resources, etc.
Theme: Teacher Support for Learners
Teacher encourages learners' participation; Teacher disciplines learners; Teacher engages in scaffolded learning/ guided facilitation; Teacher engages in inclusive forms of learning, etc.
Theme: Learner interaction/ engagement
Learner co-operating within groups; Learner preferring to work alone during maths practice activities; Learner exhibiting the desire to self-direct their learning; Learner disengages with group discussion/ collaboration to work; etc.
Theme: Motivational Factor/s
Learner motivated by game elements, including rewards and feedback; *Learner exhibiting a desire for collaboration and competition; Learner exhibiting a desire to successfully complete the activities; Learner exhibiting the desire to engage in Mathletics beyond class-time* ; *Learners displaying interest in connecting/ competing with other learners; Learner discerning the degree of challenge of questions and impact of this on their performance;* etc.
Theme: Human Computer Interface design (Mathletics - eye-tracking)
Learners ignoring the avatar, and assistance facilities; learners ignoring textual question in favour of numerical or visual question on-screen; Learners mainly engaging with visual or numerical questions; Learner using mental mathematics; learners using fingers to scaffold counting on-screen; etc.
Theme: Learner Dispositions
Learner expressing enjoyment from the use of Mathletics; Learner expressing/ displaying a lack of interest in the task; Learner is displaying level of anxiety/ frustration with more challenging mathematics activities; Learner displaying a self-challenging disposition; etc.
Theme: Other – Learner Cognitive Factor
Learner lacking the mental capacity to understand large numbers (such as 1000) at this grade level; etc.

3.6.2 Quantitative Data Analysis Tool.

For this study, the Statistical Packages for Social Sciences (SPSS) was utilised to analyse the data obtained from the surveys Mathematics Disposition Survey (MDS), Teacher Survey and the Mathematics Performance Test.

A paired-sample t-test was performed to compare the scores on the MDS, the categorical dependent variables of which were Confidence (C), Interest (I), Satisfaction (S) and Anxiety (A), while the independent variable was time (pre- and post-intervention). In addition, the Wilcoxon signed-rank test was performed for this survey as an alternative to the paired t-test in cases where the data were not normally distributed. It should be noted that, as the sample size was small, the Shapiro-Wilk test of normality distribution was also used to verify the distribution of the data (See Appendix F).

Furthermore, a paired t-test was used to compare the scores on the Mathematics Performance Test in the same group of learners pre- and post-intervention.

The Teacher survey items were designed to be combined, in order to construct meaningful summaries of the survey concepts. Exploratory factor analysis was used to determine optimal question combinations; however, the small sample size precluded the use of factor analysis. Thus, survey questions items were combined to form factors in a similar fashion to that used for the original survey – namely, Obstacles to the use of ICT and Teachers' Professional Development. SPSS software version 24 was used to produce descriptive statistics exploring primary teachers' access to, experiences of, and professional development in ICT within the context of teaching and learning. Moreover, Mann-Whitney U Test was used to test the differences between male and female teachers in their opinion and attitude to the aforementioned areas. Mann-Whitney U Test was performed for this survey as an alternative to the Independent Sample t-test in cases where the data were not normally distributed. It should be noted that, as the sample size was small, the Shapiro-Wilk test of normality distribution was also used to verify the distribution of the data. The categorical dependent variables of which the impact of ICT on teaching and learning, the relevance of ICT use in different learning processes, on the impact of ICT on students' skills, motivation, and achievement, general issues, 21st century education challenges, ICT potential in teaching and learning, while the independent variable was genders.

3.7 Validity and Reliability.

3.7.1 Validity and Reliability of Qualitative Data

Validity in qualitative data means that a researcher checks for the accuracy of the findings by employing some strategies such as triangulation, rich and thick descriptive data

(Creswell, 2014). Reliability is ‘consistency’ or ‘repeatability’. This means that if the study is repeated, it will deliver the same results. Achieving the same results from qualitative data is difficult, however, Lincoln and Guba (1985) suggest that instead of *‘aspiring for the same results, qualitative researchers can use triangulation, peer examination, investigator’s position and audit trail to ensure dependability and consistency’* (p.288). To ensure the rigour of this study, the triangulation technique was employed, as well as using rich and thick descriptive data set, and maintaining an audit trail of all analysis processes. The qualitative data collected from the learner and teacher interviews and class observations were triangulated. In order to construct an audit trail, a diary was maintained during the process of collecting data to capture questions, ideas and decisions that were made regarding the study. This record ultimately presents evidence of how data was collected and analysed and how the research was conducted. Also, the interviews were recorded and transcriptions retained for the record.

Additionally, to ensure satisfactory quality and reliability of eye-tracker data, two steps were taken. Firstly, the system (eye-tracking hardware and software, computer system and the experiment environment) was properly evaluated in order to assess its suitability with respect to the requirements of the research study. Secondly, the data collection was carefully evaluated and calibrated in order to ensure that the system had produced accurate and precise data. In this regard, Tobii studio provides ‘tracking status test’ that can determine the distance between the user and the monitor, and thus ascertain the position of the eyes on the screen. The calibration procedures were initiated in this study by the researcher asking the children to sit on chairs 60 cm away from the monitor of a Tobii X2-30. The room was lit normally and children were asked not to move, pull the chair or touch the computer screen during the time of calibration. They were asked to look at a point on the screen until the procedure was completed and the quality of the calibration was illustrated by the appearance of a green line. A long green line indicated a large offset. If required, re-calibration was conducted to ensure the accuracy of the procedure. The children were prepared for the calibration procedures and trained twice on how to sit and act during the process of using the eye-tracker. Data obtained from these training sessions were not included in the final study. The quality of the eye-tracking data can be determined by having actual participants look at targets. That can be the most common data quality evaluation method and it serves to validate the system calibration (Holmqvist, Nyström & Mulvey, 2012). For this study, in order to ensure that the calibration for data selected for analysis is of good quality, a screenshot was taken every 5 to 10 seconds to track the position of the eyes on the screen.

3.7.2 Validity and Reliability of Quantitative Data

Validity in quantitative research refers to one whether one can draw meaningful and useful inferences from scores on particular instrument (Creswell, 2014). The three forms of validity are content validity, concurrent validity and construct validity. For this research, both the Mathematics Disposition Survey and Teacher Survey were derived from existing surveys, and thus validity whilst assured in their original formats, needed to be re-examined within the hybrid versions.

In terms of the content validity of the teacher survey, both versions (Arabic and English) of the survey was sent for review to experts in the ICT field. These experts were asked about their opinion on whether the instruments measured the intended research objectives, and they broadly agreed that they were suitable for intended purposes, with minor recommendations on reducing the number of questions as it was too long and some items were unnecessary. Furthermore, Cronbach's alpha was used to test the reliability of the Teacher Survey. The result (see Table 3.5) shows that internal consistency was between .75 and .96. Therefore, the Teacher Survey was found to be highly reliable.

Table 3.5: Cronbach's alpha for the Teacher Survey.

	Cronbach's Alpha	Number of Items
ICT access for teaching	.75	13
ICT based activities	.85	16
Learning activities.	.93	12
Obstacles to using ICT	.80	23
Support to teachers	.90	15
Teacher opinions	.96	17
Teacher skills	.95	21

In terms of the predecessor of the Math Disposition Survey i.e. the Math Anxiety Questionnaire, there was some comfort in it having already been shown to be highly reliable in primary school learners aged 6-9 according to a paper published in German, 'Is the FAR 'Fragebogen für Rechenangst' a reliable and valid instrument?', with '*the internal* *consistency (Cronbach's alpha) varying between .83 and .91 for the whole questionnaire depending on the age group (6 to 9 years old*)' (Krinzinger et al., 2007 2007 cited in Krinzinger, Kaufmann & Willmes, 2009). However, some minor adaptations were made to this survey (i.e. the addition of a fifth element aiming to assess 'satisfaction level/s') and of course the context of Saudi Arabia was different to that of Germany where the instrument was initially validated. Therefore, the hybrid survey was re-tested and found to have internal consistency (Cronbach's alpha) of between .6 and .93, which means that the Mathematics Disposition Survey was still considered reliable for testing in primary school learners aged 7-9 years (see Table 3.4) in Saudi context.

Table 3.6: Cronbach's alpha for both groups.

	Cronbach's Alpha Grade 2	Cronbach's Alpha Grade 3	Number of Items
Confidence (C)	.870	.870	7
Interest (I)	.776	.709	7
Satisfaction (S)	.602	.650	7
Anxiety (A)	.875	.939	7

Ethical Considerations.

An initial step in ensuring the necessary ethical considerations were applied in this study was to obtain approval from the DCU Research Ethics Committee. The process of receiving ethical approval from the DCU Research Ethics Committee requires the submission of documents including research tools, a plain language statement, informed consent forms, approval from external sources (letter from Saudi Ministry of Education) and a notification form for low-risk projects. The plain language statement is the explanatory information given to potential participants. It identifies the purpose of the study and the proposed research tools. It must be written in lay language that can be understood by all participants. Informed consent is a process to acquire permission before conducting a research. The informed consent form aims to confirm that participants of the research are volunteers, and can withdraw at any stage in the study process.

For this research, the plain language statement and informed consent form were written for all participants (teachers, students and parents), and the students' form was supported by pictures to make it easy for children to understand. In addition, all the documents were translated to Arabic and written in language that could easily be understood by all participants. Before the approval from DCU, all research instruments and a timeline had to be submitted in order to get an approval from the Saudi Ministry of Education. This approval letter was necessary to facilitate the researcher's access to the schools. The project then was approved by DCU Research Ethics Committee as a low-risk social research project. The researcher adhered to the ethics approval granted throughout the study, by ensuring all participants signed informed consent forms, and ensuring that the participants were aware that they could access on request their transcripts and/ or a summarised version of the findings of the study. The documentation relating to ethics approval can be viewed in Appendix B.

3.10 Challenges and Limitations of the study

For this study, the researcher faced challenges during the process of collecting and analysis data. The main difficulty in the data collection process was during the last phase. It was difficult for the researcher to locate teachers for the pilot and large-scale surveys in Saudi Arabia, while she was based in Ireland. However, the Saudi Arabian Department of Planning and Development did take responsibility for sending the survey link to teachers at the target schools and sent reminders to them. Furthermore, the survey was left open for more than a month to further encourage teacher participation.

The challenges encountered during the process of the analysis of data were twofold. Firstly, the second phase was conducted in a public school setting with the main language being Arabic. All research instruments (interviews & survey questions) had to be first written in the English language and then translated to Arabic. The Teacher Survey and Mathematics Dispositions Survey for example were initially developed in English and then translated to Arabic. All documents, in translated stage, had to be sent to someone to check translations and make sure that the translation did not change the meaning. After collecting data, the interviews were transcribed using the main language 'Arabic'. Then the transcripts were translated to English. For example, the Mathematics Disposition Survey which included 35 questions, was obtained from the children in paper format in Arabic language which needed to be translated and manually transferred to an English version of SPSS. All these challenges were time-consuming.

A limitation of this study is the fact that as a female researcher, it was not possible for me under the Saudi education system to access boys' single-sex schools, as Saudi rules only allow for interaction between teachers and learners of the same sex. Therefore, it was not possible to study how boys would engage in similar interventions aiming to integrate online Mathletics practice activities.

Another limitation of this study relates to ascertaining the number of different schools represented by teachers participating in phase 3. In order to protect the identity of teacher participants in Tatweer schools, anonymity had to be guaranteed, and as such a decision was made not to ask participants to declare the name of their School. This meant there was no way to determine how many different schools were represented within the cohort of 24 participating teachers. However, as there were male and female Tatweer teachers within the cohort of 24 participants, we can definitely state that there were a minimum of 2 schools represented (as the single-sex school system is in operation in Saudi Arabia – male teachers teach in all boys schools; female teachers in all-girls schools). In terms of research findings, it means that the findings from Phase 3 may be heavily influenced by the culture of a small number of schools with respect to poor integration of technology or inadequate provision of opportunities for teacher professional development, rather than being reflective of a broader issue across a large set of schools in the Eastern district of Saudi Arabia.

3.11 Conclusions

This chapter has provided a detailed account of the multi-phase mixed methods approach used to guide this research study, how rigour was ensured in this study, ethical considerations, and the limitations of the study. The following three chapters present the findings from phase 1, phase 2 and phase 3 of the study respectively.

Chapter 4: Findings from International School Context

4.1 Introduction

This chapter presents the findings from the first phase of research undertaken in an International primary school in Saudi Arabia. The chapter begins by providing a re-cap of the methodology for this phase of the study, followed by an overview of findings from an exploration of the traditional practice of mathematics education and the impacts of integrating online gamified mathematics practice activities (using Mathletics) in the International primary school. The second section presents six in-depth case studies illustrating the nature of learner-computer interaction within Mathletics. The final section presents the conclusions from phase one of this study.

4.2 Phase 1 Methodology

This first phase of the multi-phase mixed methods study utilised a qualitive approach and tools to explore the following questions:

- *How is mathematics education presently being performed by teachers and learners in Grades 1 to 3 in a Saudi International primary school?*

- *What impact, if any, does the integration of online gamified mathematics 'practice activities' have on learning* in Grades 1 to 3 *in this Saudi context?*

With respect to the first question, the study aimed to explore the teaching and learning approaches and strategies currently used by teachers in this International school to teach conceptual knowledge and to practice mathematics concepts in Grade 1, Grade 2, and Grade 3 contexts, as well as the interaction and engagement of learners within these traditional spaces. In terms of the second question, the study attempted to reveal whether the integration of online gamified mathematics practice activities affected learners' disposition, engagement, motivation and/ or academic performance in Grade 1, 2 and/ or 3 contexts in the International primary school context.

The data-sets were generated from whole class observation, interviews with 3 class teachers (one from each grade level) and with six learners from each grade level, as well as information provided from Mathletics activity report for Grade 1, Grade 2 and Grade 3. Furthermore, the findings for the six case studies were informed by data sets gathered from software tracking the eye-movements of learners engaged in Mathletics activities, and from focused interactive observations of 6 participants by the researcher, with two learners from Grade 1, Grade 2 and Grade 3. The overall research process in phase 1 is displayed in extracted section from Figure 3.2 below.

Research Phase 1

Data Collection Time - Sept-Dec 2015

Research Approach: Qualitative Research

Focus of Research -

- Critiquing teaching and learning approaches used, and learner engagement, in traditional mathematics education sessions

- Exploring learners engagement and interaction within online gamified mathematics practice (Mathletics) sessions (individually and in whole class settings)

Cohort - Learners and the teachers in Grade 1/2/3 in International School in Saudi Arabia.

Particpants' Numbers: Grade 1 (n=21)

Grade 2 (n=16), Grade 3 (n=19) and three teachers.

Number of Sessions: Grade 1 (18), Grade 2 (18) and Grade 3 (18), and 6 Individual cases (2 at each Grade level).

Data Collection Tools - Class observation notes, Learner Interviews, Teacher Interviews, Eye-tracking tools, Interactive Observation.

Data Analysis: Thematic coding

Other Minor Focus:

Qualitative data on Teachers' ICT skills, use and training. (n=3)

It is important to note that a small amount of data was also gathered relating to the teachers' ICT experience, access to technology, and professional development and this data-set is discussed in chapter 6, which presents the findings relating to Saudi teachers' readiness to integrate technology in their practice.

4.3 Findings from Whole Class Observations (Traditional and Mathletics)

This section summarises the findings from a review of learner and teacher interactions in mathematics sessions in traditional mathematics class and in bolt-on sessions that integrated online practice exercises using Mathletics across three grade levels in an International School in Saudi Arabia. The format for each session involved the class being taught mathematics in the traditional way, which generally involved the introduction of mathematics concept/s followed by mathematics activities. It is important to note here that the Mathletics session replaced the use of the workbook in the International school (with the prescribed workbook activities usually completed at a later stage in the school day). The online gamified mathematics practice activities in Mathletics were introduced in a session at the end of the traditional class. The findings from the three grade levels are presented in the discussion that follows.

4.3.1 Grade 1: Key Findings

4.3.1.1 Introduction

This section summarises the findings from a review of learner and teacher interactions in mathematics sessions in traditional mathematics class and in bolt-on sessions that integrated online practice exercises using Mathletics with Grade 1 learners in an International School in Saudi Arabia. The group of learners and their teacher were observed during 18 traditional mathematics sessions ranging for circa 40-45 mins over an 8-week period in 2015-2016, including a bolt-on 15-20 minutes session with Mathletics. This section opens with a short description of the teacher and cohort of learners, and then moves forward to summarise the findings on the general pedagogic approaches and nature of learner engagement within the traditional setting and the Mathletics sessions, with the conclusion sections comparing and contrasting findings in the practice of mathematics learning in traditional mathematics sessions with those that integrated Mathletics to facilitate the online mathematics practice.

4.3.1.2 General Information: Teacher and Learners.

This teacher of Grade 1, Teacher 1 [T1], had six years of experience teaching at primary and elementary level, and was in her first year of teaching at this International school during the period of study. The teacher was female and her primary subject degree was in the English language. The teacher indicated that she had never undertaken professional development in ICT but considered herself to have an advanced level of knowledge of technology integration in education. This teacher was their class teacher, thus she taught this cohort the majority of the curriculum (including mathematics). The mathematics sessions were taught through English.

There were 21 Grade 1 learners (aged 6-7 years) in this class grouping. These learners were all female, and came from a range of Middle Eastern countries including Saudi Arabia, with Arabic their main language and English their secondary language. The learners engaged in five 40-45minute sessions of mathematics classes per week (including the observed session), and covered mathematical topics including addition and subtraction during the initial part of the year.

4.3.1.3 General Pedagogical Approaches & Learner Engagement

This section presents the general pedagogical approaches that were used by the first-grade teacher, under the following headings: Pedagogy used to teach the mathematics concept in the traditional setting, Pedagogy to practice mathematics in the traditional setting (paper-based mathematics practice activities); and the Pedagogy used to practice mathematics in the online gamified learning setting (using the Mathletics practice activities). Furthermore, it includes discussion on the nature of learner interaction and engagement across the observed sessions.

4.3.1.3.1 Pedagogy used to teach mathematics in the Traditional Setting

The teacher always opened the mathematics session by revising the previous topic. Generally, the teacher provided the learners with individual feedback, by rotating around the classroom and correcting individual homework. She also engaged the whole class in a question and answer-type approach to engage learners in discussion of the homework questions. On several occasions, she typed the question from the previous topic on the smart-board and invited the learners to answer.

Following revision of previous topic, the teacher presented a new mathematics topic at the outset of each session. In terms of presenting the new mathematics topic, the teacher used different strategies. She sometimes started the mathematics class by playing a game connected to the new topic. This could take the form of a physical game (such as using dice to generate numbers that the learners had to add together). The teacher indicated in the interview that she does also generally integrate online games at the outset of class but she didn't during the period of observation to allow time for the integration of the Mathletics online mathematics practice activities in-class as part of this study. Therefore, she confirmed that she often also plays online games with the learners when starting new topics. She expressed the belief that integrating games make the learners' more focused and engaged, and make the lesson fun, and thus preferred using games at the outset of class in mathematics, science and other subjects, rather than progressing straight into paper and pencil work, '*, we play videos [video games] related to the topic in the computer… before we start addition, we play some addition songs and addition games. So, it makes their mind more focused on the topic and they feel more active when they see things really on the screen visualizing it's better than paper and pencil work, it's better when it's focused. So, I feel kids are learning with fun'. [T1]* Furthermore, the teacher generally presented new topics on the smart-board to help explain the topic. The teacher was observed using online resources in her class to display mathematics tasks. For example, she used information from a website from the mathematics book publisher to introduce the new topic. In the interview, the teacher confirmed that she uses technology, such as the smartboard and online resources, in an attempt to make the lessons more fun and enable learners to better visualize the mathematics concept, '*Technology makes learning more fun. it's visualizing the concept'.*

The teacher was observed to also facilitate group work and provide opportunities for collaborative learning within the observed sessions in Grade 1. For example, she often demonstrated how to answer the first question of the guided activity on the smart-board and then gave the learners a chance to work in groups to solve a second example. The teacher further regularly invited the learners to try to solve the question on the smart-board and in doing so, promoted participatory forms of learning - '*We use of course, a smartboard in there in the class and we have the smart pen so when we work with our worksheets and paper-work, we project this in the screen. So, as it's projected on the screen, we give each student chances to come forward and use the smart pen and find out the answers…these answers were done by kids. Not by me as a teacher'*. [T1] Thus, there was some evidence that this teacher utilises technology in promoting a learner-centred approach, and believes that she is not only the one who can provide learning, and that learners should be engaged in the learning processes '*So, learning in my class, I don't prefer teacher orientation [i.e. teacher-centred approach]… A teacher is not the one teaching in the class, I let the students come forward. You [learner] do the teaching today, so you get a chance to go to the board. So, I pick each one of them to work. So, I try to engage them with technology. It's not the way I'm using it [technology], they are using the technology'.* [T1] Furthermore, the teacher used a question and answer approach to stimulate the learners' thinking about the new topic. Also, she sometimes asked one of the learners to read out loud information about the new topic from the book.

Moreover, the teacher was observed engaging in inclusive form of learning. She was observed actively seeking learners' inputs on alternative ways to solve mathematics problems. For example, she provided the learners with one way to solve the problem and asked them to think about another way to find the answer.

Generally, learners were observed actively listening to the presentation of new mathematics topic. The learners typically then moved to work in assigned groups on the mathematics practice activity that the teacher provided. Some learners volunteered answers to the questions posted by the teacher. Some of these learners went up to the board and provided the answer, on request from teacher. For example, the teacher on one occasion was revising the previous lesson (which covered the mathematics topic of 'Double'). She picked two learners from two different groups and asked them to come over to the board. She asked the first learner to draw six circles (adding 3 and 3) and the second learner to draw eight circles (adding 4 and 4). She picked another two learners to answer the questions. She then added one circle to each question and asked learners from the other two groups to find the sum of all circles. The learners raised their hands and the teacher chose one learner to come over the smartboard and answer. The teacher then explained the meaning of 'Near Double'.

However, there was also evidence from the class observation that on some occasions some learners showed a lack of interest in new topic areas. These learners typically sat quietly or had informal chats with each other instead of paying attention to the new topic that the teacher was presenting.

4.3.1.3.2 Pedagogy of Mathematics Practice in Traditional Setting (paper-based mathematics practice activities).

So, once the mathematics concept had been explained to learners and they indicated an understanding of it, the teacher moved forward to engage learners in mathematics practice activities. The teacher provided the standard textbook/workbooks where learners engaged in mathematics practice activities, that were completed in class-time and submitted to the teacher. The teacher generally did not provide direct feedback to the learners individually on the mathematics practice activities completed within class-time. She usually asked the learners to leave their activity and/ or workbooks on her desk, which she would check after class.

Therefore, on completion of the mathematics introduction activities, the teacher generally progressed learners to mathematics practice exercises using textbooks. The Grade 1 learners were observed completing the activities during the class-time and generally dropped their work on the teacher' desk before the end of class. In terms of interaction, the learners were observed to typically collaboratively engage in completion of mathematics practice exercises in the workgroups. In this regard, they were observed helping each other and explaining the mathematics problem as required to each other. For example, in one observed group in Session 8, one of the learners explained to her friends her way to write a sentence about addition and subtraction.

However, there were some learners who disengaged with the group and did work alone to complete the mathematics practice activities. For example, in Session 15, one learner was sitting in her group and decided to work by herself on the 'Near Double' activity. She was observed using her fingers to count and took her time to individually complete the questions, and then submitted these to the teacher.

The class observation further revealed that some learners expressed anxiety with some of the more challenging questions presented in the textbooks and asked the teacher for more explanation of the mathematics concept before returning to attempt to complete the question. For example, when the teacher was moving around to check the learners' answers one of the learners requested more explanation of the concept of 'Near Double', the teacher provided assistance and/ or asked other learners to help the learner solve the questions. Other learners were observed to be less interested in completing the mathematics practice activity and tended to informally chat or mess with other instead of doing the activity. The teacher in these cases was observed disciplining the learners and reprimanding them for informally chatting or distracting others.

The teacher was also observed on some occasions displaying some of the mathematics practice activities on the smartboard (using the publisher's website), and furthermore made use on some occasions of different kinds of online games to engage learners in practicing what they had learned. In respect of the latter, the teacher said that she sometimes used 'Turtle Diary' and more general games from Google which were suited to the learners' age-group and the mathematics topic. She commented that: '*In classrooms I play with kids, like math games. We have a game, we have websites like Turtle Diary where it's devoted to math. We have A to Z reading skills [game], also math games are included. Some google sites in general, where it takes you directly to math games. For their age, for example we are learning about fractions and addition and subtraction, so [I search for related games I put them into Google. And they as a class, we play together on the smartboard*'. [T1]

During the teacher-directed activities using the smartboard, a few learners were observed to be concentrated on the board and fully paid attention. They raised their hands to ask for a chance to come to the board and type the answer. Others were doing the activity in the textbook. For example, the teacher was moving around to check on the learners' work on the independent activity of 'Connecting Addition and Subtraction'. The teacher noticed that one of the learners had difficulties in solving the problem. The teacher went over the smartboard and asked all the Grade 1 learners to pay attention. A small number of the learners paid attention and interacted with teacher. The teacher then chose one of the learners from the first group to come over the board and explain the process to her friends, whereas, most of the other learners kept doing the activity.

The teacher in her interview said that she played online games with the learners for mathematics practice when they have time '*Usually like three times a week, four times a week. It depends because usually we have our worksheets to be completed and [they need to work on] their writing skills. The day like when we finish early or sometimes, we have more* *time to work, I play math games and I let them, again come again and play with me the math games. So, it's like 3 times maximum in a week'. [T1].* The teacher believed that these games helped learners to focus better and provided them with more knowledge, '*If you say benefits mean [of mathematics games], it focuses them better. The lessons and concepts we're teaching them with worksheets, they are grasping more knowledge when it comes to when we tell them "you are playing, but you it means that you are also learning addition or subtraction skills". So, it's like two in one. They're getting the idea [of mathematics problem] from the paper but [they get] more ideas [on how to solve the mathematics problem] from the computer which is the benefits'.* Therefore, the teacher preferred the aforementioned games as they related to what was covered in the classroom. In the interview she confirmed that '*We could play many games, but I prefer the games that relate to topics covered in class, and they are excited enough that they play with this. Not with any random games because maybe they might now know, or it would not have been related to what we are learning. So, it's better that they learn from what I am giving them and the resources that I mentioned.' [T1]*

The teacher paid attention to the learners' mathematics ability when selecting online mathematics games/ exercises. The teacher in the interview mentioned that when she played online games, she started the learners at the lowest level and then moved to more advanced level/s, so that the learners could challenge themselves, '*Addition has certain standards that they need to know how to count and find out the figures. So, related to these easy games, I post the games on the website. I write like "math games for grade one", "lower level", "advanced level", "middle level", so usually when I start playing games I start with the below level. When you write in google there are websites where you have [mathematics games] for low beginners. So, we play the beginner games then the second day or the third day when we have time, we play middle, like a little bit advanced level, and then finally the advanced where they can challenge themselves and you know, learn better, I mean learn better through games' [T1].* The teacher further encouraged learners to play online games at home, and provided online resources to facilitate this on her class website. In her interview she commented that she uses her web-space to publicly share online resources: '*Yes. I have a website, it's my classroom website and I have mentioned a lot of educational websites over there which they can even access at home'. [T1]*

The teacher contended that to her knowledge the parents helped learners when playing mathematics games at home. *'No, because they usually use games at home, I'm sure the parents are helping.' [T1]* The teacher further mentioned that parents mentioned that some activities were easy for learners, and that this may be because the games that she posted to them are related to what they have learnt in the classroom: '*And parents ask me that, like which game is more suitable like "we [the parent and learner] went to the Turtle Diary and we are playing math games" and I'm like "yeah, wow you could still continue" and they're like "yes it's easy for our kids and they are challenging themselves". I said, "because maybe they know from school"'* [T1]. The teacher said that the learners are interested to play at home the same game that they played at school to show off their mathematics abilities, '*So, when they're playing the same game at home, they feel more interested because they're happy to show their parents they know' [T1].*

So, in conclusion, the teacher was observed using a variety of approaches in practicing mathematics activities in the traditional classroom context. She used activities and textbooks but also used online games, where relevant to context. She involved the learners in solving mathematics problems and encouraged them to work in groups. The teacher supported learners' collaboration by for example inviting other learners to re-explain to friends how to solve the mathematics practice activities on several occasions. The teacher also undertook the role of facilitator. She offered support and advice when needed and provided scaffolding when necessary. Learners were observed to complete the mathematics practice activities as requested within activity book, and to engage as requested in whole class mathematics practice activities using smartboard. The learners generally did not display excitement or high levels of enthusiasm when completing the activity book practice exercises or when participating in the teacher--facilitated mathematics practice activities using smartboard.

4.3.1.3.3 Pedagogy of Mathematics Practice in Online Gamified Learning Setting (Mathletics Practice Activities).

Typically, the teacher would present (bronze) certificates from Mathletics at the outset of this part of the session, to those Grade 1 learners who had achieved the required number of points or certificates. The teacher then was observed acting primarily as a facilitator (thus supporting a high degree of self-directed learning among learners) when Mathletics was used to practice mathematics. She sometimes moved around and checked on the learners' work within Mathletics, but primarily monitored their interaction at a distance. In the interview, the teacher commented that '*I like the game [Mathletics] and there is no one get bored when they are doing the activity by the platform. I posted the certificates on my website to motivate other girls and their families to play the game at home. This game helps them to be more active in math class'.* *[T1]*

The class observation revealed that the learners in this group displayed more interest in doing practice mathematics activities within the gamified Mathletics platform, as opposed to in the traditional setting. In this regard, learners were observed as being visibly happier when the teacher let them get out their own iPad from the bag and have access to the Mathletics platform. They tried to finish the mandatory in-class mathematics activities in the mathematics activity/text book as fast as they could and dropped it on the teacher's desk in order that they would be allowed to open the iPads and engage in Mathletics online mathematics practice activities. Some of the learners in the interview stated that they like to do the activity using Mathletics because they considered it as fun way to learn - learner G1C7 said that '*I like to play Mathletics because it's fun and I learn new things'*, learner G1C8 '*I like Mathletics it's so much fun, ...'*. It is interesting to note that their interest and general excitement did not appear to reduce during the overall period of the observation of the use of Mathletics to practice mathematics.

The learners demonstrated pride in their achievements by striving to complete as many of the mathematics practice activities as they could within Mathletics. They were observed looking proud of themselves, particularly when they completed the Mathletics activity without help. One of the learners in the interview said that '*I can play and collect points without any help even when I start a new game. I am proud to collect them by myself'*.

The learners also exhibited a desire to *successfully* complete all of the Mathletics activities. The learners were observed really concentrating in an effort to solve questions and trying to get the answers as quickly as possible. They were hyperactively doing the activity. In this regard, some students were standing up, holding the iPad in one hand hand and using the other hand for answering. The learners were so excited when they got the final score with all correct answers, with many of them typically running to show the teacher their scores and/ or sharing these scores with their peers.

The learners were observed exhibiting a desire for friendly competition in terms of successfully completing mathematics practice activities. They thus expressed their enjoyment in racing to complete mathematics practice activities with their peers in groups. For example, in one group, a learner set the challenge for the person who finished first with all correct answers to raise her hand, say "I am the first" and run to the teacher to show her final scores. Some of the learners in the interview confirmed that they liked to play in school because they have friends to compete with in class. Learner G1C1 for example said that '*I like to play Mathletics at school because there is a friend [to play with]*', learner G1C3 '*I like to play Mathletics at school because I have friends [who can play with me]*', learner G1C5 '*I like to play Mathletics at school because of my friends*'. However, it is important to note that there was evidence from the class observation showing that some of the learners prefer to work alone in the activities.

During the observation, it was noted that many of the learners orally shared their experience of completing the Mathletics activities at home. The learners talked about the Mathletics activities that they have completed at home and the points that they earned during class-time. From these conversations, it appeared that learners were spending considerable time engaging with mathematics practice exercises/ activities within Mathletics at home. Statistics generated from the Mathletics support this (summarised within the Mathletics Report, MR). Table 1 shows that 1,007 activities in Mathletics were completed by the learners in this grade. 627 of the activities (about 62% see Figure 1) were completed at home (school starts at 7:30 to 2:30 – Sunday to Friday). In the interview, many of the learners confirmed that they played at home, learner G1C2 '*I play Mathletics at home*', learner G1C3 '*I play Mathletics at home by myself*', learner G1C5 '*I play at home…*'.

Table 4.1: Completed activities in and out of school time by Grade 1 learners.

Grade 1- In School vs Out of School Activity	
Time period	Number of Activities
In School Hours (Sun-Thu)- 7:30 – 2:30	380
Out of School Hours	627
Total	1,007

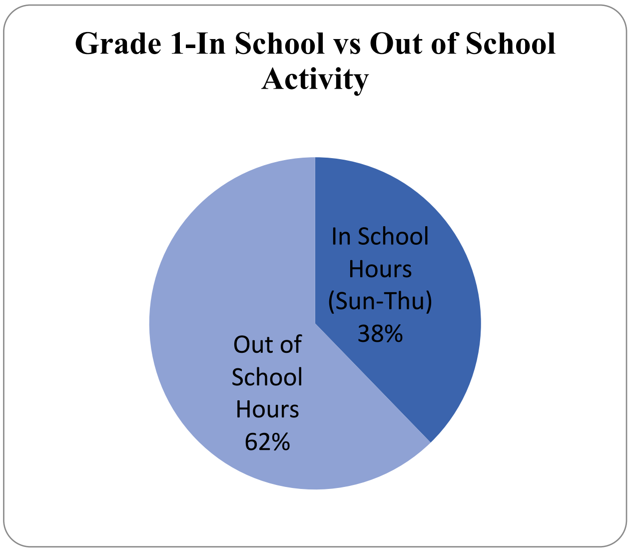


Figure 4.1: A pie chart from Mathletics Report showing completed activities in and out school time by Grade 1 learners.

The data from the Mathletics Report also showed that some of the leaners re-tried mathematics practice activities that they already took with the teacher (e.g. Figure 4.2) and some of them visited mathematics topics/ areas that had not been introduced by the teacher (e.g. Figure 4.3).

Student Name	Class Year-Grade	Topic Name	Activity	Result	Attempt	Date Completed	Time of Completion
C2	1		Add and Subtract Using Graphs	80	1	Nov-02-2015	7:31:46 pm
C4	1		Add Three 1-Digit Numbers	90	1	Nov-14-2015	2:44:42 pm
C10	1		Add Three 1-Digit Numbers	100	1	Nov-21-2015	5:48:11 pm

Figure 4.2: Sample of learner G1C2, G1C4, and G1C10 engagement with activities covered in-class, from Mathletics Report.

Student Name	Class Year-Grade	Topic Name	Activity	Result	Attempt	Date Completed	Time of Completion
C1	1		Make Big Numbers Count	60	1	Nov-01-2015	3:31:21 pm
C2	1		Compare Numbers to 100	60	1	Nov-01-2015	5:15:29 pm
C3	1		Sort It	40	1	Dec-02-2015	5:27:42 pm
C4	1		Collect the Shapes 1	80	1	Oct-30-2015	4:50:24 pm

Figure 4.3: Sample of learner G1C1, G1C2, G1C3 and G1C4 engagement with activities not covered in-class, from Mathletics Report.

Furthermore, some learners in the interview confirmed that they found difficulties with some of the Mathletics practice activities undertaken at home (primarily those topics not already explained by the teacher). Learner G1C7 for example said that '*Sometimes, the game that I play by Mathletics at home is easy sometimes it's hard because we didn't learn it'*, learner G1C8 '*I like 'Add to Ten' and I like 'Add and Subtraction Problems'. And I like other games. I like 'Fact Family'. I like other games too. I know how I think my myself, but sometimes I* *need a teacher just a little bit to show me how to do it'*. The activities that learner G1C8 mentioned liking in the latter part of the quote had been introduced by the teacher, thus these activities would be easier for her to complete by herself.

The Mathletics Report also showed (as illustrated in Figure 4.4) that learners typically scored very low (50% or even less) in topics that had not already been introduced by the teacher in school.

Student Name	Class Year-Grade	Class Name	Group Name	Topic Name	Activity	Attempts	First Score	Recent Score	Recent Attempt
C3	1	1A	1A		Sort It	1	40	40	02/12/2015 - 17:27:42
C4	1	1A	1A		Picture Graphs: Who has the (	1	50	50	02/12/2015-15:43:02
C8	1	1A	1A		Sorting Data	2	30	40	01/12/2015 - 18:23:40

Figure 4.4: Mathletics Report extract showing scores for three different learners (learner G1C3, G1C4 and G1C8) for sample activities undertaken at home not already covered in-class.

During the observation, it was noted that most of the learners in this group connected with other learners around the world in a section of Mathletics known as 'Live Mathematics' and appeared very much to enjoy this interaction. This group were doing basic arithmetic practice exercises, while competing with pupils in other countries, during the live session. This finding aligns with the data from Mathletics Report (as shown in Figure 4.5). The Mathletics Report also showed that there were a few learners who never played Live Mathematics (for example learner G1C3) and also some others who tried Live Mathletics, did not get any correct answers (e.g. learner G1C11, G1C12, G1C17 and G1C18).

		1		
Student Nam	Group Name	Total Correct	Top Score	Accuracy %
C1	1A	2	1	67
C2	1A	79	15	99
C3	1A	-	-	-
C4	1A	219	25	98
C5	1A	210	20	96
C6	1A	138	35	97
C7	1A	25	17	96
C8	1A	576	38	97
C9	1A	348	37	94
C10	1A	316	20	94
C11	1A	0	0	-
C12	1A	0	0	-
C13	1A	48	10	83
C14	1A	37	14	95
C15	1A	139	16	93
C16	1A	263	20	92
C17	1A	0	0	-
C18	1A	0	0	-
C19	1A	308	35	95
C20	1A	47	16	90
C21	1A	535	34	95

Figure 4.5: Mathletics Report showing learners' engagement with 'Live Mathematics'

*Explanation of the categories in Figure 1: The number 1 on the top row refers to level 1 (degree of challenge of mathematics problem). The term ‘Total Correct’ refers to the total number of correct answers achieved by the learner. in 60 seconds. The term ‘Accuracy’ refers to the percentage of correct answers out of the total of questions completed. The term ‘Top Score’ is the highest score earned at that level. It should be noted that learners can earn one point for one correct answer.

From observation of interaction in the classroom setting, the learners were seen to display a self-challenging disposition. So, for example, they were observed repeatedly practicing the questions and making more attempts to get all correct answers. This finding is in line with data presented within the Mathletics Report. Figure 4.6 shows that the learners improved their average score by about 15% through multiple attempts at the same question. (The ‘Activity Average Improvement’ is only calculated where there has been more than one attempt at the activity).

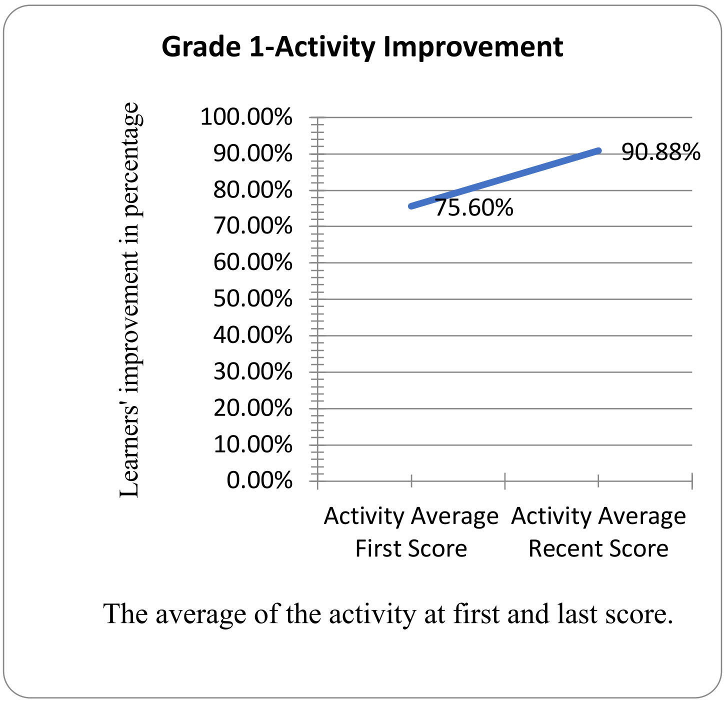


Figure 4.6: A line chart from Mathletics Report showing Percentage of Activity Improvement for Grade 1 learners

Figure 4.7a provides evidence of some Grade 1 learners engaging in multiple attempts at mathematics activities to improve their final score. Leaner G1C2 for example had three attempts on the activity ‘Related Facts 1’, improving her final score by 20%, and also learner G1C4 had three attempts on ‘Adding in Any Order’ improving her final score here by 10%.

Student Name	Group Name	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C2	1A	Related Facts 1	3	80	100	20%	100	17/11/2015 -11:40:35
C4	1A	Adding In Any Order	3	90	100	10%	100	04/11/2015 -09:50:49

Figure 4.7a: A sample from some learners' (e.g. learner G1C2, learner G1C4) engagement with activities showing multiple attempts at home to improve their final score.

Also, there is evidence from the Mathletics Report that shows some of the learners re-tried the activities at home to improve the final score. Figure 4.7b shows that some of the learners re-tried the activities many times at home and their final scores were improved. For example, learner G1C1 attempted to 'Make Big Numbers Count' seven times at home, improving the final score by 30%. Learner G1C5 had three attempts on the 'Compare Numbers to 100" and her final score improved by 50%.

Student Name	Group Name	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C1	1A	Make Big Numbers Count	7	60	90	30%	90	19/12/2015 -16:48:12
C2	1A	Picture Graphs: Who has the	2	90	100	10%	100	15/11/2015 -16:09:04
C3	1A	Addictive Addition	2	60	90	30%	90	01/12/2015 -18:03:38
C5	1A	Compare Numbers to 100	3	40	90	50%	90	14/11/2015 -16:47:39

Figure 4.7b: A sample from some learners' (e.g. learner G1C1, learner G1C2, learner G1C3 and learner G1C5) engagement with activities showing multiple attempts at home to improve their final score.

Moreover, the learners were observed enjoying scoring and receiving points for their endeavours within Mathletics in the classroom The Grade 1 group was observed sharing the number of points they earned with one another. The data from MR (Figure 4.8) shows that the learners collected around 88,500 points from the curriculum (topic areas directly related to class content/ national curriculum) and a further 3,400 points from playing 'Live Mathematics' (typically contains basic mathematics operational type practice activities).

Figure 4.9 shows that all learners each collected 450 points or more by playing the same activity or multiple times or a new activity from the curriculum activities during the period of research (the duration of the research was six weeks, the learners were asked to do three activities per-week so each learner had the potential to earn up to 30 points/ week). Learner G1C6 for example earned 14,000 points from engagement in multiple activities within Mathletics. Also, the learners were never asked to play 'Live Mathematics' during the period of the research but most of them chose to play it and collected additional points from it. Learner G1C8 for example earned more than 500 points from Live Mathematics (see Figure 4.10).

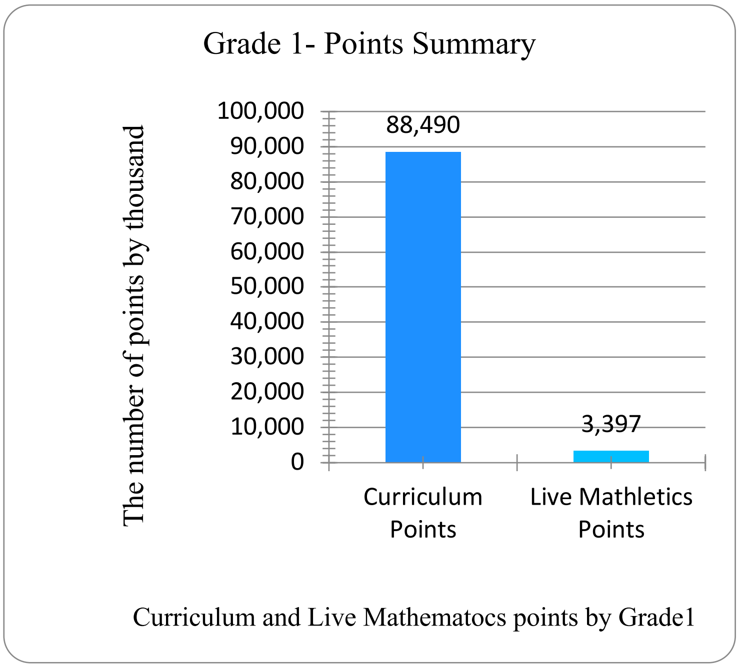


Figure 4.8: A bar chart from Mathletics Report showing the points from Curriculum and Live Math earned by the learners in Grade 1.

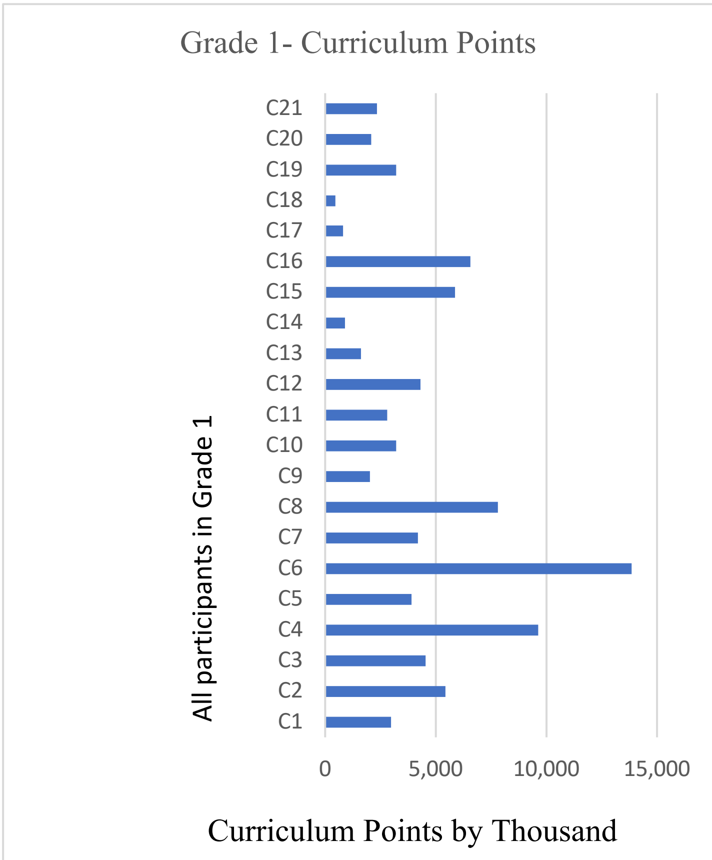


Figure 4.9: A bar chart from Mathletics Report showing the earned points from curriculum by each learner.

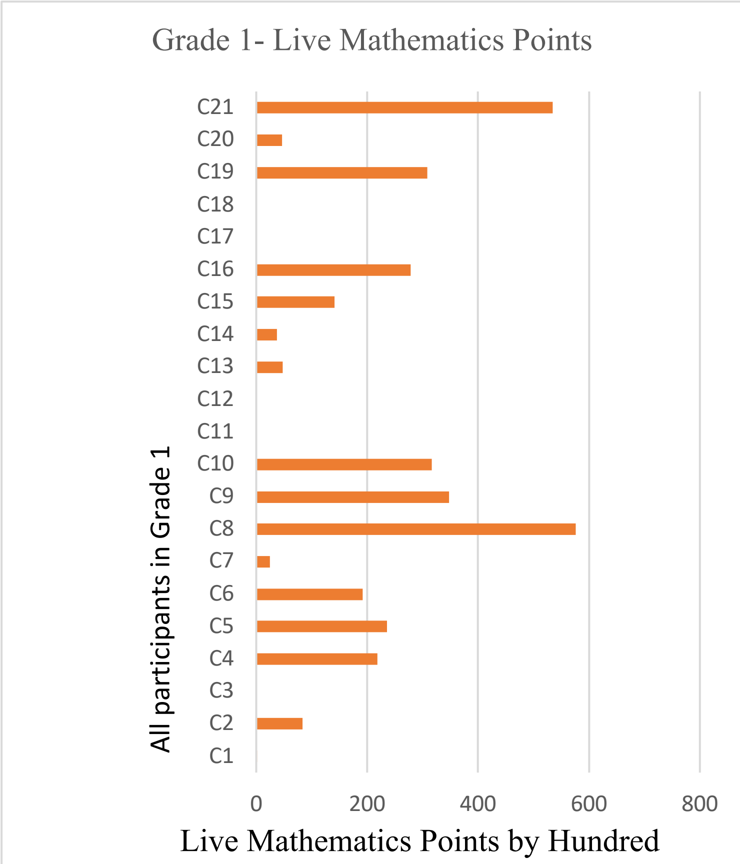


Figure 4.10: A bar chart from Mathletics Report showing the points from Live Mathematics earned by each learner.

The interviewed learners confirmed that they enjoyed collecting points and were proud of themselves when they did so without help. Learner G1C1 said that *'I have 20 points that I collected right now without any help'*; learner G1C3 '*I have 100 points and three certificates. I can collect them without help*'. However, the learners expressed sadness when they could not collect 1000 points, with Learner G1C1 commenting '*I will feel sad [if 1000 points not earned]'*, learner G1C5 '*So, if I could not collect more points. I feel sad*' learner G1C6 '*If I could not collect points, I will feel sad*'. One of the learners (learner G1C4) expressed worry if she can't collect '1000' points '*So, I could not collect points I will feel worry*'.

Also, as observed in class, the students displayed enjoyment on receiving a certificate from the teacher related to their engagement in Mathletics. Figure 4.11 shows that a total of 30 Bronze certificates were earned by the learners in this grade. ([Bronze is 1000 points/ week- Silver is awarded when 5 Bronze certificates achieved, and Gold is awarded when 4 Silver Certificates have been achieved] The duration of research was six weeks, thus there was only an opportunity for learners to potentially earn Bronze or Silver certificates/ awards. Only Bronze Certificates were awarded during the period of observation in this study.

Some of the interviewed learners expressed enjoyment by the number of the certificates that they had. Learner G1C3 '*three certificates*', learner G1C4 '*I have two certificates'.*
However, some learners expressed worry about their inability to collect "1000' points as they would not have a chance to earn a certificate without that level of points. For example, learner G1C4 '*So, if I could not collect points, I will feel worry because I will not have a certificate*'.

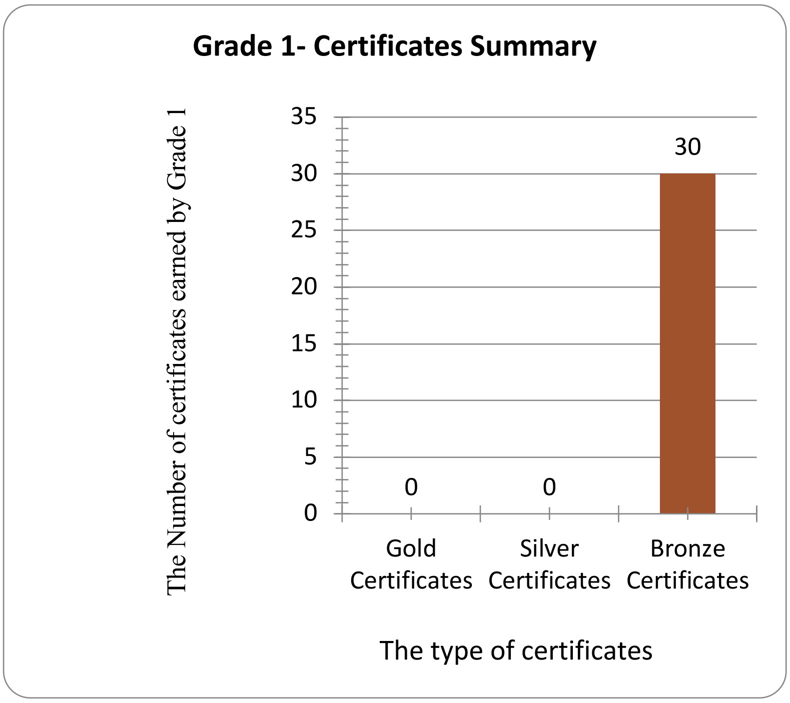


Figure 4.11: A bar chart from Mathletics Report about the earned certificates by the learners in Grade 1

The class observation also revealed that the learner who earned a certificate exhibited high levels of positive excitement when the teacher called her name to present the certificate at the platform. These learners always seemed eager to display this achievement to others. However, for those learners not receiving awards, they continually asked the teacher when they would be able to receive a certificate, displaying frustration at not achieving certificates at particular points during the study. Figure 4.12 shows that most of the learners in Grade 1

(15 learners) had at least one certificate, and two learners (learner G1C4 and G1C6) got four certificates.

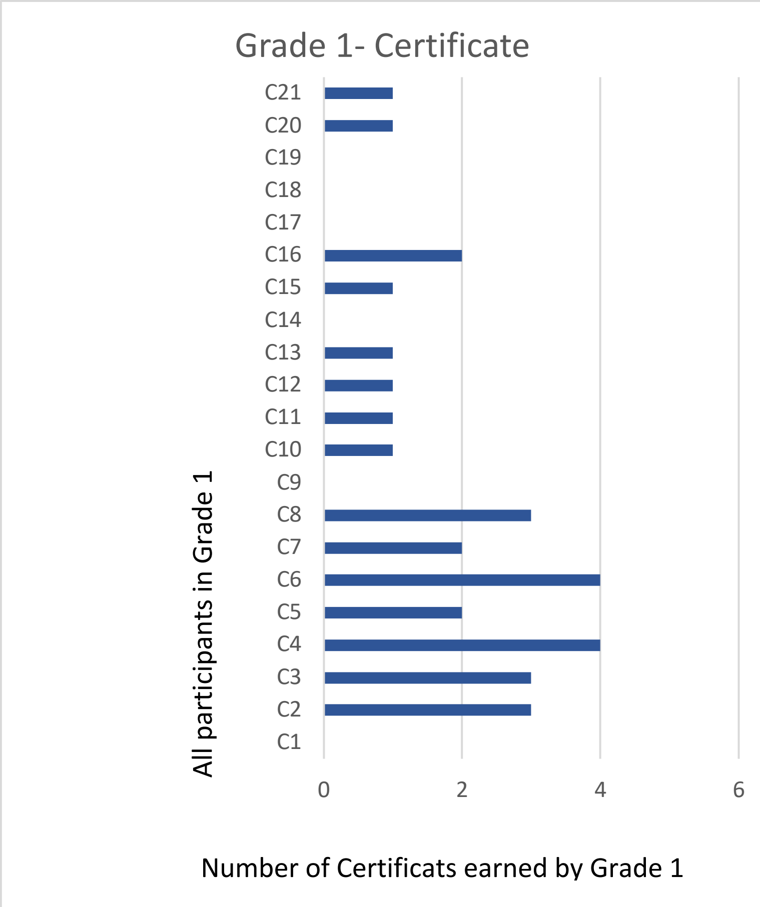


Figure 4.12: A bar chart from Mathletics Report about the earned certificates by each learner.

Moreover, it was evident that some learners had difficulty understanding the number of points required to earn the certificate, most likely due to the fact that these learners were at Grade 1 level and thus had not developed a full understanding of larger numbers (such as 1000). Some of the learners were observed asking the teacher questions about the points, including which learner had the most points and who is ready to have a certificate. Even during the interview, many of the learners could not read the number of points that they had. Some of them showed the points that they had received in class and other learners tried to read it for them - for example learner G1C6 '*Yesterday I had six here, and another six here and zero (she meant 660 points) and now I have nine here and nine here and zero (she meant 990).*

4.3.2 Grade 2: Key Findings

4.3.2.1 Introduction

This section summarises the findings from a review of learner and teacher interactions in mathematics sessions in traditional mathematics class and in bolt-on sessions that integrated online practice exercises using Mathletics with Grade 2 learners in an International School in Saudi Arabia. This group of learners and their teacher were observed during 18 separate mathematics sessions ranging for circa 40-45 mins over an 8-week period in 2015-2016. This section opens with a short description of the teacher and cohort of learners, and then moves forward to summarise the findings on the general pedagogic approaches and nature of learner engagement, with the conclusion sections comparing and contrasting findings in the practice of mathematics learning in traditional mathematics sessions with those that integrated Mathletics to facilitate the online mathematics practice at Grade 2 level.

4.3.2.2 General Information: Teacher and Learners.

This teacher of Grade 2 [T2], had ten years of experience teaching at kindergarten and primary level (Kindergarten to Grade 5) and this was her fifth-year teaching in this International school. The teacher was female and her primary subject degree was in the language arts, with a focus on 'English Literature'. The teacher indicated that she had never undertaken professional development in ICT but had learned about technology through personal use and considered herself to have an advanced level of knowledge on the integration of technology in education. As in Grade 1, this teacher was their class teacher, thus she taught this cohort the majority of the curriculum (including mathematics). The mathematics sessions were taught through the medium of English.

There were 16 Grade 2 learners (aged 7-8 years) in this class grouping. These learners were all female and came from a range of Middle Eastern countries including Saudi Arabia, with Arabic their main language and English their secondary language. The learners engaged in five 40-45minute sessions of mathematics classes per week (including the observed session), and covered mathematical topics including addition and subtraction during the initial part of the year.

4.3.2.3 General Pedagogical Approaches & Learner Engagement

This section presents the general pedagogical approaches in the second grade, under the following headings: Pedagogy used to teach the mathematics concept in the traditional setting, Pedagogy to practice mathematics in the traditional setting (paper-based mathematics practice activities); and the Pedagogy used to practice mathematics in the online gamified learning setting (using the Mathletics practice activities). Furthermore, it includes discussion on the nature of learner interaction and engagement across the observed sessions.

4.3.2.3.1 Pedagogy used to teach mathematics in the Traditional Setting

Similar to the Grade 1 teacher, the Grade 2 teacher opened the mathematics session by revising the previous topic over the first few minutes. The Grade 2 teacher primarily used three approaches to check for the homework. The teacher sometimes corrected individual homework and gave each student personal feedback. The teacher also engaged groups of learners and/ or the whole class in collaboratively answering the homework questions. For example, she typed the homework questions on the smart-board and asked some of the learners from particular groups or from class grouping to come up the board to complete the questions. The teacher also encouraged peer assessment of homework. She sometimes asked the learners to exchange the workbooks and then typed the answers on the smart-board and asked the learners to correct each other's work.

Following revision of previous topic, the teacher presented a new mathematics topic at the outset of each session. In terms of presenting the new mathematics topic, the teacher used different strategies. She sometimes started the mathematics class by playing a game connected to the new topic. This Grade 2 teacher generally was observed taking a central role in the process of explaining the new learning objective i.e. the new mathematics concept. The data from the observation revealed that the teacher used some technological tools and resources to introduce the new topic such as the smart- board and specific online resources such as the book publisher website (as was the case with the Grade 1 teacher). In her interview, she confirmed that she primarily uses technology such as smart-board and video clips in her class room, '*Usually I use smart-board and videos. That's it'. [T2]* The teacher also expressed the belief that technology can support different learners' capabilities, '*I use* *technology in my class actually because not all of the students can work well with paper. Some of them prefer to work, or are really good at working with oral things, or some of them really work good if it's a project. Some of them really work well when they are watching something. Some of them get more out of watching, or hearing, when they do something. That's why, whenever we have time for example like let them do small projects like, drew about what we are talking about in math, or draw what we were talking about in science or, just to give them the sense that it's not really a question and answer'.* The teacher was observed actively involving learners in class work. She used question and answer technique to motivate learners and encourage their thinking on the new topic. She gave them opportunities to use the smart-board, thus enabling them to show how they solved the mathematics problem. She also used probing questions to enable learners to consider alternative ways to solve mathematics problems. The teacher encouraged collaborative learning, by providing the learners with opportunities to work together in the small groups (that she created).

The class observation revealed that when the teacher was explaining the new mathematics topic, that learners generally listened to the explanation. When learners were asked to volunteer the answer, some of them screamed the answers. The teacher in session 6 for example, started the lesson of 'Using Symbol to Compare Numbers' by asking the students for two-digit numbers. The learners screamed the answers and then she chose two of the students to write the numbers on the smartboard. Learners were seen to be engaged in the teamwork. The teacher in session 11 for example projected the Guided Activity on the smartboard and asked the learners to work in their groups to answer the first question. She was moving around to check in their work and assisted learners having difficulties. Other learners on the other hand displayed a lack of interest in the task. These learners typically sat quietly, although some were observed to mess with each other and/ or converse loudly among themselves.

4.3.2.3.2 Pedagogy of Mathematics Practice in Traditional Setting (paper-based mathematics practice activities).

The teacher was observed playing the role of a facilitator in the mathematics practice section of the session. The teacher was observed using online resources such as the book publisher website to display the mathematics practice activities and directed the learners to complete questions in the activity book. She gave the learners space to work by themselves and also get involved in active group participation during the mathematics practice activities. The teacher for example asked the learners to work on the activities and moved around to check teamwork or individual progress. Furthermore, the teacher was observed scaffolding learning. For example, when a learner requested help from her, the teacher sometimes re-explained the mathematics for the learner individually or sometimes directed the learner to the 'Math Centre' that the teacher created in her classroom to support the learner and gives a chance for self-directed learning. The Mathematics Centre was a space within the classroom that had mathematics toys and other resources, where learners can access additional resources (for example a Glossary of mathematics words) to help figure out mathematics problems or just play by themselves. Moreover, the teacher encouraged cooperative learning by directing the learners to help each other when they have difficulties in solving mathematics problems. She also encouraged group work, by asking the learners to complete some mathematics practice activities in the pre-formed groups. During the teacher-directed activities using smartboard, some of the learners were observed to focus on the board and wanted to have chance to come over the board and provide the answer. Others were doing the activities in the activity book. In session 6 for example, the teacher presented problem solving (real word problem) activity on the smartboard. She asked one of the learners to read the question out loud and another learner to come over the board and highlighted the keywords and get the answer. Some students were focused on the board others were doing the activity in their books.

The teacher sometimes ended the mathematics practice part of the class by playing games; either online games or physical games using toys. In the interview the teacher stated that: '*In my class 'I let them use math games. For example, we finish our lesson and they finish what they were supposed to do[mathematics practice exercises in activity book/workbook], or what their supposed to cover in that lesson. Then I'll let them do, for example, activities whether online or even inside the classroom like in-seats'. [T2].* The teacher utilised games because she believed that the leaners should be provided with as many different resources to support their learning, '*I use online games because I found it really helpful for students to learn from different places, and use different methods in their learning. That's why. They will be really good in answering questions' [T2].* The teacher also considered online games as tool to help learners who are not good expressing their understanding in textual forms. In the interview, she explains that '*I think yeah, they help a lot. Because some of the students are not really good in paper work. For example, in the test, they will not get a full mark, but when I ask them for example, to do a project or when they play online, they find the answer easily. So, you can tell that not all the students, maybe their attention span is not really good with paper as it is good with something that they can touch or something that they can see' [T2].* The teacher further explained that she does prefers to integrate online games in her class, but the lack of mathematics class time is one of the reasons that she doesn't frequently use games:, '*it's not very frequent to use online mathematics games. Maybe, whenever we have time'. [T2].* However, the teacher did further clarify that she encourages the learners to play online games at home, '*I ask them to use online games at home. Even in my classroom website, I post for them some favourite websites that they can use for Language Arts and for Math or for Science'. [T2].* During the mathematics practice activities in the traditional setting, the teacher did not provide direct feedback for the learners individually. Instead, the teacher asked the learners to complete the mathematics practice activities and then drop the activity book/workbook on her desk, which she checked after class.

In terms of learners' interaction in the traditional setting, the learners were observed to complete the mathematics practice activities and submitted their work to the teacher on completion. The learners primarily seemed to prefer working in their groups to complete the task and were observed engaging in discussion about how to solve the mathematics problems. In session 8 for example the teacher asked the learners to work on 'Even and Odd Numbers' practicing activities on one of the learner's activity book. The learners worked together and discussed ideas on how they can get the answers. In other cases, Grade 2 learners displayed frustration with some of the more mathematics challenging questions and asked the teacher for more explanation. For example, one of the learners has difficulty to differentiate between 'greater than' and 'less than' signs and became anxious. She went to the teacher and asked her for more explanation. Furthermore, some learners did exhibit a lack of interest in the activity and could be seen engaging in informal chats and/ or messing with other. The teacher generally reprimanded learners for chatting informally or distracting others.

4.3.2.3.3 Pedagogy of Mathematics Practice in Online Gamified Learning Setting (Mathletics Practice Activities).

As was the case with Grade 1 class, the Grade 2 teacher would present certificate/s from Mathletics at the outset of this part of the session, to those learners who had achieved the required number of points or certificates. The teacher then was observed acting primarily as a facilitator (thus supporting a high degree of self-directed learning among learners) when Mathletics was used to practice mathematics. She sometimes moved around and checked on the learners' work within Mathletics, but primarily monitored their interaction at a distance. The Grade 2 teacher explains that: *'I am is very happy to see my students did their best to get the answers without any help and have multiple time by themselves. When the students bring their own iPad and play Mathletics, they never go to the math centre as they usually do. They were waiting for the time that I let them to use the iPad and access to the Mathletics App. I liked the learners' discussion in their own groups about the activities'.* Furthermore, the teacher recommended integration of Mathletics regularly - '*I suggest integrating this technology two to three days per-week'.*

The class observation revealed that the learners' engagement never reduced during the period of the observation of Mathletics intervention. The learners expressed excitement waiting for the time to do the new mathematics practice activity on the Mathletics platform. They completed the mathematics practice activities in the mathematics activity/textbook as fast as they could and sat on their seats waiting for the teacher permission to have the iPad and have access to Mathletics App.

The learners expressed pride in their achievements within Mathletics. Some of the learners completed the activity without any help from teacher or their peers, and proudly showed each other the final feedback with all correct answers. The learners in the interview confirmed that the Mathletics activities could generally be completed without any help. Learner G2C2 for example stated that '*there is no need for any-one to help me when I am playing Mathletics even when I start a new game'*, learner G2C5 as another example said that '*I never ask for help when I am playing Mathletics'*. This was also confirmed by the teacher in the interview '*No, not really, they never ask for help when they are playing the online games because, nowadays, kids can help [themselves]. They are native in using technology'. [T2]* The learners were observed to exhibit a strong desire to successfully complete the activity. The learners showed each other and the teacher the overall progress and the ‘Gold Bar’ (which was an indicator of having successfully completed a section of the mathematics practice activities).

The learners appeared to be very happy and hyperactive when connecting with online challengers from around the world in the ‘Live Mathematics’ section of Mathletics and expressed excitement when finding other competitors to ‘race against’ in the completion of the mathematics activities. The learners appeared to particularly enjoy searching for these players (competitors) from around the world within ‘Live Mathematics’ and learning about the player’s country. They were self-motivated to create their own groups comprising of players from their own class AND players from around the world and raced against each other to complete mathematics practice activities within this group.

The learners were very excited when they saw the name of their classmate in the Live Mathematics section of Mathletics and would often challenge them in a race to successfully complete mathematics practice activities. Some of the learners in the interview confirmed that they liked to play online with their classmates, learner G2C4 for example said that ‘*I play with online friends, so I love to play ‘Live Mathematics’.* However, some of the learners expressed disappointment when they were not able to connect with their friends online. For example, learner G2C6 stats that ‘*I like to play online game at home but I'm asking my friend, "Can I play with you?" And then she is saying, "Yes”. We are opening Mathletics platform." And she is not putting us together. I try and try and try and nothing happens*.’

The data collated through the Mathletics Report (Figure 1) showed that that most of the learners had played ‘Live Mathletics’. However, there were some learners who never tried it, for example (G2C2, G2C5, G2C6 and G2C16). Furthermore, some learners tried the Bonus level (the bonus level is a level where there is the potential to score the highest points – most challenging mathematics questions) which is level 2, and these learners scored very well (e.g. learner G2C1 had 84 correct answers (168 points), as shown in Figure 4.13).

		1			2		
Student Nan	s Yea	Total Correct	Top Score	Accuracy %	Total Correct	Top Score	Accuracy %
C1	2	4,192	35	98	84	10	79
C2	2	-	-	-	-	-	-
C3	2	933	41	98	2	2	100
C4	2	678	39	99	-	-	-
C5	2	-	-	-	-	-	-
C6	2	-	-	-	-	-	-
C7	2	480	36	94	3	3	50
C8	2	49	18	92	3	3	50
C9	2	650	27	95	4	4	57
C10	2	611	35	96	4	2	40
C11	2	945	27	95	24	8	69
C12	2	621	25	92	7	5	47
C13	2	286	25	90	13	7	76
C14	2	1,845	33	95	5	3	56
C15	2	1,098	31	99	-	-	-
C16	2	-	-	-	-	-	-

Figure 4.13: Mathletics Report showing learners' engagement with 'Live Mathematics'

*Explanation of the categories in Figure 1: The number 1 on the top row refers to level 1 (degree of challenge of mathematics problem). The term 'Total Correct' refers to the total number of correct answers achieved by the learner. in 60 seconds. The term 'Accuracy' refers to the percentage of correct answers out of the total of questions completed. The term 'Top Score' is the highest score earned at that level. It should be noted that learners can earn one point for one correct answer and two points for one correct answer from the Bronze Level.

Furthermore, from the observation the learners appeared to really enjoy the competition environment facilitated by 'Live Mathematics', as well as in-class interaction facilitated during the completion of mathematics practice activities within main part of the Mathletics platform. The learners really appeared to enjoy face to face conversation in the physical classroom, while completing the mathematics practice activities. In their own groups, the learners were observed helping other learner/s that struggled with the mathematics practice activity, exchanging idea/s of solving the problem or simply helping direct learners to the activity's location within Mathletics. This was further supported by interviewed learners, some of whom mentioned their preference to work on the activity at school because they could work with peers, learner G2C1 '*I like to play at school because I play with my friends*', learner G2C2 '*I prefer to play Mathletics at school because of my friends*'. The learners displayed the capacity to retain their focus on the activity. They retained their attention and focus on the iPads screen when completing the activities.

The class observation revealed that the learners self-organized their own groups for Mathletics in the classroom and enjoyed classmate competition and expressed enjoyment when they were doing the activities. However, some learners did work alone by themselves on the activity throughout the entire Mathletics intervention, whereas some of the others started in groups but migrated to work by themselves during the session.

The class observation also revealed that the learners were able to discern different degrees of challenge of questions (with declarations of some questions being easier or harder to complete, and thus more challenging) and commented on their overall performance in relation to their perceived degree of challenge of the practice questions. Some of the learners in the interview confirmed that they preferred to do challenging questions for example, Learner G2C5 said that *'I like to play Group of Ten, but I don't like 'Which is Bigger', 'Which is Smaller' because they are easy'*. The 'Group of ten' activity was one of the activities that this learner tried before it was explained in-class by the teacher, therefore, she liked the challenge of attempting to solve mathematics problems before they were fully explained by the teacher.

The Grade 2 learners were observed showing off their math abilities. They were observed to enjoy reviewing their own work and seeing the final answers and were interested in repeating the activity for several times to improve the final score. This is in the line with the data from MR. Figure 4.14 shows that the Grade 2 learners improved their average by around 8% (Activity Average Improvement is only calculated where there has been more than one attempt at the activity). Also, Figure 4.15a shows that learner G2C2, learner G2C3 and leaner G2C7 for example engaged in multiple attempts on some of the mathematics practice activities within school time to improve their overall final scores. For example, Learner G2C3 had 11 attempts to the activity 'Which is Smaller?', she got 40 % at the first attempt and she got 90% at the last score, so, she improved by 50% through multiple attempts.

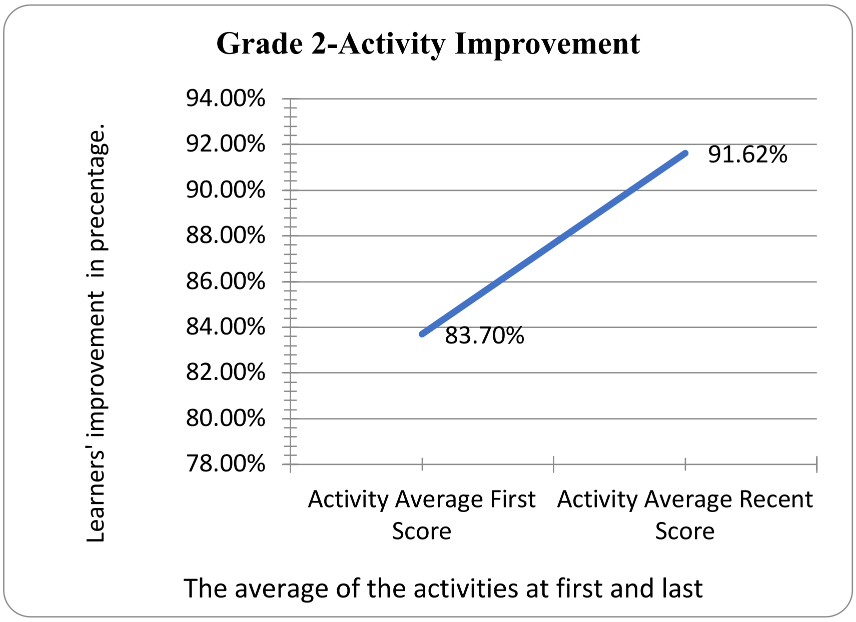


Figure 4.14: A line chart from Mathletics Report showing Percentage of Activity Improvement for Grade 2

Student Name	Class Year-Grade	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C2	2	Magic Mental Addition	2	60	90	30%	90	23/11/2015 -11:13:34
C3	2	Which is Smaller?	11	40	90	50%	100	04/11/2015 -12:08:00
C7	2	Which is Bigger?	4	90	100	10%	100	04/11/2015 -11:59:02

Figure 4.15a: A sample from some learners' (e.g. learner G2C2, learner G2C3 and learner G2C7) engagement with activities showing multiple attempts at mathematics activities to improve their final score.

Furthermore, some of the learners visited the Mathletics mathematics practice activities at home to improve the final scores. Figure 4.15b shows that learner G2C2, G2C3 and G2C5 visited the activities many times at home to improve the final scores, with G2C2 re-doing the question set 4 times, and G2C3 and G2C5 re-doing the question set twice

Student Name	Class Year-Grade	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C2	2	Add Three 1-Digit Numbers	4	90	100	10%	100	27/10/2015 - 20:10:47
C3	2	Bar Graphs 1	2	60	100	40%	100	30/10/2015 -15:51:52
C5	2	Which is Smaller?	2	60	100	40%	100	14/11/2015 -16:06:28

Figure 4.15b: A sample from some leaners (e.g. learner G2C2, learner G2C3, learner G2C5) engagement with activities showing multiple attempts at mathematics activities at home to improve their final score.

The learners were observed engaging in peer assisted learning, with many of those having difficulties in solving the problem in Mathletics preferring to ask peers in their own groups for assistance as opposed to the teacher.

The data from the observation revealed that the learners enjoyed visiting the activities at home, with many learners talking about the activities completed the previous night and showing their peers the main interface that displayed the "Gold Bar" showing completed activities as well as the points they collected at home. The learners in the interview confirmed that they played Mathletics at home for about 10 – 30 minutes. Learner G2C1 said that '*I enjoy Mathletics. I play at home about 20 mins*', learner G2C3 '*I play Mathletics at home about 30 minutes or 20 minutes*', learner G2C6 '*I only play this one "Mathletics' at home. I love it the best for me*'. The data from Mathletics Report (Table 4.2) showed that that the learners in this group completed 293 activities, out of which 110 activities were completed in class and a further 183 of the activities were completed out of school hours (the school hours: Sunday – Thursday from 7: 30 to 2:30). Also, Figure 4.16 shows that 62% of the activities had been completed out of school time by Grade 2 learners.

Table 4.2: Completed activities in and out of school time by Grade 2 learners.

Grade 2- In School vs Out of School Activity	
In School Hours (Sun-Thu)- 7:30- 2:30	110
Out of School Hours	183
Total of completed activities	293

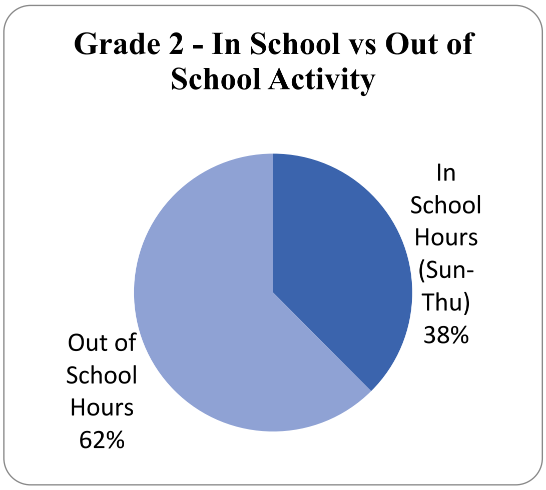


Figure 4.16: A pie chart from Mathletics Report about Grade 2 completed activities in and out school hour.

At home, some of the learners re-visited the activity that they took with the teacher and some attempted activities that were not taken with the teacher yet. Figure 4.17a & 4.17b from the Mathletics Report showed that learner G2C3 and learner G2C2 for example re-visited some of the activities completed in-class at home.

Student Name	Class Year-Grade	Activity	Result	Attempt	Date Completed	Time of Completion
C3	2	Odd or Even	100	3	Nov-10-2015	5:10:00 pm
C3	2	Odd or Even	100	4	Nov-25-2015	5:36:04 pm
C3	2	Odd or Even	100	5	Nov-30-2015	6:11:48 pm

Figure 4.17a: Sample of learner's G2C3 engagement with some activities that they took with the teacher.

Student Name	Clas:	Activity	Result	Attempt	Date Completed	Time of Completion
C2	2	Add Three 1-Digit Numbers	90	1	Oct-27-2015	7:57:31 pm
C2	2	Add Three 1-Digit Numbers	90	2	Oct-27-2015	8:00:57 pm
C2	2	Add Three 1-Digit Numbers	80	3	Oct-27-2015	8:03:54 pm
C2	2	Add Three 1-Digit Numbers	100	4	Oct-27-2015	8:10:47 pm

Figure 4.17b: Sample of learner's G2C2 engagement with some activities that they took with the teacher.

Furthermore, Figure 4.18a and 4.18b are samples showing some of the learners made attempts at some activities at home not taken in-class, so the method had not yet been explained by the teacher.

Student Name	Class Year-Grade	Activity	Result	Attempt	Date Assigned	Date Completed	Time of Completion
C3	2	Bar Graphs 1	60	1		Oct-30-2015	3:45:46 pm
C3	2	Bar Graphs 1	100	2		Oct-30-2015	3:51:52 pm

Figure 4.18a: Mathletics Report showing scores learner G2C3 for sample activities undertaken at home, and not already covered with the teacher.

Student Name	Class Year-Grade	Activity	Result	Attempt	Date Completed	Time of Completion
C2	2	Groups of Two	90	1	Nov-04-2015	7:47:32 pm
C2	2	Groups of Two	90	2	Nov-04-2015	7:50:20 pm
C2	2	Groups of Two	100	3	Nov-04-2015	7:52:53 pm
C2	2	Groups of Three	100	1	Nov-04-2015	7:57:23 pm

Figure 4.18b: Mathletics Report showing scores learner G2C2 for sample activities undertaken at home, amd not already covered with the teacher.

The learners appeared to enjoy playing, scoring, and receiving points within Mathletics. They shared information about their achieved points and challenged each other to gain the most points. They also exchanged iPads to compare and discuss their performance, i.e. the number of points gained and the degree of challenge of question set etc.

The learners in the interview expressed excitement about the points and the certificate/s that they collected so far. However, they also expressed sadness over their inability to collect

1000 points/ week. Learner G2C1 for example stated: *'I collected 230 points and I have one certificate. So, if I couldn't collect 1000 points, I will be sad*', Learner G2C2 *'I have two certificates and this week I collected 290. So, if I cannot collect 1000 points this week I will be sad', and* Learner G2C3 '*I have one certificate but right now I have zero points because we started a new week. I can collect the points without any help. So, I feel sad if I could not collect 1000 points this week'*. But this also encouraged them to work harder - for example learner G2C4 said that: '*I collected 100 points today and I have two certificates. If I could not collect 1000 points, I will try next time and I'll get it'*. Also, learner G2C5 stats that *'I like to collect points I have 644 points. So, I should try my best to get 1000 points. I always play and play and play until I get it'*.

The Mathletics Report (Figure 4.19) also showed that around 25,000 points had been earned by the learners from successfully completed activities. Also, the MR showed that about 12,700 points had been collected from playing Live Mathematics.

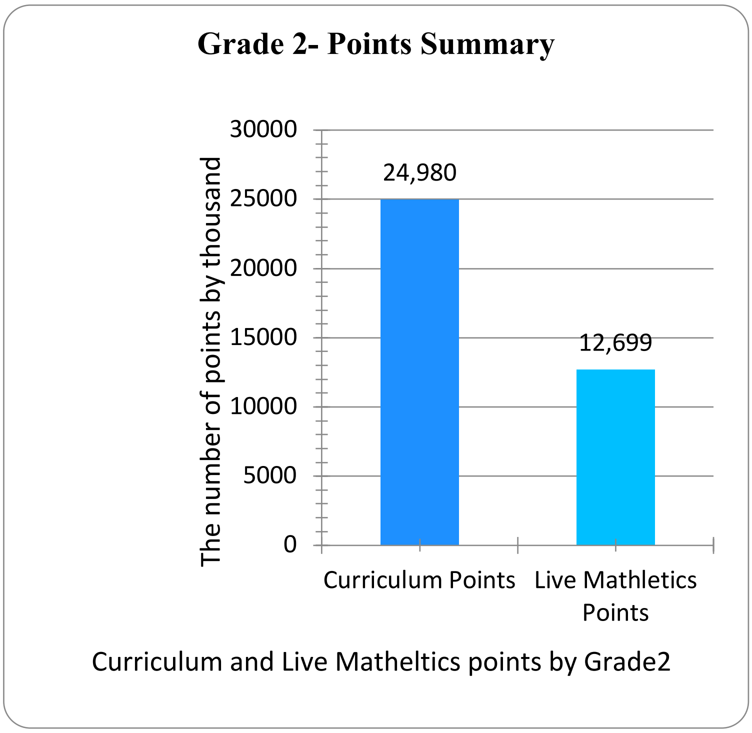


Figure 4.19: A bar chart from Mathletics Report showing the points from Curriculum and Live Math earned by the learners in Grade 2.

Figure 4.20 shows that each learner collected 200 points or more from the curriculum activities during the intervention (the duration of the research was six weeks, the learners had been asked to do three activities in each week, so the learners had a chance to earn a minimum of 30 points per week). Learner G2C4 for example had around 7000 points earned from the mathematics practice activities. Also, Figure 4.21 shows that most of the learners collected additional points from Live Mathematics. For example, learner G2C1 had earned more than 4000 points from Live Mathematics.

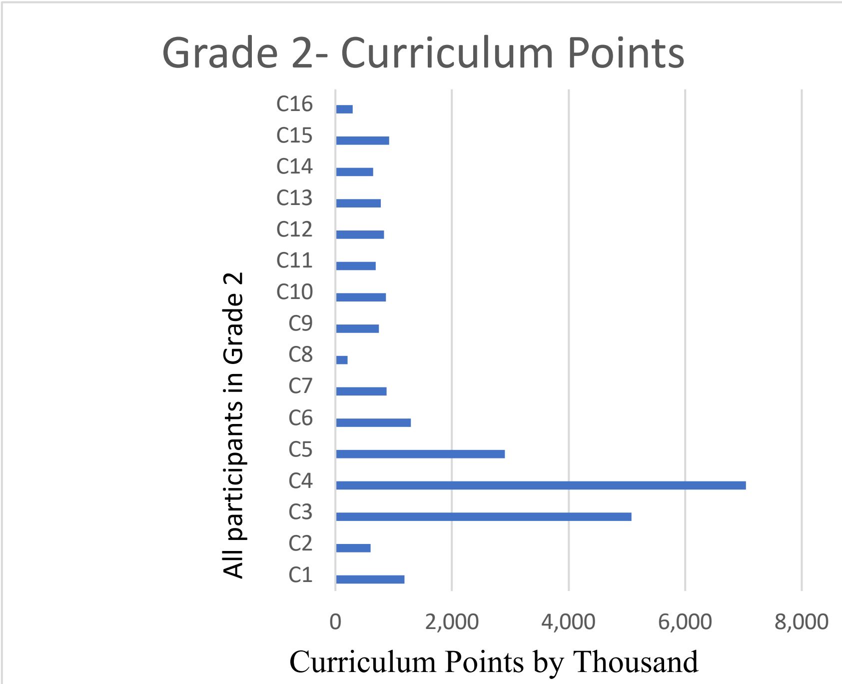


Figure 4.20: A bar chart from Mathletics Report showing the earned points from curriculum by each learner.

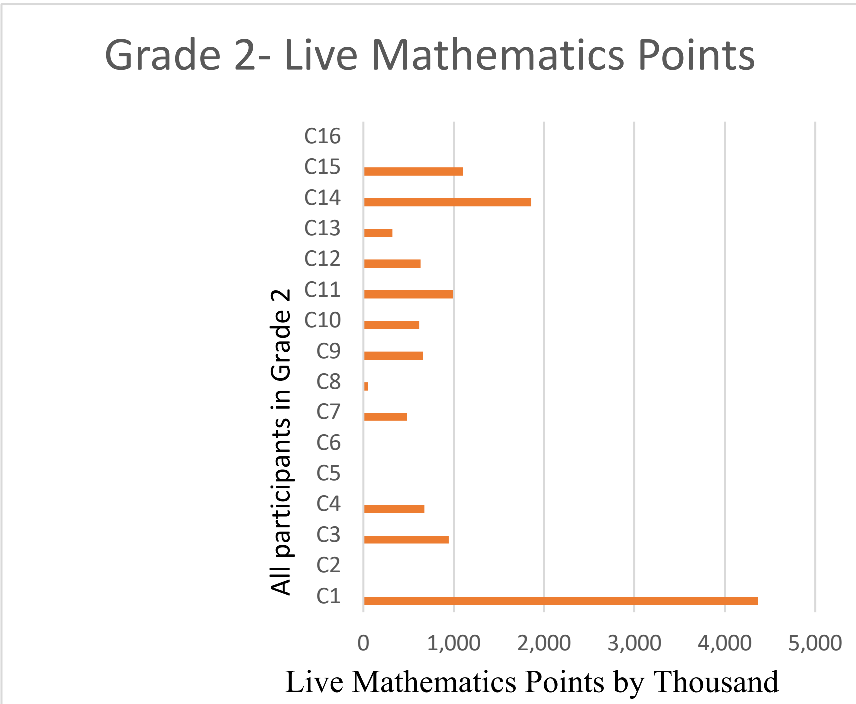


Figure 4.21: A bar chart from Mathletics Report showing the points from Live Mathematics earned by each learner.

Furthermore, the certificate was another factor that motivated learners and increased their engagement. Learners were highly excited when awarded Certificates; when one learner received a certificate, the others asked how it was obtained. The certificate holder was very happy when publicly presented with Certificate by the teacher. However, this also led to queries from the other learners, who frequently would interrupt to ask the teacher about receiving their own certificates. The data from the MR (Figure 4.22) also shows that that a total of nine Bronze certificates were earned by the Grade 2 learners. Figure 4.23 shows that five learners in this grade earned these 9 certificates, and one of them (learner G2C4) got three certificates.

Figure 4.22: A bar chart from Mathletics Report about the earned certificates by the learners in Grade 2.

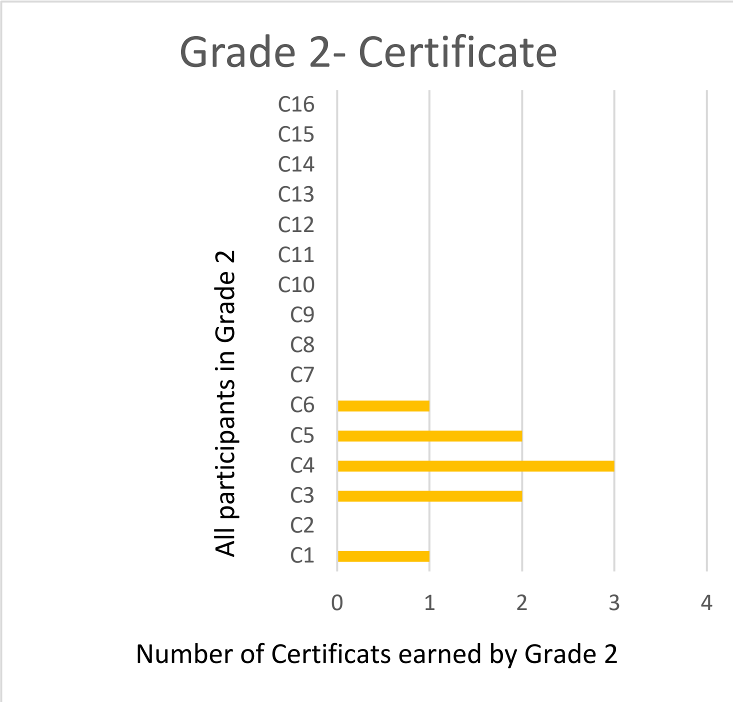


Figure 4.23: A bar chart from Mathletics Report about the earned certificates by each learner.

The accumulation of 1000 points also allowed learners to earn credit that allowed them to choose visual representations for themselves within Mathletics (avatar character development) and this also appeared to contribute to Grade 2 learner motivation. Learners tried to obtain more points to buy items within an online store to personalise their avatar. The Grade 2 learners discussed these items and their prices, and deliberated on what they would buy to create avatars.

4.3.3 Grade 3: Key Findings

4.3.3.1 Introduction

This section summarises the findings from a review of learner and teacher interactions in mathematics sessions in traditional mathematics class and in bolt-on sessions that integrated online practice exercises using Mathletics with Grade 3 learners in an International School in Saudi Arabia. The Grade 3 learners and their teacher were observed during 18 separate mathematics sessions ranging for circa 40-45 mins over an 8-week period in 2015-2016. This section opens with a short description of the teacher and cohort of learners, and then moves forward to summarise the findings on the general pedagogic approaches and nature of learner engagement, with the conclusion sections comparing and contrasting findings in the practice of mathematics learning in traditional mathematics sessions with those that integrated Mathletics to facilitate the online mathematics practice at Grade 3 level.

4.3.3.2 General Information: Teacher and Learners.

This teacher of Grade 3 [T3], had four years of experience teaching at primary level (Grades 1,2 and 3) and this was her second semester of teaching in this International school. The teacher was female and her primary subject degree was in ‘English Language and Literature’. The teacher indicated that she had never undertaken professional development in ICT but had learned about technology through personal use and considered herself to have an advanced level of knowledge on the integration of technology in education. This teacher was their class teacher, therefore, she taught this cohort the majority of the curriculum (including mathematics). The mathematics sessions were taught through the medium of English.

There were 19 Grade 3 learners (aged 8-9 years) in this class grouping. These learners were all female and came from a range of Middle Eastern countries including Saudi Arabia, with Arabic their main language and English their secondary language. The learners engaged in five 40-45minute sessions of mathematics classes per week (including the observed session), and covered mathematical topics including multiplication during the initial part of the year.

4.3.3.3 General Pedagogical Approaches & Learner Engagement

This section presents the general pedagogical approaches with the third grade learners, under the following headings: Pedagogy used to teach the mathematics concept in traditional context, Pedagogy to practice mathematics in the traditional setting (paper-based mathematics practice activities); and the Pedagogy used to practice mathematics in the online gamified learning setting (using the Mathletics practice activities). Furthermore, it includes discussion on the nature of learner interaction and engagement across the observed sessions.

4.3.3.1 Pedagogy used to teach mathematics in the Traditional Setting

The teacher was observed using three techniques to revise the previous topics. The teacher provided individual feedback for homework, by rotating around the classroom to correct individual homework. The teacher also uses peer assessment technique to check on the learners' homework. For example, she asked the learners to exchange their workbooks and check on the partner's homework. Furthermore, the teacher engaged whole class and groups to check for homework. For example, the teacher wrote the questions of the homework on the smart board and asked the learners to respond in question and answer approach.

In terms of the introduction of the new topic, the class observation revealed that the teacher sometimes explained the goal or the projected learning outcomes of the session to the learners at the beginning of the math class. For example, the teacher wrote what the learners would learn in the session and the key-words that they should know by the end of the session, on the smart-board. She would explain the new mathematics concept and showed how to solve the problems. She used different resources to display the new concept such as the normal white-board, or interactive smart-board projecting online resources such as those provided by the mathematic book publisher's website. The teacher in the interview confirmed that: '*I frequently use technology in math class such as Smart Board, You Tube, Word Process, PowerPoint presentation but the most things that I regularly use is the Smart Board and Videos'.* In her interview, the teacher recognised the potential of technology in facilitating deeper engagement of learners in the learning process.

The teacher used an Active Learning approach to engage learners in doing mathematics. One example of this approach was question and answer technique. The teacher used this technique to stimulate learner thinking and encourage learners to actively participate in the new topic. The teacher for example wrote a question on the smart board and asked the whole class about the answer. She gave them time to think about the answer and then she typed the answer that the learners provided. The teacher sometimes asked a question and invited the learners to answer the question on the smart-board and/ or on the white board. The teacher engaged in inclusive form of learning by actively seeking learners' inputs on alternative ways to solve mathematics problems and providing learners with an opportunity to talk about the different strategies to solve the problem. Furthermore, the teacher was observed facilitating opportunities for group and collaborative learning. She frequently gave worksheets to the groups, facilitating learners with opportunities to discuss mathematics ideas with one another, encouraging them to utilise multiple representations (such as writing and drawing) to find the final answers.

Some of the learners observed were actively participating in the new mathematics topics. The learners worked in the groups that the teacher created, and volunteers answered the questions. For example, in session 11, the teacher gave each group a worksheet where the learners had to work out the factors and the products (multiplication practice exercise). Then she asked the groups to exchange the worksheets to check on each other's work. The teacher generally asked one learner from each group to present the answer on the smartboard. The teacher then asked the wider cohort of learners to voice their opinion on whether answers/ process was correct, or not. Most learners screamed out the answers and pointed to incorrect answers. As was the case in Grade 1 and Grade 2 settings, some of the Grade 3 learners expressed lack of interest in the new task by sitting quietly, not paying attention or messing with other.

4.3.3.2 Pedagogy of Mathematics Practice in Traditional Setting (paper-based mathematics practice activities).

While learners practiced the activities, the teacher was observed re-organising the learners to work in groups or individually and encouraging them to use their book to practice what they have learnt in the classroom. The teacher also engaged on occasion in guided facilitation. She moved around to check on the learners' progress. She engaged in scaffolding learning by responding to questions posed by the leaners and/ or re-explained the concept to the whole class or to an individual learner in Grade 3 who needed assistance.

The teacher was observed encouraging cooperation. For example, when one of the learners requested help, the teacher directed the learner to her partner or asked a learner from another group to assist the learner. She also encouraged group work in practicing the mathematics activities. The teacher sometimes asked the learners to work in pairs or in groups to solve mathematics problems. She also encouraged peer assessment by sometimes asking the learners to exchange the workbooks and peer check each answer.

The teacher did not provide direct feedback on individual learners' performance in activity or workbook activities within class time. She usually asked the learners to drop the books on her desk, so that she could check their answers after class. Sometimes, the teacher asked the groups to do the activity on one of the group-members' activity book and moved around and checked on the answers and then asked the other group members to copy the answer into their books.

The teacher was observed deploying online resources such as the Mathematics Activity Book and/ or Publisher website to display the activity on the smart-board. The teacher sometimes ended the math class by playing a game in the classroom. However, she never used dedicated online mathematics games (such as Minecraft) for practicing in the classroom. The teacher in her interview confirms that '*Haven't used online math games yet. In math no games. Other subjects sometimes we do play games but online math not yet'*. [T3] The teacher explained that the lack of time is the main reason to do not integrate online games in the classroom '*Mostly I don't have time to integrate online games because 45 minutes went so fast, I spend half of the time for explaining the mathematics concept and then we need to practice so the lesson is done. Because there's only one period a day. If we had two periods a day it could be so possible to play a game but in one period and if it's a new lesson and one lesson must be done in one period then it's totally not'*. [T3]

However, the teacher recognized value of playing online mathematics game for homework, *'Not yet to ask the learners to use online games at home. But I'm going to do because it's interactive practices, it can be interactive homework. So as a homework it gives me a good idea of homework to give'*. [T3]

The class observation revealed that the Grade 3 learners completed the mathematics practice activity that the teacher asked them to do individually and/ or in groups. Furthermore, the learners worked in the designated groups and helped each other to solve the problem. In session 9 for example, one learner was observed explaining the problem-solving strategy of 'multiplying by 2' to her group. However, not all Grade 3 learners preferred to work within the group, with some learners observed to disengage with group and work alone to solve the mathematics practice activity. Moreover, some learners expressed a lack of interest in practising the mathematics activity, one of the learners for example copied the answer from a copy of the time table that she had in her desk, and some had informal chat and/ or messed with each other.

Finally, on occasion, the teacher was observed creating games from regular Mathematics practice activities (not designed in game-format). For example: The teacher sometimes would throw a ball out to class, and whoever caught it would answer a question displayed on smartboard. The learners really appeared to enjoy this and were seen to gentle nudge each other away in order to catch the ball and answer the question, with a learner shouting out loud one occasion: '… at least now I have a chance to play a game and answer a question'.

4.3.3.3 Pedagogy of Mathematics Practice in Online Gamified Learning Setting (Mathletics Practice Activities).

As was the case with Grade 1 and Grade 2 class sessions, the Grade 3 teacher would present certificate/s from Mathletics at the outset of this part of the session, to those learners who had achieved the required number of points or certificates. When the learners were doing the mathematics practice activities using the Mathletics platform, the teacher was observed facilitating a high degree of self-directed and independent learning. The teacher moved around to check on individual and group progress but mainly left learners to self- direct their learning. The teacher commented that the learners seemed more focused, and appeared to enjoy the self-directed nature of this, stating that '*I like the group discussion that the learners made by themselves and their effort to work out the answers together. When they were doing the activity by the Mathletics platform, they not only have fun but also it encourages them to be more focused on what they are doing and they seem to answer the questions more quickly'.* [T3]

The class observation revealed that the learners expressed enjoyment from the use of Mathletics. The learners waited with excitement for the time that the teacher let them handle the iPads, so they can access to Mathletics App. They tried to quickly finish the traditional mathematics practice activities that they were doing with the teacher on the smart board/ mathematics activity book or workbook so that they could progress to using the Mathletics activities. The learners stood up and held the iPad (in their hands) and typed the answer using the other hand. Some of the interviewed learners explained some of the reasons that made them to play Mathletics. Grade 3 Learner G3C2 for example, explained that '*I enjoy playing Mathletics because it teaches me more about math and that's good, like fast',* and learner G3C3 said that '*I like in Mathletics solving problems because it helps me to understand because when I grow-up I will be a scientist or a teacher'.*

The data from class observation revealed that the learners exhibited a desire to successfully complete the activity. The learners tried to successfully complete the activity that they supposed to do and moved to check the ‘Gold Bar’ [progress bar] on the main interface.

In addition, the class observation revealed that the learners actively connected with each other and other learners in online challenging section of Mathletics, i.e. “Live Mathematics’. They displayed significant interest in connecting and competing with their peers and with the globe, with learner G3C1 stating that *‘I like to play with online friends’* and, learner G3C3 stating that *‘I like to play with my friends the online games’.* The learners engaged in competitive races to complete mathematics practice exercises appeared extremely happy and their voices were often raised high as they outlined their progress and performance.

From the Table below (Figure 4.24) extracted from the Mathletics Report, we can see that all learners (except G3C1) connected with other in ‘Live Mathematics’, with some of them moving to the second level and other trying the third level, thus indicating a desire to compete in levels of mathematics of increasing difficulty.

			1			2			3		
Student Nam	lass Year-Grad	Group Name	Total Correct	Top Score	Accuracy %	Total Correct	Top Score	Accuracy %	Total Correct	Top Score	Accuracy %
C1	3	3B	-	-	-	8	5	67	-	-	-
C2	3	3B	290	22	89	2	1	25	-	-	-
C3	3	3B	5,271	53	97	292	21	92	129	17	87
C4	3	3B	129	17	93	-	-	-	-	-	-
C5	3	3B	428	22	88	2	1	10	0	0	0
C6	3	3B	47	26	100	5	3	45	-	-	-
C7	3	3B	453	27	94	43	8	81	20	8	63
C8	3	3B	306	35	98	-	-	-	8	6	47
C9	3	3B	357	27	98	23	9	79	29	10	67
C10	3	3B	701	30	93	3	3	50	0	0	0
C11	3	3B	390	25	100	5	3	100	0	0	-
C12	3	3B	629	28	98	6	4	86	-	-	-
C13	3	3B	587	22	98	10	7	91	7	2	64
C14	3	3B	399	29	95	8	4	44	-	-	-
C15	3	3B	731	41	97	5	5	63	1	1	8
C16	3	3B	113	19	93	-	-	-	-	-	-
C17	3	3B	148	28	97	104	25	90	31	14	76
C18	3	3B	619	28	94	4	3	40	4	4	80
C19	3	3B	484	37	98	15	8	65	7	7	58

Figure 4.24: A screenshot from Mathletics Report showing the learners’ attempts in Live Mathematics at three different levels.*

*Explanation of the categories in Figure 4.24: The number 1 on the top row refers to level 1 (degree of challenge of mathematics problem). The term ‘Total Correct’ refers to the total number of correct answers achieved by the learner. in 60 seconds. The term ‘Accuracy’ refers to the percentage of correct answers out of the total of questions completed. The term 'Top Score' is the highest score earned at that level. It should be noted that learners can earn one point for one correct answer.

The learners in this grade were able to create their own groups in the classroom and had a great time racing to challenge each other face to face to complete the online practice mathematics activities. The Grade 3 learners helped each other when someone struggled and had a chat about the activity that they were doing. Most students stood-up so they could more easily move and engage within and across the groups.

The class observation revealed that the learners exhibited a strong desire for collaboration and friendly competition (face to face collaboration and competition) when engaging in the Mathletics platform. They shared ideas about how to solve the mathematics activities. Some interviewed students said that they preferred playing in the classroom because it was enjoyable, interactive, and fun to play with their peers - for example learner G3C5 said that '*Yes, I played Mathletics at school with my friends and I enjoy it. It is better to share ideas with friends and have fun'*. Others like to play face to face with their friends to challenge them - for example, learner G3C2 stated that: '*I like to play Mathletics at school because I can play more often with my friends to challenge them and show them my points'*. Other learners in Grade 3 preferred to work at school because it gave them more time to play. For example, learner G3C3 explained that: '*I like to play at school and at home but at home I play only 20 min because I have a lot of chores to do at night', and* Learner G3C6 explained that '*I like to play Mathletics at school, because at home I have to do my homework. Then my homework takes some time. At school, I spend more time [playing Mathletics]'*.

However, there were some learners that preferred to work alone by themselves within the Mathletics platform. This was confirmed by some of the learners in the interview for example, learner G3C1 said that '*I did not ask anyone to help me to collect points'* also learner G3C2 said that '*I can collect the points by myself without any help'*. Furthermore, the class observation revealed that some learners disengaged with group discussion and preferred to work alone during math practice.

The learners showed the capacity to discern the degree of challenge of questions and indeed reported on their performance in relation to the perceived difficulty or challenge within the mathematics practice activity. For example, learner G3C4 stated that: '*The most game that I* *like in Mathletics is Multiplication because it is more challenging. I tried Addition and Subtraction, but I do not like them, they are so easy.* Also, learner G3C6 said that '*I like to play Multiplication, but I do not like subtraction because it so easy'*. (Multiplication was the new topic at that time). The learners were frequently observed to pass over 'easy questions' to undertake more challenging mathematics practice activities. However, if an easy activity was part of assigned work, they would complete it before moving to search for a more challenging activity.

The Grade 3 learners enjoyed visiting the activities beyond class time. The learners often spoke in class about the activities that they did at home and showed their friends their achievement - "Gold Bar" (the bar will fill and turn to gold only when the activity has been successfully completed). The Mathletics Report (MR) (Figure 4.25) showed that 68% of the activities were completed by Grade 3 learners out of school time. The learners completed 1,076 activities in total, with 730 of these activities completed out of school hours as shown in Table 4.3 (school hours at 7:30 to 2:30, Sunday to Thursday). (The learners in this grade were asked to do 18 activities during the period of study).

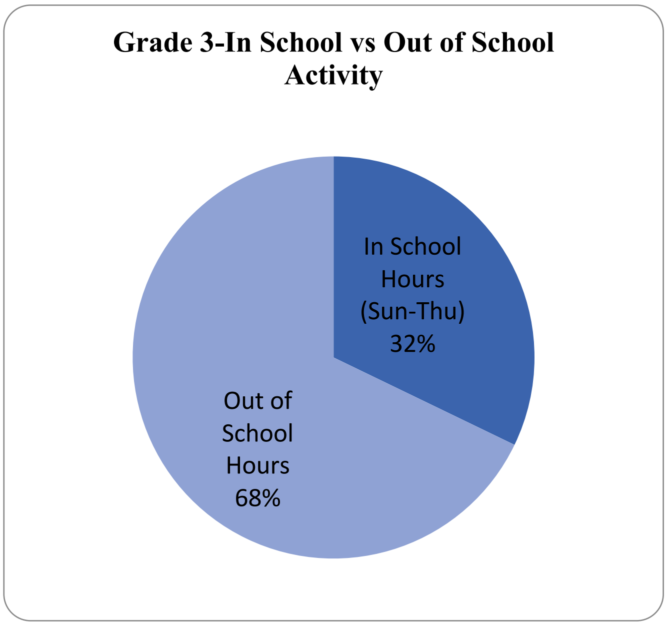


Figure 4.25: A pie chart from Mathletics Report showing completed activities in and out of school hours.

Table 4.3: Completed activities in and out of school time by Grade 3 learners.

Grade3 -In School vs Out of School Activity	
Time-period	Number of completed activities
In School Hours (Sun-Thu), 7:30 am to 2:30 pm.	346
Out of School Hours	730
Total of completed activities	1,076

In interviews Learner G3C1 explained that '*Yes, when I got back to home, I played Mathematics by myself in the car not with online players. That is like one hour (from the school to my city is like one hour),* learner G3C3 '*I play Mathletics at home about 20 min'*, learner C4 '*I play Mathletics at home about one hour'*. Some of the learners in the interview confirmed that they play Mathletics at home because they were allowed increased time. Learner G3C1 for example explains that '*I feel more like playing Mathletics at home because I have more time'*.

Some of learners re-completed the exact same mathematics practice activities that they took with the teacher at home. The Mathletics Report (Figure 4.26a & 4.26b) showed that some of the learners (for example learner G3C2 and G3C6) re-visited the activity that they took with the teacher at home. Furthermore, some of the Grade 3 learners attempted activities at home that they did not take with the teacher (e.g. Figure 4.27).

Student Name	Class Y	Topic Name	Activity	Result	Attempt	Date Completed	Time of Completion
C2	3		Groups of Ten	100	1	Nov-25-2015	3:23:16 pm
C2	3		Groups of Ten	100	2	Nov-26-2015	9:19:32 pm
C2	3		Groups of Ten	100	3	Nov-26-2015	9:23:49 pm
C2	3		Groups of Ten	100	4	Dec-01-2015	6:06:30 pm
C2	3		Groups of Ten	100	5	Dec-02-2015	8:59:13 pm

Figure 4.26a: A screenshot from Mathletics Report of learner G3C2 engagement with one of the in-class activities that she re-took at home.

Student Name	Class Y	Topic Name	Activity	Result	Attempt	Date Assigned	Date Completed	Time of Completion
C6	3		Adding Colossal Columns	100	1		Nov-10-2015	4:53:56 pm
C6	3		Nearest Thousand?	100	3		Nov-24-2015	9:16:14 am
C6	3		Subtracting Colossal Columns	100	2		Nov-11-2015	4:54:36 pm

Figure 4.26b: A screenshot from Mathletics Report of learner G3C6 engagement with one of the in-class activities that she re-took at home.

Student Name	Class Year	Activity	Result	Attempt	Date Completed	Time of Completion
C4	3	How Long Is That (Customary)?	80	1	Dec-11-2015	10:25:30 pm
C4	3	Collect the Objects 1	90	1	Dec-17-2015	9:03:53 pm

Figure 4.27: A screenshot from Mathletics Report of learner G3C4 engagement with one of the in-class activities that she re-took at home.

However, based on the information on Mathletics Report, when they visited the activities at home, some of them had difficulty with activities not taken in-class and did not successfully complete these activities. Figure 4.28 shows that that learner G3C2, learner G3C3 and learner G3C5 attempted some activities that they did not take with the teacher and they scored less than 50% on these. As we can see from Figure 4.28, Learner G3C2 attempted the section on: 'Arranging Fractions' eight times and scored very low (20%).

Student Name	C	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C2	3	Arranging Fractions	8	0	20	20%	60	25/11/2015 -20:40:50
C3	3	Measure to the Nearest Half Inch	1	30	30	-	30	02/12/2015 -15:23:39
C5	3	Divide: 1-Digit Divisor 2	1	50	50	-	50	11/11/2015 -17:59:46

Figure 4.28: A screenshot from Mathletics Report of learners' G3C2, G3C3 and G3C5 engagement with some of the activities that they did not take it with the teacher, showing very low scores.

This finding aligned with what some leaners said in the interview about having difficulties with the mathematics practice activity that they tried before being taught the concept by the teacher. Learner G3C7 for example had difficulty with one of the activities that she did before it was explained by the teacher, and she highlighted that they needed the teacher to explain the activities before commencing them, *'I play Mathletics at home, but I found some activities are hard. So, we still need a teacher to guide us first'*. Therefore, when performing activities with teacher instruction, Grade 3 learners generally were able to solve the mathematics practice exercises. This was confirmed by learner G3C1 *"It's easy to do because the questions that they asked we've learned before. They're easy because you can do many ways to add. You can do with your hands. You can mental math in your mind. There are many ways to do it and you get the answer'.*

It would appear that some Grade 3 learners wished to maintain a 'successful public image' of their performance in mathematics, these learners repeated activities to improve the final scores and ensure their performance score was maximised (which they would then share with their peers in-class). Figure 4.29 extracted from the Mathletics Report showed that the learners in this grade engaged in multiple attempts to improve their average activity score by about 15% (Activity Average Improvement is only calculated where there has been more than one attempt at the activity).

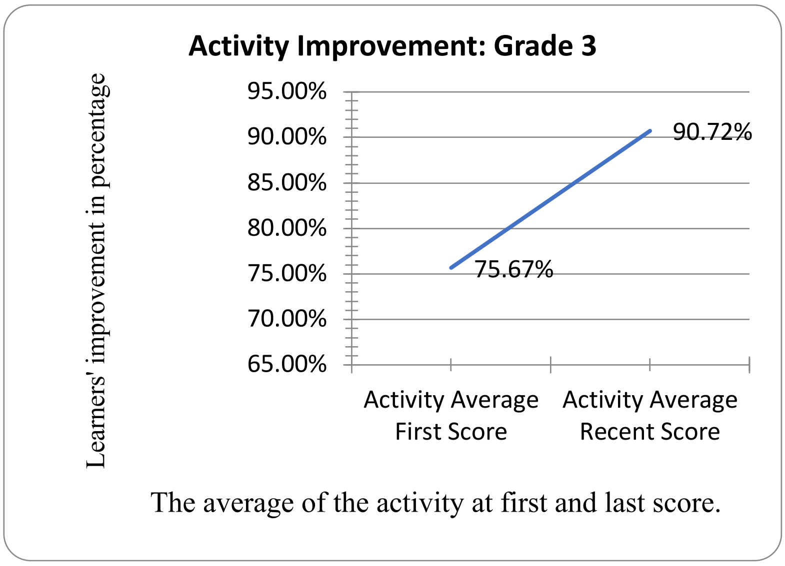


Figure 4.29: A line chart from Mathletics Report about Grade 3 learners' improvement.

Furthermore, Figure 4.30 clearly shows that learner G3C2 and learner G3C5 had multiple attempts at specific mathematics practice activities, with their final scores improving by at least 10%.

Student Name	Class Ye	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C2	3	Multiplication Arrays - SE	5	90	100	10%	100	10/11/2015 -12:22:15
C5	3	Groups of Ten	2	80	100	20%	100	25/11/2015 -12:10:28

Figure 4.30: A screenshot from Mathletics Report of learners' G3C2 and G3C5 engagement with activities in Mathletics.

Also, there is an evidence from the Mathletics Report showing learners attempted some activities at home and their final score were improved. Figure 4.31 for example shows that learner G3C2, learner G3C5 and learner G3C7 for example visited the activities at home and they improved by at least 10%. Learner G3C2 visited the activities 10 times and she improved by 80%.

Student Name	Class Ye	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C2	3	Subtracting Colossal Columns	10	20	100	80%	100	25/11/2015 -18:49:07
C5	3	Collect the Objects 1	2	90	100	10%	100	18/11/2015 -08:11:30
C7	3	Collect the Shapes 1	3	70	100	30%	100	13/11/2015 -18:32:20

Figure 4.31: A screenshot from Mathletics Report of learner G3C2, learner G3C5 and learner G3C7 engagement with Mathletics at home to improve their final score.

The learners demonstrated pride in their achievement. They appeared happy when they completed the activity without help and/ or without any mistakes. When they got the final feedback from Mathletics with all correct answers, the Grade 3 learners moved around and showed the teacher and each other the final feedback. In the interview some learners explained that they were delighted to see their names pop up in the leader-board. In this regard, learner G3C1 said that '*I want to see myself in the leader-board. If I see myself in the leader-board, I feel like that I've tried very hard this week. I feel proud that I got a lot of points. If I didn't see myself on the leader-board, I feel that I need to try to get more points and try to keep playing until I'm there'*, learner G3C2 states that '*I want to see myself in the leader-board, I will be so happy because I like when we play and beat players.*

Learners were engaged with the learning and motivated by some of game elements within Mathletics, including the reward and feedback mechanisms. The learners appeared to enjoy scoring and receiving points, as they orally sharing the number of points earned with each other. They used collected points as indicators of achievement. The learners with the most points appeared to be the happiest in class. The data from the Mathletics Report showed that the learners earned than 80,000 points from the mathematics practice activities and a further 13,500 from playing Live Mathematics.

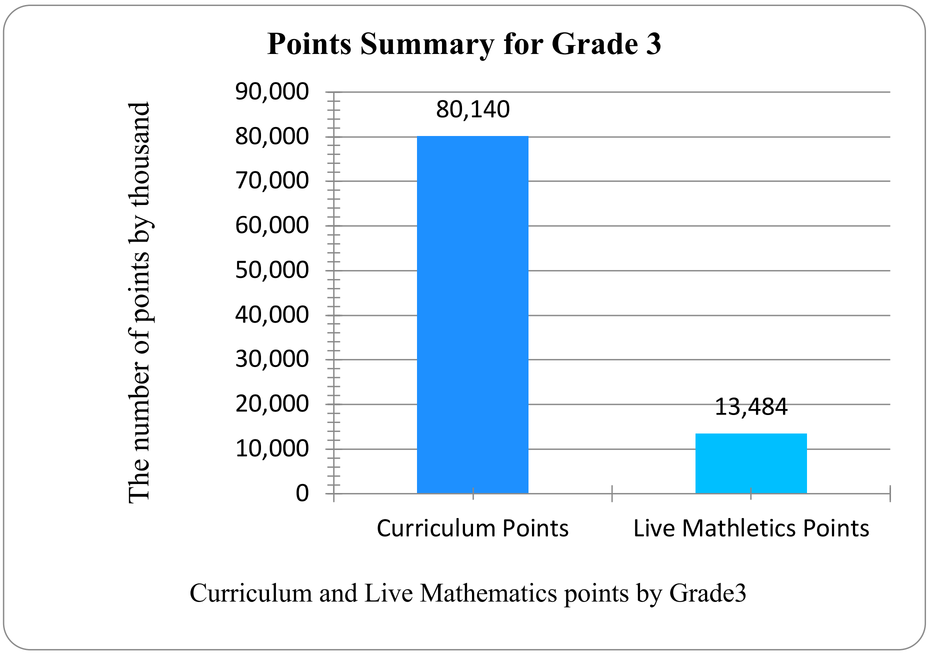


Figure 4.32: A bar chart from Mathletics Report presenting the earned points from Mathematics practice area and Live Mathematics.

Also, Figure 4.33 showed that all learners in this grade collected points form the curriculum activities. Learner G3C3 had more than 39,500 points. Furthermore, Figure 4.34 shows that all learners collected points from Live Mathematics. The same learner (learner G3C3) had about 6,000 points.

Student Name	Activity Points
C1	640
C2	510
C3	39,720
C4	900
C5	580
C6	800
C7	2,000
C8	6,340
C9	2,020
C10	2,220
C11	1,650
C12	1,230
C13	1,420
C14	2,300
C15	6,520
C16	2,170
C17	3,260
C18	1,250
C19	4,610

Figure 4.33: A screenshot of a summary of curriculum points for each learner in this grade.

Student Name	Live Mathletics Poin
C1	16
C2	294
C3	6,029
C4	129
C5	453
C6	57
C7	559
C8	314
C9	432
C10	707
C11	400
C12	641
C13	615
C14	415
C15	742
C16	113
C17	416
C18	631
C19	521

Figure 4.34: A screenshot of a summary of Live Mathematics points for each learner in this grade.

The rewards 'Certificate' was another factor that increased both student engagement and motivation. Learners who earned certificates indicated that they were happy with the achievement. Figure 4.35 showed that a total of 24 Bronze certificates and one Silver certificate were earned by the learners in Grade 3.

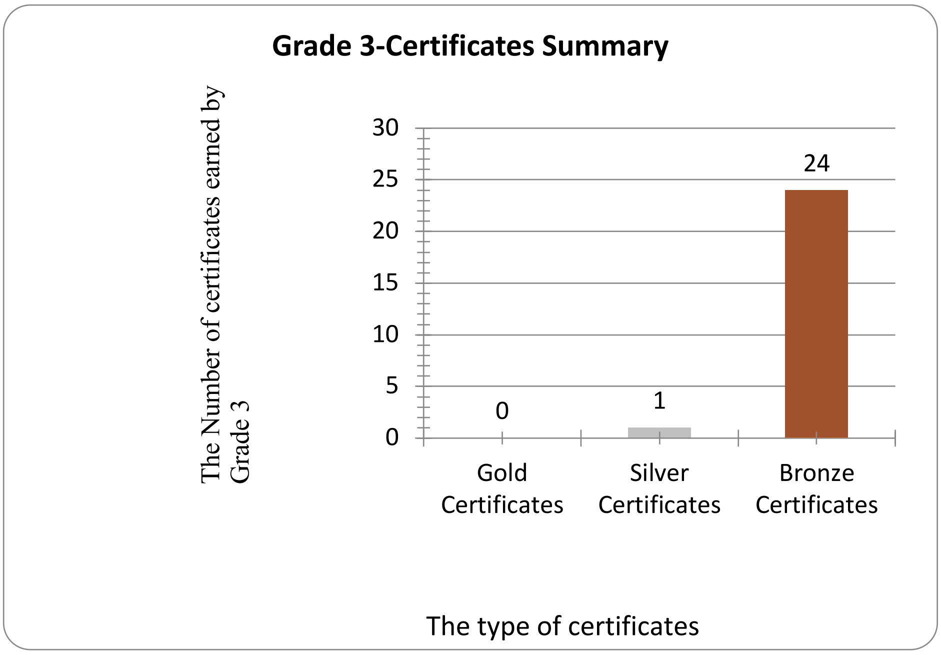


Figure 4.35: A bar chart from Mathletics Report showing the earned certificates in Grade 3.

Figure 4.36 showed that a good number of learners in Grade 3 (12 learners) had at least one certificate. Again, learner G3C3 earned 8 Bronze certificates and one Silver.

Student Name	Bronze	Silver
C1	0	0
C2	0	0
C3	8	1
C4	0	0
C5	0	0
C6	0	0
C7	1	0
C8	3	0
C9	0	0
C10	1	0
C11	1	0
C12	0	0
C13	1	0
C14	1	0
C15	3	0
C16	1	0
C17	1	0
C18	1	0
C19	2	0

Figure 4.36: A screenshot from Mathletics Report about the earned certificates by individual learners.

The learners in the interview expressed happiness in collecting points and certificates. Learner G3C1 for example, said that '*I have one certificate and 100 credits……I got a lot of* *points from when I was playing in the car……we started a new week yesterday and I have 500 points'*. Learner G3C2 stated that '*I have three certificates and now I have 990 points, so I need 10 points to get the certificate. Then, I'll change my profile and I'll do it in the computer'*. Learner G3C4 *'I have 1820 points, I collected them by myself. Also, I have one certificate'*. With the line of this, Figure 10 showed that the learners collected more points from the curriculum activities (more than 80,000 points) and about 13,500 from playing Live Mathematics. Therefore, these rewards encourage the learners to work harder on the activity. For example, learner G3C1 in the interview explained that '*If I could not collect 1000 points this week, I feel like I need to try harder in it and try to get 1,000 points or more.'*.

However, some learners in the interview expressed sadness from their inability to collect '1000' points a week. For example, learner *G3*C2 stats that *'If I could not collect 1000 points I'II feel so sad because I want 1000 points',* learner G3C3 *'I don't know how many points that I have and also, I have zero certificate because somebody deleted the Mathematics game and all my points restarted again. So, if I did not have 1000 points, I feel sad, mad.'* Learner *G3*C4 *'So, if I could not collect 1000 points a week, I feel sad'*.

4.3.4 Conclusions: Phase 1 Whole-class observation

The findings from whole class research in phase 1 of this study showed that the teachers across all grade levels adopted 'teacher show and tell' approaches to introduce and teach the new mathematics concept, mainly involving the use of the whiteboard or interactive smartboard to demonstrate to the whole class how to work out the mathematics problem. In addition, it was heartening to see the use of physical resources to scaffold learning during knowledge building component of the session. In this regard, there was evidence of the deployment of physical objects (such as blocks) to enable learners to actively practice mathematics concepts. It was also interesting to see more playful aspects being introduced to encourage engagement by the teacher in Grade 3, who threw a ball out to learners to mediate whole class discussion on how to solve a mathematics problem. Furthermore, all teachers sub-divided the class into smaller groups and actively promoted collaborative and peer forms of learning within these groups to enable learners to solve the mathematics practice activities. However, there was evidence of some learners disengaging with the collaborative group work across all grade levels, preferring to work by themselves on the in-class mathematics activities, or disrupt the learning for others in their group or in class. The teachers did engage to check on whether particular learners were having difficult from a learning perspective, and/ or to reprimand learners (where appropriate). During the observed sessions, there was evidence of teacher actions to support a fairly basic integration of technology in mathematics education, which included for example the display of examples from the online textbook on smart-board. When interviewed, all teachers mentioned the use of online games and other technological resources (Powerpoint etc.) in their teaching of mathematics, but this was not broadly observed to be the case in practice during the period of study in any of the grade levels. In the practice component of the traditional mathematics setting, the learners were asked to complete the assigned activities in the activity book or workbooks and submit to the teacher. During this time, there was evidence of a good level of self-directed work by learners individually and/or in groups. Importantly, the teacher did make herself available to provide assistance and support for the learners as required throughout the practice part of the sessions, and teachers did where necessary re-explain the problem-solving process with the whole-class using the smartboard. There was further evidence of some learners preferring to work by themselves on the assigned activities in activity or workbook. Finally, all the learners did complete the assigned activities in the books which were then submitted to the teacher towards end of class, but the learners did not receive any feedback from the teacher on their progress or performance in completing the mathematics activities in class-time. This feedback was delivered at a different stage in the day and/or at the beginning of the next session on a different day.

The findings from the intervention with learners across all grade levels showed that when comparing the traditional mathematics practice setting with those in the Mathletics group, that while the learners did complete the mathematics practice activities across both groupings, the learners in the Mathletics group exhibited higher levels of interest and excitement while practicing mathematics activities in class.

In the Mathletics part of the session, learners across all grades visibly and audibly exhibited higher levels of excitement and engagement throughout the session/s. Learners further demonstrated high levels of motivation to complete the mathematics practice activities both in-school time and also completed additional mathematics activities at home. The learners across all grade levels appeared to be particularly motivated by points and rewards within the Mathletics system, with learners re-visiting the activities multiple time to improve their final score. The learners exhibited excitement when they received feedback for successfully completing activities from the Mathletics software. It is important to note that learners in Grade 1 and Grade 3 did acknowledge that there was a real need for teacher presence/ explanations while learners were engaging in online activities, particular for more challenging questions. Even through individual and group engagement could be facilitated entirely through online Mathletics platform, Grade 2 and Grade 3 learners self-created challenge groups and did appear to enjoy solving the Mathletics problems in physical class based settings, and were frequently observed calling out to friends for support and to relay progress in completing the mathematics activities. In the case of Grade 1, the learners solved the Mathletics problems within the groups assigned by the teacher, and really didn't move out of these groupings. Furthermore, the 'Live Mathematics' part of Mathletics that facilitated competitive completion of mathematics practice exercises, really appeared to enthuse and engage learners – they appeared to really enjoy connecting with and challenging their classmates and peers in other countries in the online competition environment and that encourage Grade 2 and Grade 3 learners to move to challenging level.

Overall, the findings indicate that integrating online gamified mathematics practice activities does appear to heighten learner engagement and motivation in mathematics practice activities. Learners across the upper two grade levels really embraced opportunities to lead the learning, through self-creation of own groups and engagement within and beyond these groupings. Learners across all grade levels exhibited a strong desire for collaboration and friendly competition (face to face collaboration and competition) when engaging in the Mathletics platform. Furthermore, the learners in upper levels showed the capacity to discern the degree of challenge of questions and indeed reported on their successful achievements in relation to the perceived difficulty or challenge within the mathematics practice activity. This indicates that learners want to be challenged in mathematics practice activities, and also want to openly share their success in solving these more difficult questions.

The findings indicate that the learners were really motivated by the integration of Mathletics in their mathematics sessions; they were observed to complete the traditional mathematics practice activities (in activity books) as quickly as possible so that they could progress to using the Mathletics activities. The findings further indicate that particular game elements (such as points, certificates, progress bars, a friendly 'competitive' environment, direct feedback on progress and performance in completing mathematics practice activities and avatar character development) have positive effects on increasing the learners' interest in mathematics, and in keeping them on task. However, it is equally important to note that at Grade 1 level, the learners had difficulty in understanding their overall progress, as a result of their inability at that level to understand large numbers (1000 points). Furthermore, learners at other levels expressed sadness at not being able to gain a certificate, as they had to reach mandatory level of 1000 points in the period of a week. These speak to the need for re-consideration of the game design to ensure that expectations can be understood by and realistically reached by learners within each of the target grade levels.

4.4 Six Case Studies of Mathletics Interface Interaction

This second aspect of the first phase of the study utilised a qualitive approach and used two tools (the eye-tracking data and interactive observation by the researcher) to deepen the exploration of the following question: *What impact, if any, does the integration of online gamified mathematics 'practice activities' have on learning* in Grades 1 to 3 *in this Saudi context?* Through the examination of six case studies, the researcher hoped to reveal factors in the instructional design of the Mathletics activities and interface that impacted on learners' disposition, engagement, and motivation in Grade 1, 2 and/ or 3 contexts. This section begins with a brief explanation of the layout of the Mathletics interface, and is followed by a detailed account of the engagement by six learners within a sequence of mathematics practice activities in Mathletics over the period of study.

4.4.1 Overview of Mathletics Interface Design.

The focus of the following 6 case studies was to uncover more information about the impact of the instructional design of Mathletics (particularly the human-computer interaction) on learners' engagement with the mathematics practice activities at each grade level. It is important to re-iterate here that Mathletics is not a programme designed to teach mathematics concepts; it has been designed as a tool to practice mathematics, with the expectation that the relevant mathematics concepts have already been taught to the learner (by a teacher in class). To begin with, an overview of the Mathletics interface is described, as familiarity with this is important in terms of understanding the aesthetic and pedagogic considerations, and corresponding experiences of learners within Mathletics.

Within the Mathletics interface, as shown in Figure 4.37, the mathematics practice activity itself is always positioned in the central part of the screen, and usually comprises of framing and/or representation of the question in at least two formats but more often 3-4 different formats, for example, on-screen there may be: i) a textual-question (question written using words), ii) a graphical activity/question (question supported using visual or graphic,), iii) a numerical question (a question written using mathematical notation and numbers, or, iv) a mix of the above. The key-word/s in the word-type questions in most of the activities, are highlighted by different colour. The activities also may include interactive features such as being able to ‘drag and drop’ items, ‘select items’ from a range of answers, ‘colour’ some elements, ‘write some words’ and/ or ‘enter numbers’.

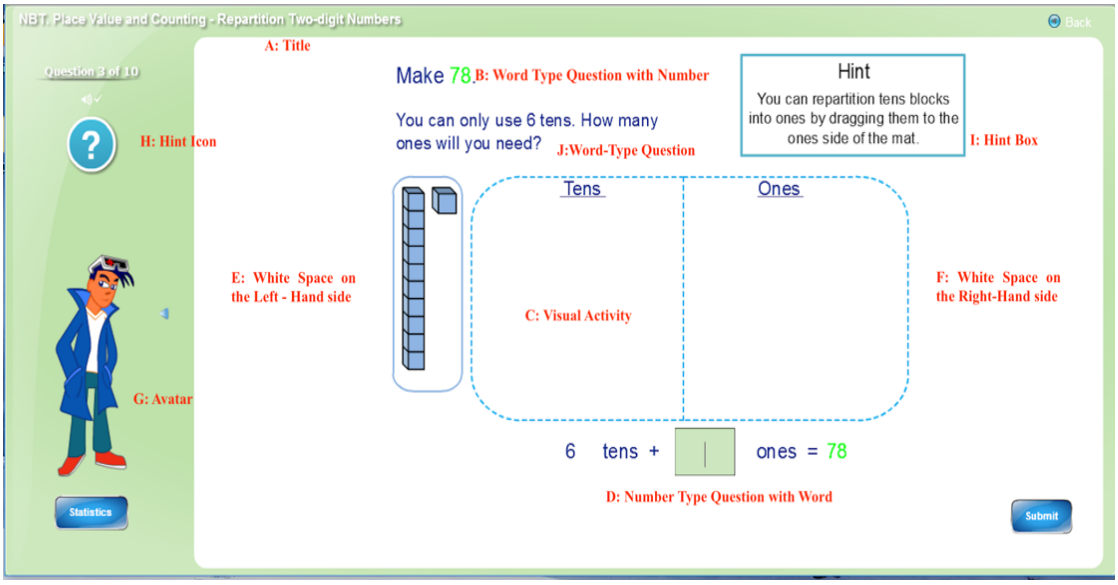


Figure 4.37: Screenshot of an example of the interface design for Mathletics activity.

Furthermore, the Mathletics interface design integrates some scaffolding tools, that can support learning such as the Hint button and feedback button. The hint button or support area (in form of a question mark) gives step-by-step explanation of the activity if a learner struggles with the activity. In some cases, the interface has a hint box on the right-hand side, which displays a hint on how to solve the problem. Feedback also is included within the interface design. A learner receives an immediate feedback on each question answered. There is also an Avatar on left-hand side of screen, which doesn’t have a pedagogic function but rather is there as an aesthetic feature that aims to motivate learners (the avatar can be customised by learners using points earned through the gamified system).

4.4.2 Background

All six learners were Arabic, and fluent in English language. The thematic areas of mathematics covered within the Mathletics practice sessions were introduced by the teachers in a session previous to the Mathletics intervention, so learners had been taught the key concepts and had engaged in basic practice exercises within class-time. However, some of the Grade 1 and Grade 3 learners choose to move ahead and complete Mathletics practice activities in themes that hadn’t yet been covered. The researcher sat alongside each learner in individual sessions as they engaged with Mathletics on a laptop computer, and asked questions as each learner progressed through the activities – thus, this mode of data collection has been titled 'Interactive observation'. The eye-tracker system recorded eye-travel within and across the screen as the learner engaged in the activity, and the data were collated and visually represented in scan-path visualisations and gaze plots, as already discussed in the methodology chapter. Appendix D shows the frequency and duration of each of the six learners within Mathletics sessions.

4.4.3 Grade 1 Case 1 (G1C1)

Learner G1C1 was at Grade level 1 (6 to 7 years of age), and interacted in a sequence of activities: *Related Facts 1; Missing Numbers; Doubles and Halves to 20 and Who has the Goods; and Collect Simple Shapes* (see Appendix D). The learner took 4 sessions and spent from 3 to 5 mins in each, with the total interaction spanning 20 minutes. The learner answered 50 questions in total. For the purposes of this research, her interaction in 14 of these questions, across the four themes, were analysed. Overall she successfully completed all of the questions on the first attempt, except the 'Missing Number' activity, where only five of the 10 answers were correct.

The eye tracking data clearly showed that G1C1's eyes first landed on the graphical objects on entry to all activities, an example is shown from the 'Related Fact 1' theme in Figure 4.38a, thus indicating this learner's preference for interaction with visual elements rather than textual elements on-screen.

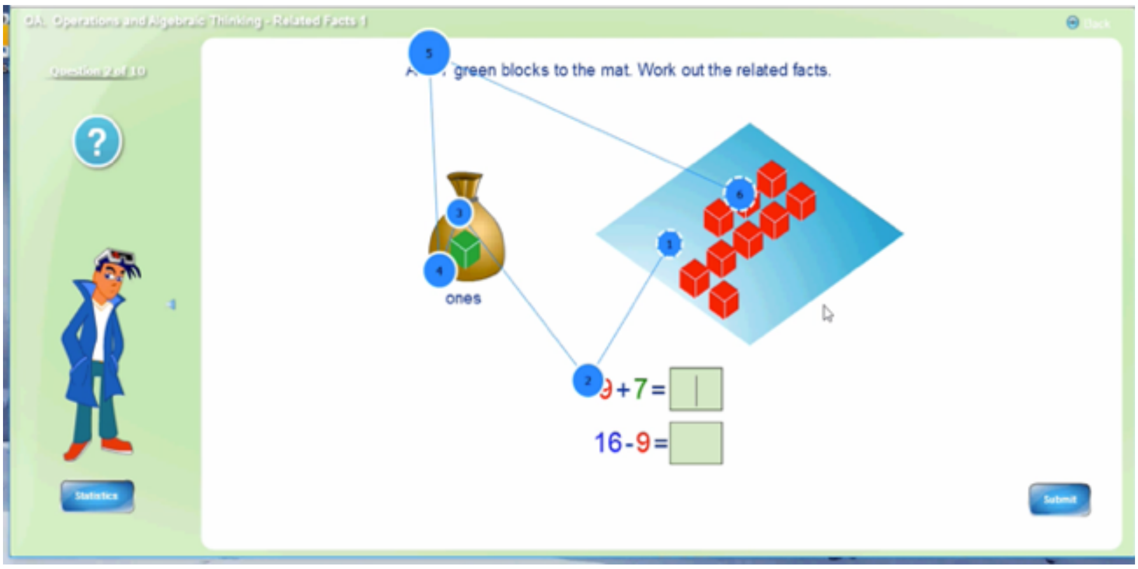


Fig. 4.38a: Screenshot of the learner's interaction with Related Fact 1 activity. [It shows that the eye first landed on the visual activity. It also shows that the student had longer fixation duration on the key-word only.]

Furthermore, this data also showed that the student's eyes had a long fixation duration on key-word/s in the questions after she had a number of fixations on the visual activity within each activity, as example shows in Figure 4.38b. However, this student generally didn't start by reading the textual question on-screen. Instead, she appeared to prefer to read the graphical or numerical question but if she struggled with completing the question graphically or numerically, she reverted back to the textual question but only read key words in the question.

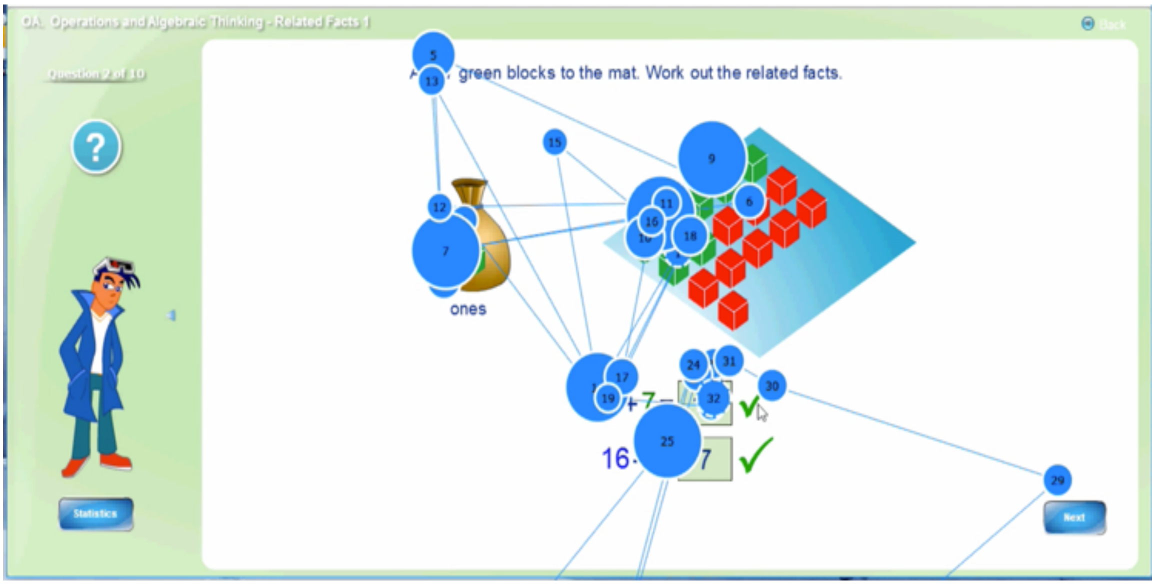


Figure 4.38b: Screenshot of the full interaction of the learner with the Related Fact 1 activity. [The screenshot shows that the learner never looked at the avatar, the statistic icon or the question mark icon. It also shows that the learner's eyes sometimes look down off the screen.]

The learner used a variety of problem-solving strategies such as mentally solving mathematics problem, using fingers, or interaction with the visual supports on-screen. The evidence from the observation revealed that the learner mainly stayed focused on the activity on-screen during the solving of basic mathematics problems, even when she tried to get the answer mentally or using fingers (i.e. she rarely took her eyes off-screen to look at her hands even when counting on fingers). During the interactive observation, the learner confirmed that she has the ability to work with simple numbers to add and subtract without the help of shapes but would always need to use her fingers in counting numbers (which explains why she looked down from screen on occasion). She also said that the visual objects on screen can help in working out the answers for the questions that cannot be solved by fingers and/or mentally.

In a different section, the learner said that after she submitted the final answer and was waiting for the next question to appear on the screen, she wished that the next question would be more challenging, as this wanted to ascertain her true abilities (thus, she indicated that she was internally competitive). This acted as a motivator for her to continue to complete mathematics problems. From the interactive observation, the learner indicated that when the game design is straightforward and intuitive then she seeks a higher degree of challenge within the mathematics problems as, when the interface design is more seamless, it encourages her to be more concentrated on the screen. The observation notes also revealed that the learner expressed happiness when she received immediate feedback from game and appeared excited about moving to the next question. The learner prepared herself physically (she pulled her chair, moved closer to the computer, and really focused on the screen) to be ready for the next question.

Interestingly, the observation also revealed that the learner's engagement on-screen reduced during extremely challenging activities (such as in the 'Missing Number' activity) that can't be solved using fingers and/or in head and was not supported by visual/ graphic (Figure 4.37c). The data showed that the learner eyes were frequently off the screen and back to the activity in such cases. The learner at this time spent about 4 to 5 sec off screen to try to get the answer using her fingers and/ or mentally. The learner visibly did not spend much time on the hard questions and submitted answers quickly so that she could progress out of this section more quickly. When asked by the researcher about this, she said that when answering the questions, she knew some answers were incorrect, and thus, was not surprised by the results, and wanted to move forward to more doable mathematics problems.

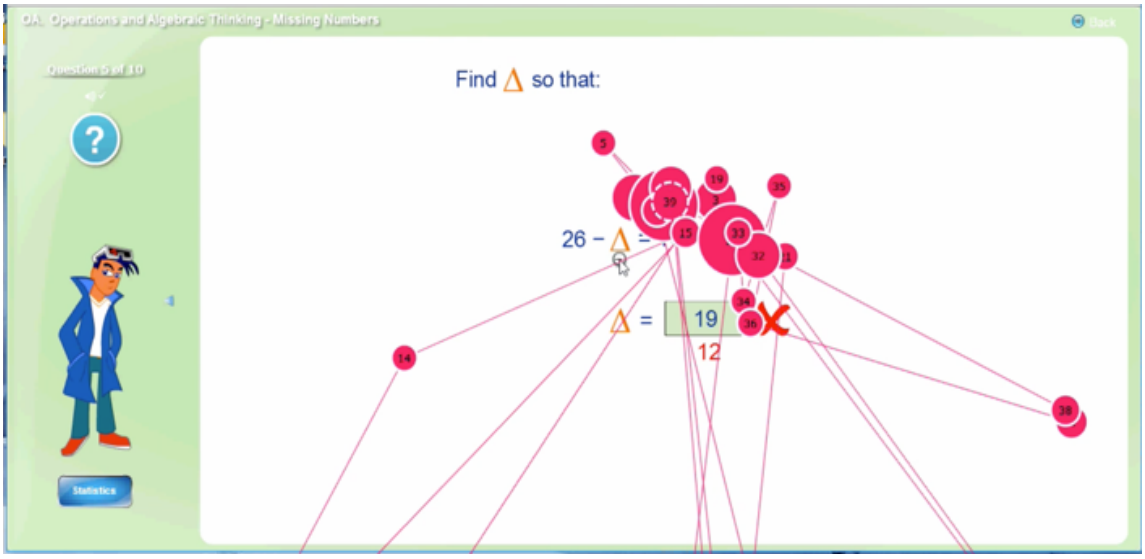


Figure 4.38c: Screenshot showing learner interaction in a challenging activity. [She frequently looked off the screen to think of the answer, using fingers and/ or mentally. The activity has no graphical support to enable learner to work out the answer on-screen.]

Furthermore, the data revealed that the inclusion of the avatar and help icon did not appear to interest the learner. The data from the eye-tracking software shows that no gaze plots were recorded on the avatar, the statistic icon or the question mark icon, as illustrated in Figure 4.38c. Based on the overall data-set, learner G1C1 never used/ accessed the avatar, the statistic icon or the question mark icon to help solve problem, nor clicked on them to see what they had to offer in terms of help or guidance during any of the activities. When the learner was asked about that during the observation, she confirmed that the avatar didn't interest her.

4.4.4 Grade 1 Case 2 (G1C2)

Learner G1C2 was at Grade level 1 (6 to 7 years of age), and interacted in a sequence of activities (see Appendix D): *Operations: Adding in Any Order, Related Facts 1, Doubles and near Doubles, and Geometry: Sort it*. She did 3 sessions and spent 6 to 8 mins answering the questions, with the total interaction spanning 21 minutes. The learner answered 40 questions in total. For the purposes of this research, her interaction in 8 of these questions, across the three themes, were analysed. Overall she successfully completed all of the questions on the first attempt.

The eye tracking data clearly showed that G1C2's eyes first landed on the textual questions on entry to some activities, an example is shown from the 'Geometry-Sort It' theme in Figure 4.39a, and furthermore, she focused on graphical or numerical question types in other questions as shown in 'Operations: Adding in any order' theme in Figure 4.39b. For example, in Figure 4.39a, the learner had longer fixation duration on the key-word/s in textual question rather than on the shapes in the graphical question, whilst the opposite was the case in Figure 4.39b. When the learner was asked about this during the observation she commented saying that the word question in Figure 4.39b was too long, and that she felt the visual activity offered better guidance on what needed to be done there.

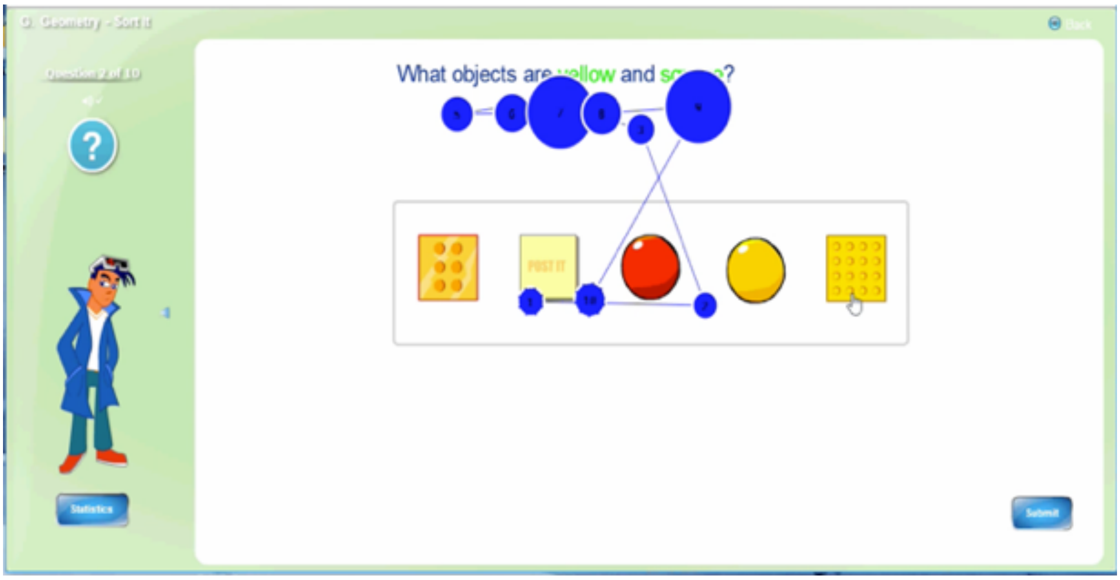


Figure 4.39a: Screenshot of the learner's interaction with the 'Sort It' activity. [The eye first landed on the visual activity. The screenshot shows that the learner had longer fixation duration on (gazed at) key-words in the textual question.]

]The learner showed an eagerness to be ready-to-engage and strove to keep her attention focused for this activity with one hand generally gripped on the external mouse most of the time. Furthermore, the learner sometimes arranged her hands on keyboard so that she didn't have to waste precious time to look away from the on-screen mathematics practice activity (Figure 4.39a) but other times she did have to look down from the screen to use the key-board to type the answer (Figure 4.39b).

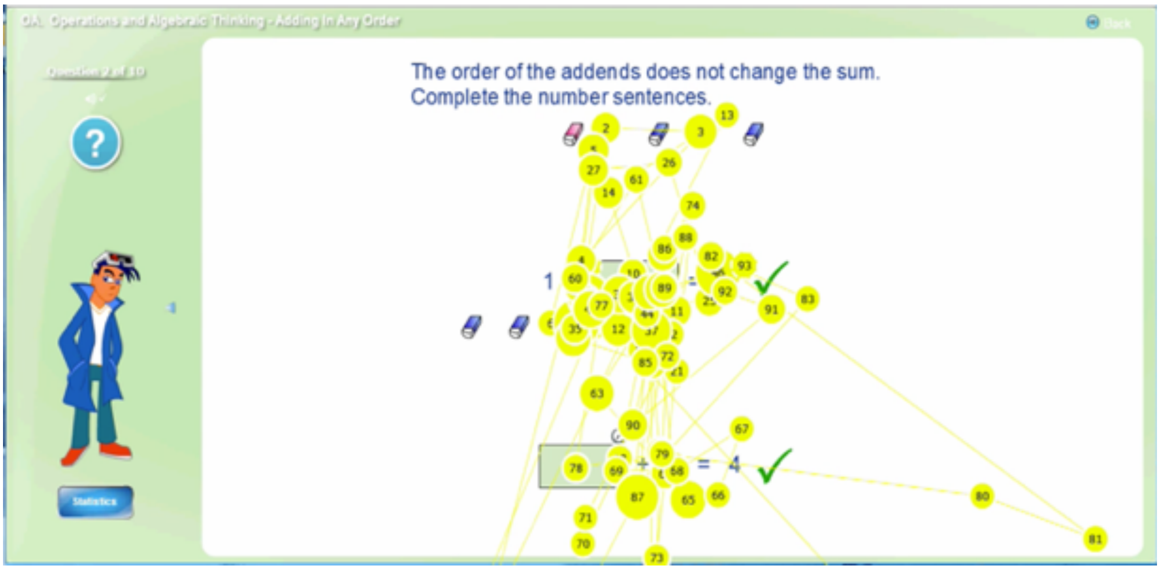


Figure 4.39b: Screenshot of the full interaction of the learner with the 'Adding In Any Order' activity. [The screenshot shows that the learner never looked at the textual question, avatar, the statistic icon or the question mark icon. It also shows that the learner never read the textual question.]

The learner used a variety of problem-solving strategies such as mentally solving mathematics problem, using fingers, or interaction with the visual supports on-screen. During the interactive observations, the learner confirmed that she prefers using the shapes (graphical representations) rather than working out the answer mentally as these shapes help her to get the answer more quickly. Furthermore, it seems that some aesthetic elements such as the avatar and help icon did not appear to interest learner at all. The data from the gaze plots (Figures 4.39a & 4.39b) shows that no gaze plots were recorded on the avatar, the statistic icon or the question mark icon. Therefore, the learner never used/ accessed to these elements to help in solving a problem. When the learner was asked about she said that this avatar looks funny because of his acting/ movements on-screen. The observation revealed that the learner expressed enjoyment in game-play - she was particularly happy when she got the feedback from the game. Therefore, it appears that feedback is an important motivational factor for this learner when engaging in the online mathematics practice activities in Mathletics.

Finally, Internet delays caused frustration and impatience for this learner. The learner was observed patiently waiting for the next question but when it was delayed for long time (about 3 mins) by a weak Internet connection, she then shut down the game, and re-started a new session.

4.4.5 Grade 2 Case 1 (G2C1)

Learner G2C1 was at Grade level 2 (7 to 8 years of age), and interacted in a sequence of activities (see Appendix D): *Odd or Even, Place Value 1, Number Line Order and Count by 2s, 5s, and 10s.* She completed four sessions, spending 5 to 12 mins in each, with the total interaction spanning 30 minutes. The learner answered 40 questions in total. For the purposes of this research, her interaction in 9 of these questions, across three of the themes, were analysed. Overall she successfully completed all of the questions on the first attempt.

The data for this learner initially indicated that she preferred to read either graphical- or numerical-type questions and that if she struggled with numerical-type question, she would go back to read the textual question. For example, the data from the eye-tracking data-set in Figure 4.40a shows that there were a number of gaze plots on the visual activity while there were no gaze plots recorded on the textual question. In this case, the learner completed the activity without viewing the textual question at all.

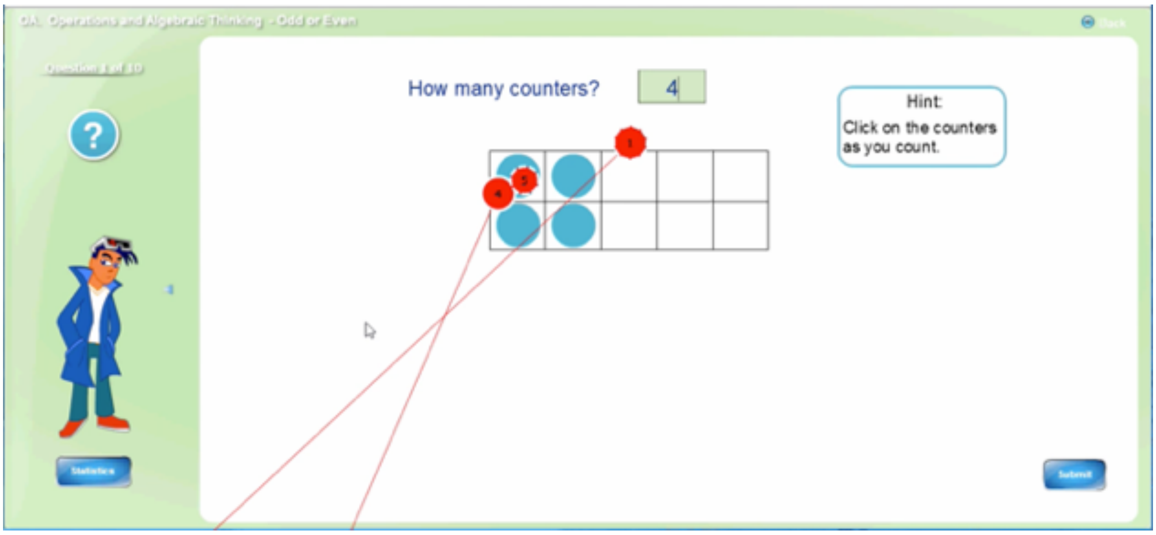


Figure 4.40a: Screenshot of the interaction of the learner with the 'Odd or Even' activity. [The screenshot shows that the learner did not pay attention to the hint box on the right hand-side of screen. The screenshot further shows that the learner never looked at the avatar, the statistic icon or the question mark icon.]

In contrary to this, Figure 4.40b shows that the learner initially had short gaze fixations on the numerical question then moved to substantively gaze at the textual question. The sequence of gaze plots (Figure 4.40b) indicated that the learner read the full textual question (this was also observed by the researcher as the learner read the question out loud). The observation revealed that the learner started doing the activity but when she did not get the idea of how to solve the problem using the numerical and graphical scaffolds, she returned to read the textual question.

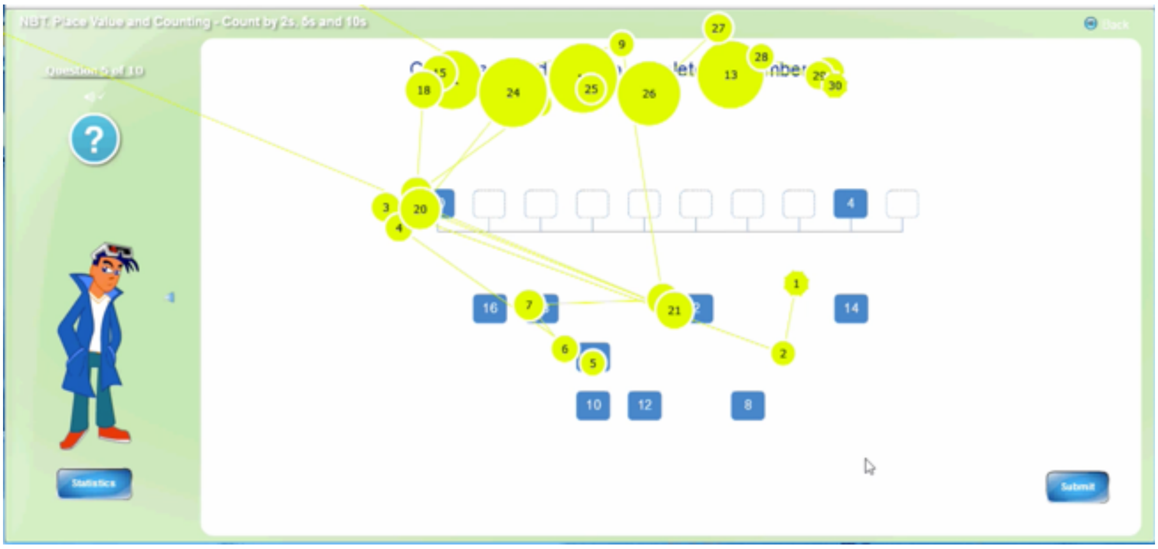


Figure 4.40b: Screenshot of the learner's interaction with 'Count by 2s, 5s and 10s' activity. [The screenshot shows the eye first landed on the visual activity. The learner started viewing the visual activity but when she did not get the idea of the answer, she read the textual question.]

From the interactive observations, there was evidence that the learner also used different approaches to solving the mathematics problems such as counting out loud, mental arithmetic approach as well as using the on-screen graphical support (where appropriate). The data from the interactive observation also reveals that this learner was very happy when receiving immediate feedback from the platform. She displayed excitement when ready to progress to the next question, preparing herself physically (pulled her chair, move closer to the computer, put her hand on the touch pad and focused on the screen) for the next question-set. The learner's eyes typically were more focused on the screen during problem solving. However, in some activities (e.g. Figure 4.40a) the learner's eyes could be seen to move quickly off-screen and then back to the activity. The learner was observed by the researcher looking off the screen to use the key-board to type and submit the answer, at these times.

Furthermore, the data from the eye-tracker revealed that the learner generally started counting from left-hand-side to right-hand side (when engaged in Operations and Algebraic type activities). However, interestingly, in one of the activities the learner counted from right-hand side to left-hand side (Figure 4.40c). This result indicated that the learner's behaviour to solve mathematics problem was very likely affected by her native Arabic language where reading always starts from right hand side to left hand side of page.

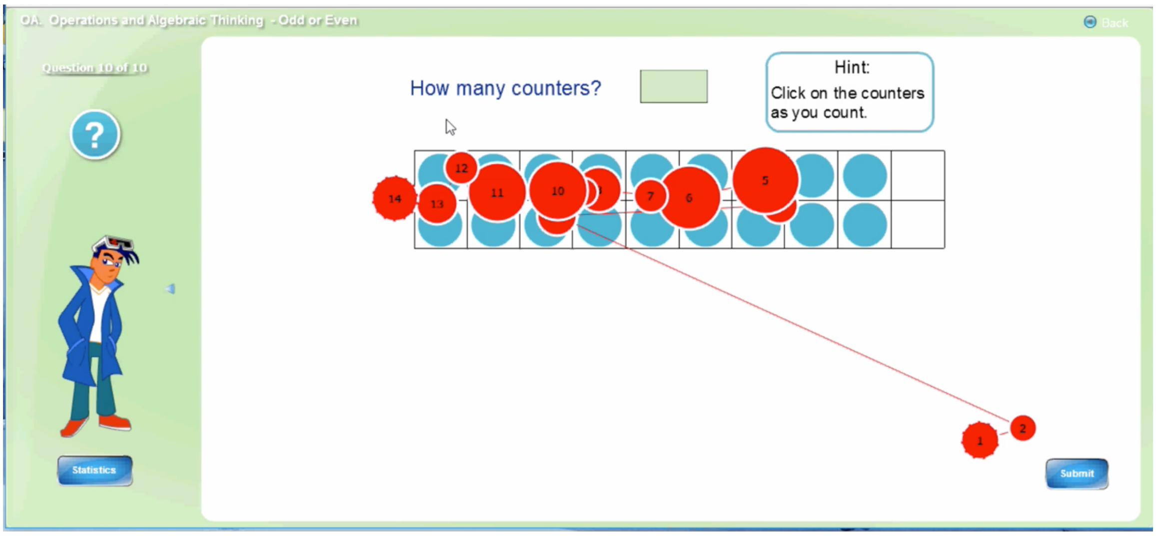


Figure 4.40c: Screenshot of the interaction of the learner within the 'Odd or Even' activity. [The screenshot shows that the learner started counting from right-hand side of the screen. The learner doesn't look at the Avatar, Statistics or Question mark, or at the Hint box.]

Furthermore, the data from the eye- tracking software (Figure 4.40a) showed that there were no gaze plots recorded on the avatar, the statistic icon or the question mark icon, which indicated the learner did not use these to help to solve the problem. When the learner was asked about this in the interactive observation, she said that she tried to ignore the avatar as she didn't see the point of his presence on screen. Moreover, in some activities, a hint box appeared on the right hand- side (Figure 4.40a). The data from the eye-tracking (illustrated in Figure 4.40a) shows that the learner did not fixate at the information that was provided by the hint box. When the learner was asked about this, she said that she could answer without the help of the hint and tried to find her own way to answering the question. Furthermore, the learner expressed her happiness in being able to get the right answer without the help of the hint option during the interactive observation process.

Finally, the internet sometimes slowed down for a few seconds, during which time the student was observed patiently waiting for the next question. However, when the internet took a longer time to upload the next activity (about 2 mins), the learner exited the programme and returned to the previous activity to continue solving the rest of the questions.

4.4.6 Grade 2 Case 2 (G2C2)

Learner G2C2 was at Grade level 2 (7 to 8 years of age), and interacted in a sequence of activities (see Appendix D), including: *Add and Subtract activity, Count by 2s, 5s and 10s activity, Place Value 1 and Repartition Two-digit Numbers* activity. She did four sessions and spent about two to ten minutes in each, with the total interaction spanning 27 minutes. The learner answered 40 questions in total. For the purposes of this research, her interaction in 10 of these questions, across the four themes, were analysed. Overall she successfully completed all of the questions on the first attempt.

The eye tracking data clearly shows that the first few gaze plots were generally on the graphical objects, as illustrated in Figure 4.41a, and that the learner had short glances (low gaze fixation durations) on a key-word within the textual question. This learner generally didn't read the full textual question.

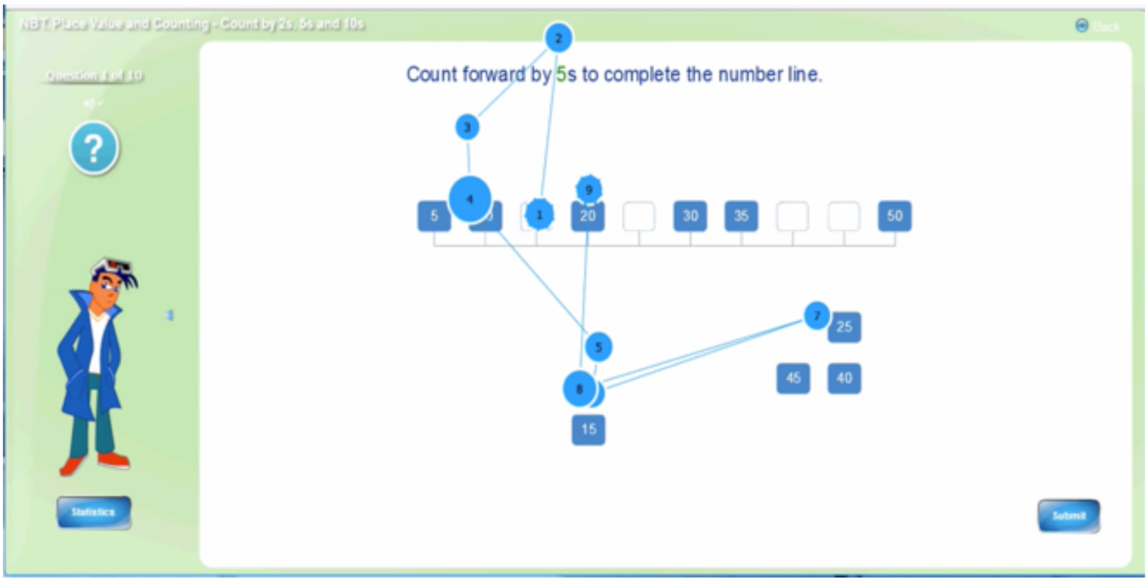


Figure 4.41a: Screenshot of the learner's interaction with '*Count by 2s, 5s and 10s'* activity. [The screenshot shows the eye first landed on the visual activity. The learner started viewing the visual activity but when she did not get the idea of the answer, she read a key-word in the textual question.]

The data from the interactive observation revealed that the learner expressed enjoyment when working on the activity and was very concentrated on the screen. The learner was happy when she saw the feedback for the game, and appeared to enjoyed engaging in the mathematics practice activities. She continually readied herself for the next question, frequently sitting on the edge of the chair to be closer to the computer and placing her hand on the touch pad.

The learner generally seems to prefer to mentally solve problems, with a preference for numerical or graphical type-questions rather than textual questions. For example, the data from the eye- tracking (Figure 4.41b) shows that the gaze plots were shifted between the numbers whereas there were no gaze plots at all recorded on the graphical support (i.e. the abacus image).

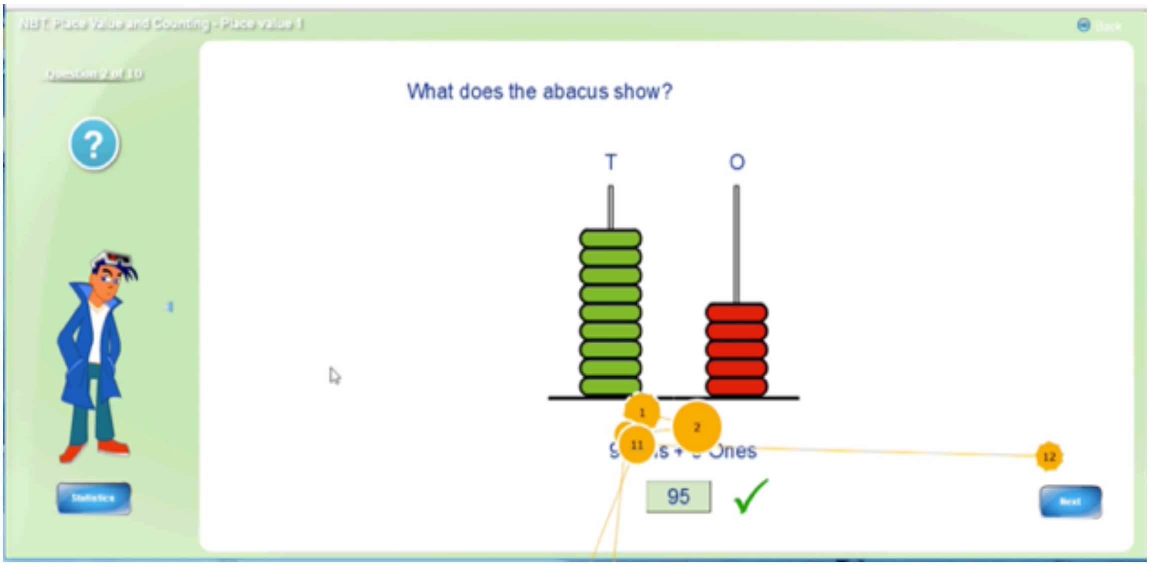


Figure 4.41b: Screenshot of the full interaction of the learner with the ‘Place Value 1’ activity. [The screenshot shows that the learner had longer fixation duration on the numbers in the numerical question. It also shows that the learner never looked at the textual question, the graphical support, the avatar, the statistic icon or the question mark icon.]

During the observation, the learner confirmed that she worked out the answer in Figure 4b by entering the number in front of tens and ones on the numerical question (without counting the circles in each column). She also confirmed that she has ability to add and subtract mentally in cases such as this, but in other activities she explained she did try to find a simpler way to get the answer, such as using scaffold of a graphic or numerical question.

The learner never looked at the avatar, or the hint icon on the left-hand side. On one of the activities, the learner asked the researcher about the purpose of the avatar, and then she clicked on the avatar and ignored it, returning back to the activity. When the learner was asked the reasons why she ignored the avatar, she said that she disliked the avatar character because of his acting/ movements on-screen (the avatar would wave or move around from time to time on screen). Furthermore, it seems that when the interface design contains redundant information, it can cause confusion for the learner. For example, Figure 4.41c shows that in a question-set on 'Place Value and Number Repartition', the learner's gaze shifted between the hint box, the textual question, the numerical question and the graphical scaffold. It even momentarily moved out to the Question Icon.

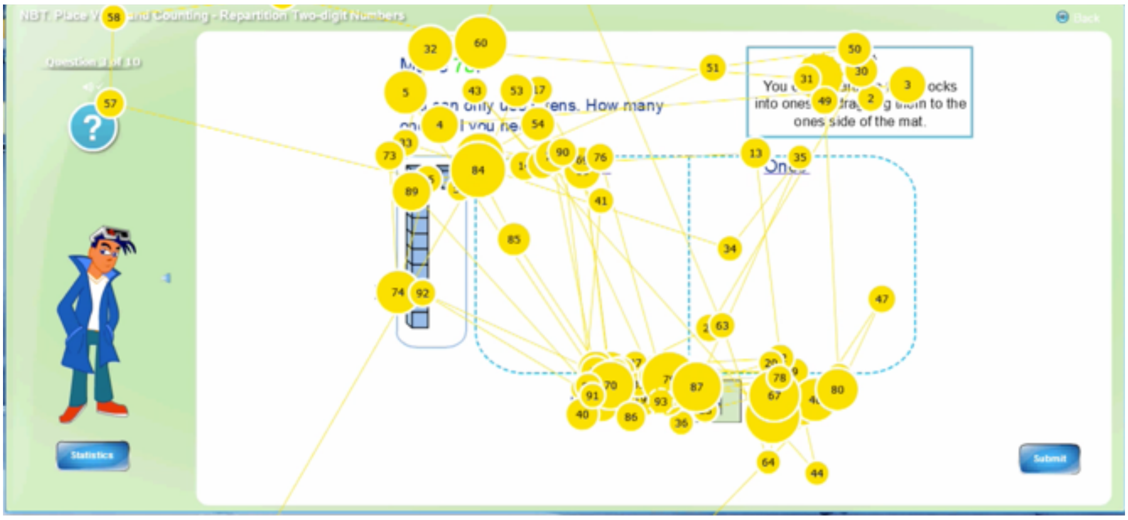


Figure 4.41c: Screenshot of the interaction of the learner with the "Repartition Two-digit Numbers" activity. [The screenshot shows that the learner's eyes shifted between the textual question, the hint box, the numerical question and the graphic scaffold.]

From the interactive observation, it appeared that the learner found it very difficult to "piece together" the information to figure out how to answer the question in this case. The learner confirmed that she got confused between the hint box and the information provided on screen (i.e. the textual and numerical question), and didn't understand what she needed to do, so moved to complete the question using the graphical scaffold on occasions such as this.

4.4.7 Grade 3 Case 1(G3C1)

Learner G3C1 was at Grade level 3 (8 to 9 years of age), and interacted in a sequence of activities (see Appendix D), including: *Groups of Three, Groups of Six, Arrays 2, Arrays 1 and Multiplication Arrays*. She did four sessions and spent 6 to 20 minutes in each, with the total interaction spanning 46 minutes. The learner answered 47 questions in total. For the purposes of this research, her interaction in 11 of these questions, across the four themes, were analysed. Overall she completed all the questions on the first attempt but she had some incorrect answers in ‘Group of Six activity’, ‘Arrays 2’ and ‘Arrays 1’.

The eye tracking data clearly shows that the learner never read the textual question, as illustrated in Figure 4.42a. This learner used different strategies to solve the problem but she confirmed during the interactive observations that she preferred to work with visual questions rather than reading textual questions.

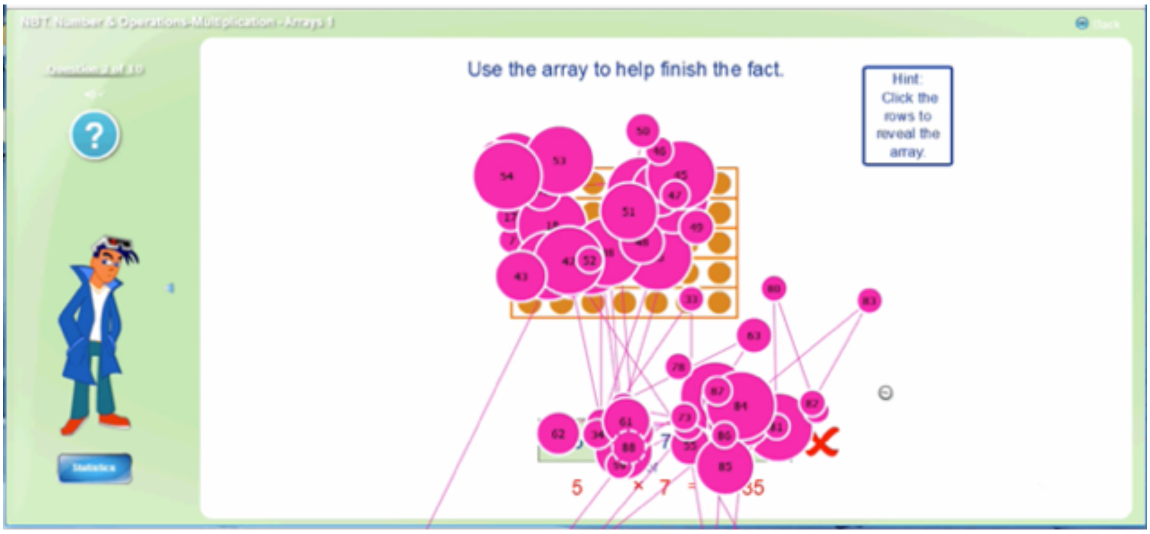


Figure 4.42a: Screenshot of the ‘Array 1’ activity. [The screenshot shows that the learner never looked at the textual question. It also shows that there were no gaze plots on the avatar, help icon and hint box.]

The data from the eye-tracking data-sets showed that she did not pay attention to other interface design elements such as the avatar, the hint box, the statistic icon or the question mark icon, as illustrated by gaze plots from eye-tracking software in Figure 4.42a & Figure 4.42b. Furthermore, it showed that the learner sometimes looked down off the screen (as illustrated in Figure 4.42a), which was confirmed during interactive observation to be to use the key-board and sometimes to mentally work out the answer.

The learner was more focused on the graphical scaffolds on screen and tried to get the answers for examples by counting the graphical objects one by one (counting was expressed out loud by the learner). The learner confirmed during the interactive observation that she has ability to get the answer using her fingers but this took up too much time. Therefore, she counted the circles to avoid making a mistake and to make sure that her answer was correct. The learner prepared herself for the next question (she put her hand on the key-board to use it for counting the circles) and was more focused on the screen. The learner also mentioned that the visual objects on screen helped in working out the answer if she did not remember 'times table'. The learner further suggested that it would be more helpful if the colour of some of the circles was patterned as the same colouring in circles made them difficult to count (see Figure 4.42b). Interestingly, when the visual activities were not intuitive, the learner indicated that she tried to get the answers by imagining there were circles in the blank array and using the mouse to count the invisible circles.

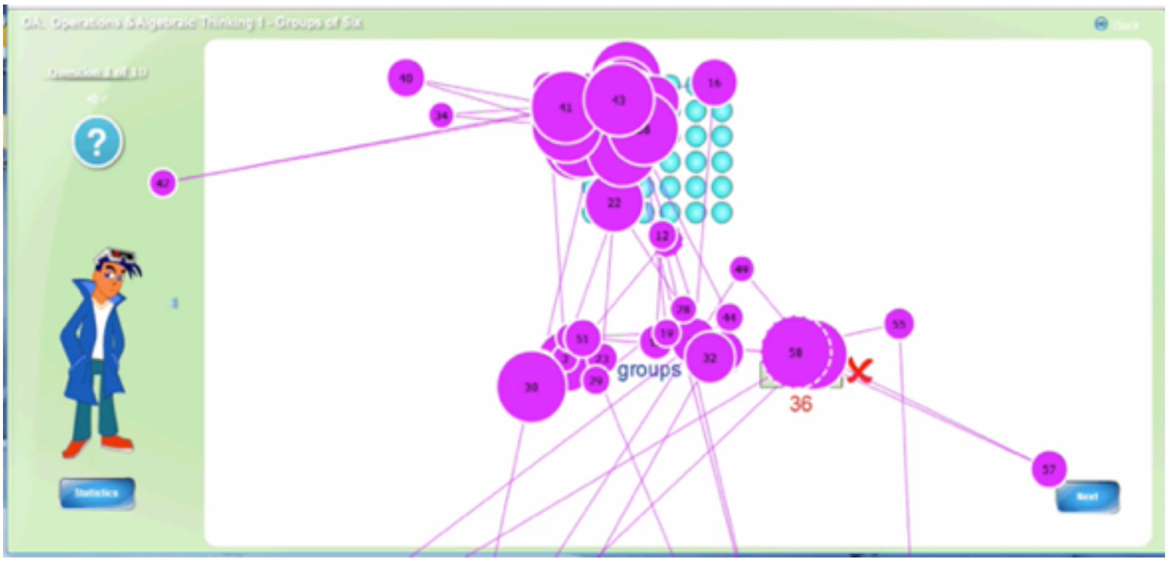


Figure 4.42b: Screenshot of 'Group of Six' activity. [The screenshot shows that all circles have the same colour which in this case caused confusion for the learner.]

The data from the interactive observation showed that the learner expressed happiness when feedback provided from the activity. However, she sometimes expressed anger and frustration when some questions were repeated and indicated that she hoped that the next one would not be a repeat. She also mentioned that she was proud of herself when she got the correct answer without using any visual support. When she got an incorrect answer, she said she felt sad but recognised that she always tried her best.

4.4.8 Grade 3 Case 2 (G3C2)

Learner G3C2 was at Grade level 3 (8 to 9 years of age), and interacted in a sequence of activities (see Appendix D), including: *Groups of Three, Array 1 and Multiplication to 5×5.* She engaged in three sessions and spent six to twenty minutes in each, with the total interaction spanning 24 minutes. The learner answered 30 questions in total. For the purposes of this research, her interaction in 7 of these questions, across the four themes, were analysed. Overall she successfully completed all of the questions on the first attempt but she had some incorrect answers in ‘Array 1’ activity.

The data from the eye-tracking shows that the learner generally fixated first on the visual activity. As shown in Figure 6a, the data from the eye-tracking software shows that the learner primarily fixated on the graphical support and then moved to the numerical question.

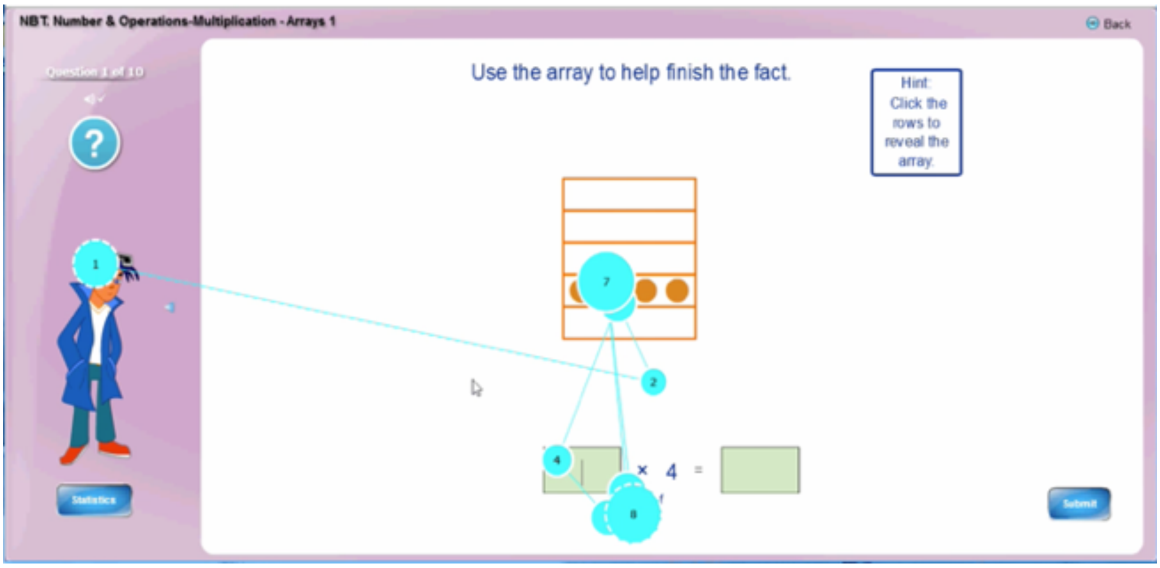


Figure 4.43a: Screenshot of the ‘Array 1’ activity showing eye movement across the visual activity and numerical question.

The learner explained that she counted the circles to calculate the total number and tried to mentally work out the answer. She also said that she was so proud of herself to get all correct answer by using mental calculation to work out the total from the number of rows and the number of circles per row, as opposed to manually counting each circle in the graphical shape. However, when she did not understand the activity, she reverted back to the textual question, as shown in Figure 4.43b.

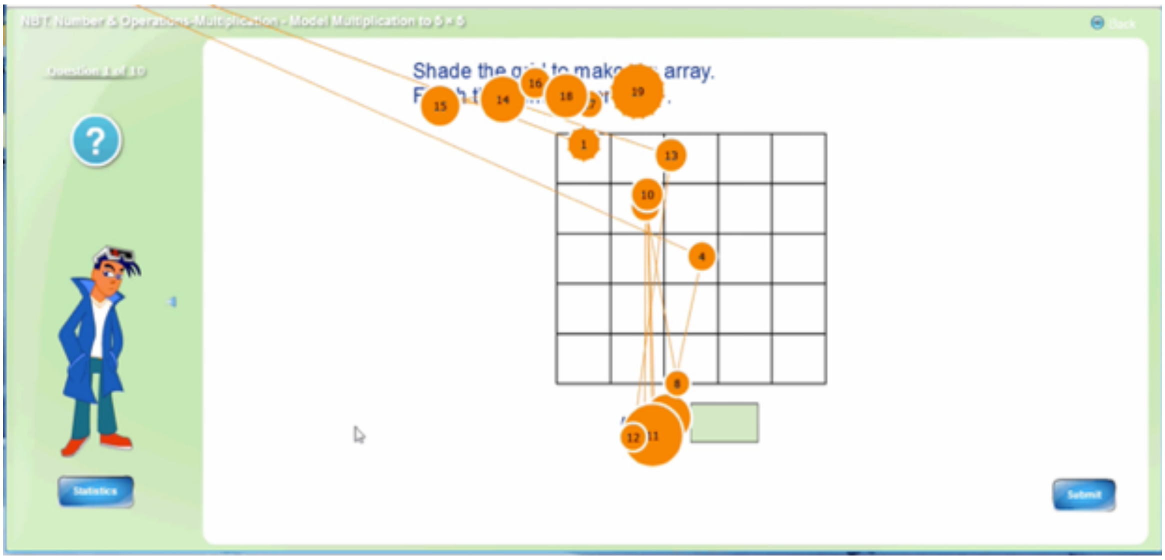


Figure 4.43b: Screenshot of the 'Model Multiplication to 5× 5' activity showing eye-movement across the visual activity and textual question.

The learner was observed on occasion looking off the screen to work out the answer mentally and/ or to use the key-board. Furthermore, the eye-tracking shows that the learner did not fixate at the avatar, the statistic icon and the question mark icon at all as shown in Figure 4.43c.

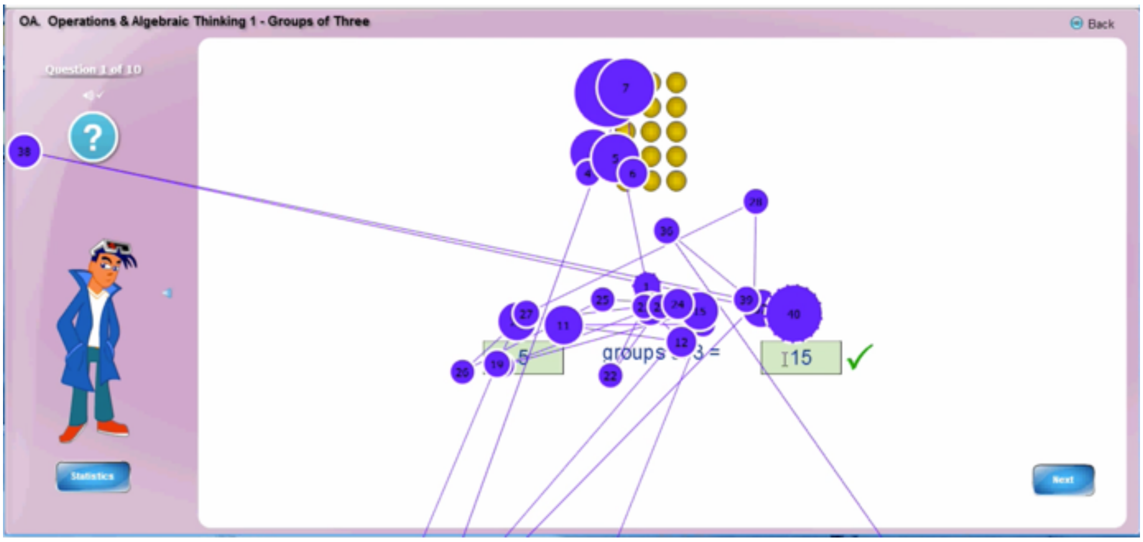


Figure 4.43c: Screenshot of 'Group of Three' activity showing eye fixations initially on left side of the activity and then on the numerical question. [This learner frequently looked of the screen. Also, the screenshot shows that the learner never looked at the hint box and the statistic icon or the question mark icon.]

Interestingly, this Grade 3 learner progressed to undertake activities in mathematics themes that were not explained by the teacher in-class, and successfully completed many of these advanced level problems. During the interactive observations, this learner indicated that she enjoyed challenging herself and tried to see how many correct answers she could get in doing advanced level problems. The learner further mentioned that she sometimes challenged herself to answer ‘times tables’ questions without using the graphical/ visual support and felt very proud of herself when she got the correct answer/s. The data from the interactive observations noted that the learner expressed happiness when she received positive feedback on her performance within Mathletics but she did not show any expression when she got an incorrect answer.

4.4.9 Findings from the Review of Six Cases

The 6 learners in the case studies expressed excitement and showed readiness and full attention throughout their engagement with the online mathematics practice activities within the Mathletics platform. The majority of learners, with the exception of one case in Grade 3, successfully completed all questions, with all expressing their enjoyment during their engagement with the online mathematics practice activities, and happiness in terms of receiving immediate feedback on their performance as they progressed through the Mathletics activities. Furthermore, some learners challenged themselves to complete activities in themes that hadn’t been covered in-class, and had varying levels of success in correctly answering these questions. The learners were observed to interact frequently with the visual scaffolding (graphical representation/ activity on screen), and also leaned on mental computational skills and/ or counting out loud using their fingers to solve the mathematics problems. Interestingly, one learner employed a most unusual technique to visually solve a problem, whereby she counted *imaginary circles* situated within an on-screen graphical object in Mathletics, an idea that could inspire, and perhaps be further translated into, design features in future mathematics practice activities.

In terms of improving the broad pedagogic design of Mathletics, the data shows that the learners typically avoided reading the textual questions, preferring to engage with graphical questions/ scaffolds and/ or numerical questions, to solve the mathematics problems. This could be problematic from a number of viewpoints, the first being that learner avoidance in reading the textual questions may lead to issues in the long term in their (textual) literacy level, and secondly, moving quickly to graphical supports may suggest a non-cognitive - ‘trial and error’ - approach is being prioritised over more authentic cognitive/mental model of engagement by the learner, the downside of which is that the only very superficial forms of learning results in the latter case. To support the enhancement of textual literacy within the pedagogic design of the mathematics practice activities, it may be better to present textual questions in the first few seconds and allow time for learners to read the question before presenting any visual scaffolds or numerical alternatives. Alternatively, perhaps some of the questions presented should solely be presented in textual form to force learners into improving textual literacy, and other questions might only be presented in numerical form to enhance their numerical literacy. With respect to the latter, it should be noted that there is a danger in learners bypassing questions presented in a single format if they cannot reconcile how to solve it in that format (as shown in the case of a Grade 1 learner in this study), and thus as a general rule it would appear that at least two representations of the question would be required within the interface. Finally, it is necessary to point out that the framing of the textual questions could be improved within Mathletics, as some of the questions were difficult for those with English as a second language to fully comprehend.

In terms of improving the aesthetic design of Mathletics activities, the learners in the case studies provided some interesting feedback particularly on where there is redundancy within the Mathletics interface. None of the learners in the case studies actively engaged with the Avatar, or the Hint icon. Furthermore, in many cases, hint boxes were provided alongside multiple representations of the question (in textual, graphical and numerical forms). One of the participants had particular difficultly with this and articulated that it caused confusion for her. This calls into question the existence of the Hint box as learning support and/ or the Avatar as a motivational element on the interface, and the findings would indicate that they constituted *redundant* design features of Mathletics for the learners in this study. Therefore, the inclusion of elements claiming to support learners needs to be critically considered to avoid over-scaffolding or indeed, confusing learners.

Other aesthetic considerations of concern included the issue of a single colour being used in some graphical scaffolds/ representations, which caused confusion for some learners, indicating a need for more careful consideration of how the colour scheme within visual representation can better scaffold learners understanding of the mathematics problem. Interestingly, the data also showed the need for careful consideration of the cultural roots of learners when software such as Mathletics is being adapted for use in other jurisdictions. In the context of the case studies, one learner was observed reading from right to left the visual information presented on the graphical supports (which needed to be read from left to right), which in the case of mathematics problems involving decimals ultimately results in the answer being incorrectly calculated. Designers need to carefully consider how best to design visual scaffolds for learners coming from Arabic and other settings with natural inclinations towards reading 'diagrams' and 'visuals' from orientations different to those from the left-to-right orientation of learners from the West.

Finally, some learners experienced delays due to weak Internet connections, and this caused considerable frustration. Therefore, proper Internet connectivity really is a pre-requisite for engagement in learning in online mathematics practice activities within platforms like Mathletics.

4.5 Overall Conclusions from Phase 1 in International School

This first phase of the multi-phase mixed methods study utilised a qualitive approach and tools to explore the following questions: *How is mathematics education presently being performed by teachers and learners in Grades 1 to 3 in a Saudi International primary school?, and, What impact, if any, does the integration of online gamified mathematics 'practice activities' have on learning* in Grades 1 to 3 *in this Saudi context?*

With respect to the first question, the study showed that Saudi teachers engaged in predominantly teacher-led approaches to learning which did involve a significant amount of teacher *demonstration* of problem-solving strategies, but it was heartening to see their promotion of high levels of collaborative and peer learning opportunities in their facilitation of mathematics education across all grade levels. Furthermore, it was good to see the utilisation of physical resources to help learners understand key concepts in mathematics. In addition, learners were regularly invited to present or explain their understanding to peers in groups and in whole class discussion. In terms of the practice of mathematics, there was a heavy reliance on textbook for guidance and for practising mathematics in the traditional setting, and the absence of individual feedback on mathematics practice activities during class was a cause of concern. In contrast to this, the study showed that the integration of the online practice activities through the Mathletics platform resulted in significant visual and auditory expressions of excitement by learners, and corresponding high levels of engagement and collaboration in terms of completing the online mathematics practice activities. The Mathletics results also show that game elements such as points, certificates, progress bars, a friendly 'competitive' environment, direct feedback and profiles are factors that positively impact on learners' engagement and motivation. The case studies further highlighted areas for improvement in terms of the pedagogic and aesthetic design of Mathletics, including but not limited to: the framing of textual questions, promotion of textual literacy alongside numeracy within mathematics practice activities, removal of redundant scaffolds such as Hint box and unused features like the Avatar, and deeper consideration of the implication of cultural habituations in language acquisition (such as reading from right to left in Arabic contexts) in the design of graphical/ visual activities.

Finally, a limitation of phase one of this study was that it was not possible to examine improvements in academic performance in the absence of pre- and post- mathematics tests. Furthermore, while learners' dispositions were observed during this phase, it was felt that an additional tool to examine their dispositions pre- and post- engagement within traditional and Mathletics sessions would be beneficial in terms of further triangulation of data-sets from observations, interviews, and the Mathletics platform. Therefore, it was decided that in phase 2 of this study, two groups would be formed, namely, the Control group and Mathletics group, so that factors including dispositions and performance could be examined in more detail at each grade level, within the public school setting of a Tatweer school.

Chapter 5: Phase Two: Findings from Tatweer Public School Context

5.1 Introduction

This section summarises the findings from the second phase of the research, which comprised a comparative review of mathematics education in traditional mathematic practice sessions, with those that integrated online practice exercises using Mathletics, with Grade 2 and Grade 3 learners in a Tatweer public school in Saudi Arabia. These groups of learners and their teachers were observed during 8 separate mathematics sessions ranging for circa 40-45 mins over a 4-week period in from February to April 2016. This section opens with a re-cap of the methodology for this phase of the research, and progresses to present the findings from the Grade 2 learner group, followed the findings from Grade 3 learner group, with overall conclusions in latter part of the chapter.

5.2 Phase 2 Methodology

This second phase of the multi-phase mixed methods study utilised a mixed methods approach, including qualitive and quantitative tools to explore the following questions:

- *How is mathematics education presently being performed by teachers and learners in Grades 2 and 3 in a Saudi Tatweer public primary school?*

- *What impact, if any, does the integration of online gamified mathematics 'practice activities' have on learning* in Grades 2 and 3 *in this Tatweer public school context?*

With respect to the first question, the study aimed to explore the teaching and learning approaches and strategies currently used by teachers in this Tatweer public school to teach conceptual knowledge and to practice mathematics concepts in Grade 2 and Grade 3 contexts, as well as the interaction and engagement of learners within these traditional spaces. In terms of the second question, the study attempted to examine whether the integration of online gamified mathematics practice activities affected learners' disposition, engagement, motivation and/ or academic performance in Grade 2 and/ or 3 contexts in the Tatweer public primary school context.

Although the research questions are the same, this phase differed from the first phase in that it included a control group at Grade 2 and Grade 3 levels, that could be used in a comparative review within each grade level. The control group was taught and engaged in practice mathematics activities in the traditional way, and the other group were taught mathematics concepts in the traditional way but practised mathematics using Mathletics, the online mathematics practice platform. Basically, the entire cohort of learners in the Integrated Group were taught the mathematics concepts together in a traditional way, but the learners within the Mathletics (sub-) group were allowed to complete the mathematics practice activities using Mathletics, whereas the others had to complete the practice activities using the workbook (hence, the latter have been named as the Workbook Group, WG), as shown in Figure 5.1.

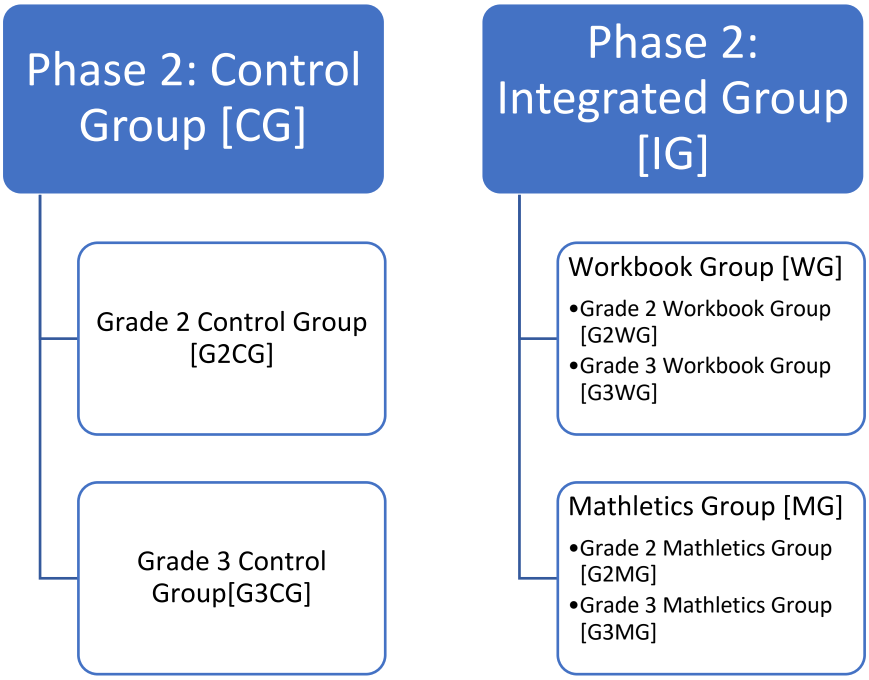


Figure 5.1 Overview of Participant Groupings in Phase 2

Furthermore, the range of data-collection tools was extended to include quantitative tools, in order to assess and compare learner dispositions and performance/ability before and after the interventions.

Research Phase 2

Data Collection Time- Jan-May 2016

Research Approach: Qualitative & Quantitative Research

Focus of Research -

- Critiquing teaching and learning approaches used, and learner engagement, in traditional mathematics education sessions

- Compare and contrast experiences of learners across two groups, one of whom uses Mathletics to practice mathematics and the other uses traditional teaching approaches to practice mathematics exercises.

Cohort - Grade 2 and 3 learners, teachers and parents in Public School in Saudi Arabia.

Particpants' Numbers- Grade 2 CG (n=19)

MG (n=10), Grade 3 CG (n=20), MG (n=19), Three Teachers and Five Parents (Mothers).

Number of Sessions: Grade 2 (8) and Grade 3 (8)

Data Collection Tools - Survey instrument, Mathematics Performance test, class observation notes, interviews with teachers, parents and learners.

Data analysis: Paired t-tests, Thematic coding

Other Minor Focus: Qualitative data on Teachers' ICT skills, use and training. (n=3)

[NOTE: CG=Control Group; MG=Mathletics Group]

Figure 5.2: Overview of Phase 2 Research

In this regard, two new survey instruments were used, one examined learners' levels of interest, confidence, anxiety and Satisfaction and the other was a mathematics performance test, each of which were deployed pre- and post- intervention with both the Control Group and the Mathletics Group, with Grade 2 and Grade 3 learners. The qualitative dimension of this mixed method approach in phase two included the collation and analysis of data-sets from whole class observation, interviews with 3 class teachers and focus groups with three learners from each grade level. As in phase 1, a small amount of data were also gathered in phase 2 relating to the teachers' ICT experience, access to technology, and professional development, and this data-set is blended into findings in chapter 6, which presents the overall findings relating to Saudi teachers' readiness to integrate technology in their practice. Furthermore, it is important to note that it was not possible to gain access to Grade 1 learners in the Tatweer school during phase two, and therefore, they could not be included in this phase of the study.

5.3 Grade 2 Findings Tatweer School

This section opens with a short description of the teacher and cohort of learners in Grade 2 class, and then moves forward to summarise the findings on the general pedagogic approaches and nature of learner engagement in traditional mathematics and Mathletics sessions, with the conclusion section comparing and contrasting findings relating to learner dispositions and performance in traditional mathematics sessions, with those that integrated Mathletics to facilitate the online mathematics practice.

5.3.1 Grade 2 Control Group Tatweer School

This section summarises the findings from a review of learner and teacher interactions in mathematics sessions that used traditional practice exercises from workbooks with Grade 2 learners in Tatweer School in Saudi Arabia, heretofore referred to as the Control Group (CG) for Tatweer school. This group of learners and their teacher were observed during 12 separate mathematics sessions ranging for circa 40-45 mins over a 4-week period in February/ March 2016. This section opens with a short description of the teacher and cohort of learners, and then moves forward to summarise the findings on the general pedagogic approaches and nature of learner engagement in the traditional mathematics sessions.

5.3.1.1 Grade 2 Control Group: Background Information

The Grade 2 Control Group Teacher [CT2] had four years' experience teaching at primary level (lower level), and was in her second year at this Tatweer school during the period of study. The teacher was female, and her primary subject degree was Islamic Studies. The teacher indicated that she had undertook three months ICT professional development, that was organised by Ministry of Education and considered herself to have basic level of knowledge of integration technology in education. This teacher was their class teacher; thus, she taught this cohort the majority of the curriculum (including mathematics). The mathematics sessions were taught through Arabic.

There were 29 Grade 2 learners (aged 7-8 years) in the control group. These learners were all female and came from Saudi Arabia and a range of other Middle Eastern countries, with Arabic as their main language. The learners engaged in five 40-45minute sessions of mathematics classes per week (including the observed session), and covered mathematical topics including Measurement, Addition and Subtraction during the latter part of the year.

5.3.1.2 Grade 2 Control Group: Pedagogy in Introducing Mathematics Concept/s.

Generally, the Grade 2 Control Group teacher opened the mathematics sessions by reviewing the previous topic. She used three strategies to revise the previous topic. The teacher provided the learners with individual feedback by rotating around the classroom and correcting individual homework. She also engaged the whole class in a question and answer-type approach to engage learners in discussion of the homework questions or previous topic. On several occasions, she typed the question from the previous topic on the white-board and invited the learners to answer within a whole-class discussion.

Following this, the teacher presented a new mathematics topic at the outset of each session. The teacher used different strategies to present the new topic. She sometimes started the new topic by explaining the goal setting for the sessions. The teacher was observed generally actively encouraging leaners' engagement in the new topic by asking general questions related to the new topic. She fostered opportunities to develop 'textual' literacy in mathematics class, by asking one of the learners in each session to read the information about the new topic. She also invited the learners to lead on occasion in whole-class learning. For example, in the first session the teacher asked one of the learners to come up to the board and use the cubes to measure one of the shapes that the teacher drew on the board and write the results. Furthermore, the teacher generally provided opportunities for collaborative learning and group discussion [observed during all sessions]. She usually asked the learners to work out mathematics textbook activities (following teacher-led explanation of mathematics concept/ problem-solving) in groups. For example, in session 7, the teacher then asked a question 'Is the big thing always heavier than the little one?' [referring to weights of grams and kilograms]. She let the learners work in the groups to find the answer for themselves and asked them to give an example of their answers and share their results with their friends. She also connected learners to real-life problems by asking them to engage in discussion of authentic, real-life examples of the mathematics problem in their groups.

The class observation further revealed that the teacher used a variety of resources. She usually orally presented the new mathematics concept using the white-board [observed during all sessions]. She also deployed digital resources to display mathematics concept, again observed during all sessions. For example, she used the digital copy of mathematics book (on a CD) to introduce the new topic. The teacher in her interview confirmed that she uses technology in her classroom such as the digital projector and PowerPoint software to make the lesson more enjoyable, whilst recognising that using technology can save teachers' time and effort, '*Technology is the essence of the life. It makes the lesson more enjoyable. It saves time and teacher effort. I usually use PowerPoint and Projector that is it. I can see these help learners to understand the lesson more easily because they can see, hear and write'* [CT2]. The teacher in her interview further stated that the lack of resources such as computers and the Internet access was the main reason that technology was not integrated more in the classroom. It is important to note here that the teacher was not observed actually using a Power-point presentation by the researcher at any stage during the observed sessions.

The teacher was observed on multiple occasions deploying physical resources, specifically wooden cubes and rulers to help learners to explore and understand the new topic. For example, in session 4, the teacher started the lesson by distributing small cubes that learners could use to measure items.

Learners frequently were observed actively participating throughout the observed sessions, with many volunteering answers for questions posed by the teacher. For example, on one occasion the teacher posed a question about what a doctor checks first during a patient visit [within the mathematics thematic area of Measurement]. Some of the learners volunteered answers, including: 'the doctor check on the temperature', … one of the learners said 'the doctor check on the weight…', some of the learners loudly called out their own weight in kilograms and one of them compared her weight to her brother weight [session 7]. Generally, learners worked in their groups and helped each other to provide answers. The teacher called on individual learners from each group to present their answers / solutions on the whiteboard during all sessions.

However, the class observation shows that on some occasions some of the learners displayed a level of anxiety with more challenging questions – with learners expressing frustration with the mathematics activity out loud - for example, in session 10, the teacher asked learners to answer the third question (higher order thinking question), which many learners appeared to have difficulty with and thus requested additional explanation from the teacher. This finding is in line with what the teacher stated in the interview - 'Some *of the questions are very hard so some of the learners expressed anxiety from these questions if they do not understand in the classroom. They asked to re-explain, especially higher order thinking activities*' [CT2].

Furthermore, some learners across all sessions expressed a lack of interest in new topics being presented. These learners sat quietly, un-focused and would mess with each other. The teacher generally had to reprimand learners for chatting informally or distracting others on these occasions. The Grade 2 learners in the interview explained some of the reasons that make them to display a lack of interests included a long and/or difficult lesson, or longwinded explanations by teacher. Learner G2CC1 said that '*I like mathematics but sometimes I do not, and I lose concentration when the teacher takes too long to explain*'. Learner G2CC2 stated that '*I lose concentration because the teacher sometimes talks too fast*'. Learner G2CC3 '*Sometimes, I got so bored in mathematics class sometimes and I feel like the class is too long*'. Learner G2CC4 '*When the lesson is difficult, I feel it becomes longer and I loose concentration'*. However, one of the learners mentioned that interactive activities makes a lesson more interesting, Learner G2CC4 explained that '*but if the teacher brings some things, for example cubes, or models, the lesson becomes more interesting'*. The teacher in her interview confirmed that '*Mathematics is a hard subject that requires hard work from the teacher to hold the learners' attention and keep them on task*'[CT2], thus recognising the challenge in maintaining learner attention and progressing them through activities on occasion.

5.3.1.3 Grade 2 Control Group: Pedagogy of Mathematics Practice in Traditional Setting

Once the Grade 2 teacher explained the new topic and did some practice exercises from the mathematics textbook, she then generally directed the learners to use the workbook for more practicing in class time and this work was submitted to the teacher once completed. The teacher did not generally provide direct feedback on the learners individually within the mathematics class, she sometimes asked the learners to drop the workbooks on her desk or bring them to her the next day to check.

The teacher was observed using different approaches to engage the learners in practicing mathematics activities. She encouraged the leaners in all sessions to work in groups or individually on mathematics practice activities within the workbook. She also supported cooperation in all sessions by directing one learner in a group to help her friends in solving mathematics problem or help them to read the textual questions. On several occasions, she encouraged peer assessment by directing the learners to check each other's work. The teacher also undertook a role of facilitator across all sessions by moving around and checking on their work, and by offering support and advice when needed and providing scaffolding as and when necessary.

In terms of learners' interaction in mathematics practice activities, the class observation revealed that most of the learners completed the mathematics activities. Some of the learners were observed working more cooperatively on the mathematics practice activities. They helped each other to solve the math problems. However, there were some learners who disengaged with the group work and prefer to work on mathematics practice activities by themselves. Furthermore, some of the learners displayed a lack of interest in practicing the mathematics activities. They for example closed the workbook before completing the assigned activities or copied the answer from friends and had informal chat. The learners in the interview explained that they prefer to work on easy questions only. Learner G2CC1 said that '*I like when the teacher asks an easy question. But when she gives us a hard question, I got so bored and I lose concentration…*'. In addition, there were some learners who displayed levels of anxiety [for example, learners expressing frustration by groaning or sighing, or holding head in hand accompanied by groans- observed in sessions 5 and 8, and/ or throwing down pen – observed in session 4,] with the more challenging questions in workbook. In cases such as this, learners did ask the teacher for more explanation, and frequently the teacher would lean on digital resources such as CDs to further explain mathematics activities on the white-board, where needed.

The class observation revealed that some of the learners exhibited initiative in attempting more advanced mathematics practice activities at home, and thus when teacher directed them to start the activity in the workbook, the activity had already been completed at home in advance of class – this was observed to happen with one/ two learners across all sessions.

The interviewed learners said that they tried out the activities before the teacher explained in school because they felt it would help them to understand and also that they hoped to get a reward for doing so. Learner G2CC2 said that '*I like to do the activities at home before we take with the teacher because it helps me to understand fast and the teacher gives me a gift'*. Learner G2CC4 stated that '*I like to do the workbook activities when the teacher still explaining the new topic. Because when the teacher asks us to do the workbook activities, I showed her my answers, and when all answers are correct, the teacher gives me a gift like pencil or rubber. The teacher usually brings very nice gifts*'.

5.3.2 Grade 2 Integrated/ Mathletics Group Tatweer School

The Grade 2 Mathletics Group (MG) was part of an overall grouping called the Integrated Group. Basically, the entire cohort of learners in the Integrated Group were taught the mathematics concepts together in a traditional way, but the learners within the Mathletics (sub-) group were allowed to complete the mathematics practice activities using Mathletics, whereas the others had to complete the practice activities using the workbook (hence, the latter have been named as the Workbook Group, WG).

A different teacher taught the Grade 2 Integrated/Mathletics group. This teacher [IT2] had seventeen years' experience teaching at secondary level, and was in her first year at this Tatweer school during the period of study. The teacher was female, and her primary subject degree was Home Economics. The teacher indicated that she had undertook one month of ICT professional development, that was organised by Ministry of Education, and considered herself to have basic level of knowledge of integration technology in education. This teacher was their class teacher; thus, she taught this cohort the majority of the curriculum (including mathematics). The mathematics sessions were taught through Arabic.

There were 29 Grade 2 learners (aged 7-8 years) in this IG grouping. A total of 10 learners out of the 29 learners used the Mathletics platform and the remaining 19 in the WG undertook traditional workbook activities. The learners in both sub-groups MG and WG were observed and their engagement is reported. These learners were all female and came from Saudi Arabia and other Middle Eastern countries, with Arabic their main language. The learners engaged in five 40-45minute sessions of mathematics classes per week (including the observed sessions), and covered mathematical topics including Measurement, Addition and Subtraction during the period of study.

5.3.2.1 Grade 2 Integrated Group: Pedagogy in Introducing Mathematics Concept/s

Based on the class observations, the teacher used a variety of the approaches to check on homework and revise the previous topic. She provided individual learner feedback by rotating around the classroom to check homework, or on some occasions, she reported checking on the learners' homework before the mathematics class, which she distributes to individual learners at the outset of the class. She also engaged the whole class grouping in discussion on homework and/ or previous topic. For example, on one occasion, it was a new chapter, so, the teacher decided to do the preparation activities which covered all previous topics connected to Measurement before she started the new topic 'Nonstandard Length Units'. When all questions were answered on the board, she asked them to write down the answer [session 8]. The teacher also encouraged peer assessment of homework. She usually asked the group leaders to check on her friends' homework.

Once the previous topic was revised, the teacher was observed explaining the new topic. The teacher sometimes started the new lesson by explaining the goal setting for the session. The teacher used a variety of strategies to deliver the new topic. She encouraged learners to actively participate in the new topic. She usually used question and answer to stimulate leaners thinking about the new topic. She also facilitated group-work and gave the learners opportunities to work on the task and share ideas. For example, in session 4 the teacher gave each group different size of cubes (1cm, 5cm..) and asked to measure their own stuff [book, erasers, etc.] using these cubes and write the answers. After a while, she asked one learner from each group to read their answers. She also invited leaners to answer on the board. She further attempted to enhance literacy development in mathematics class, by asking at least one learner to read the information or the questions about the new topic out loud in each session. The teacher however in her interview did highlight a challenge in encouraging participation of learners, on that '*some of the learners like to read the word question out loud but others needed help in reading*'*[MT2]* and thus not all learners would not be inclined to actively participate if asked to read. The teacher also made the lesson relevant to the learners by connecting the mathematics problems with real life examples. She usually gave them a real-life problem and used whole class or group discussion to answer.

The teacher was observed generally using the white board and digital resources such as Digital Mathematics Book (on CD) to display and explain the new topic. The teacher in her interview confirmed that she uses technology in her class '*I use technology such as Projector, PowerPoint and Microsoft Word' [MT2]*. [Note: the teacher used neither Power-point nor Word during the period of observation]. She mentioned some of benefits of the integration of technology in the classroom - '*Technology is useful in some lessons, it saves time and teacher effort'[MT2].* On other occasions such as those observed in the teacher used physical resources such as wooden cubes and ruler to help leaners to understand the new topic

In terms of learners' interaction, the class observation revealed that most of the learners expressed interest in the new topic. They typically actively participated in the new topic and volunteered to provide the answers to questions posed by the teacher. The learners worked in their own groups using the materials that were provided by the teacher on the new task and tended to help each other. For example, in session 5 the learners were doing the activity in the group and helped each other to use the ruler. They argued about how they can perform the measurement, whether to start from zero or one.

However, there is evidence from the class observation that reveals some learners expressed level of anxiety with challenging mathematics activities. So, they orally expressed frustration and did ask the teacher for more explanation. Others on the other hand expressed a lack of interest in the new topic. They sat quietly and messed with other. The teacher therefore gave out to them for chatting informally or distracting others.

5.3.2.2 Grade 2 Integrated Group: Pedagogy of Mathematics Practice in Traditional Setting

All learners in the integrated group were asked to complete at least one question from the workbook (as this is a mandatory requirement of the Saudi curriculum). However, 10 of the learners were allowed to move away from the workbook and use the Mathletics platform to practice mathematics, once this question had been completed, and the remaining 19 learners had to continue answering questions from the workbook. The section below describes what was observed during 'workbook activity' across the Integrated Group, thus it summarises

for the record the interactions from the Workbook Group in their practice of mathematics problems.
The teacher encouraged cooperation across the WG, directing learners to help other group members. In session 11 for example, one group member had difficulties in ‘Add Numbers: Regroup a Ten’ activities. So, she asked the teacher for help, the teacher was busy with one of the learners, so the teacher asked one learner from other group to help her friend. She also encouraged peer assessment by asking the learners to exchange and correct each other’s work. The teacher also played a role of facilitator and offered scaffolding when needed for those experiencing difficult in solving mathematics problems.

The learners generally engaged in cooperation within the groups and explained to each other how to solve problems. However, evidence from the class observation revealed that some of the learners disengaged in the group and prefer to work alone on solving the problem. The class observation further revealed that other learners expressed levels of anxiety with more challenging questions, and these learners asked the teacher for more explanation. In session 8 for example, the learners got frustrated in trying to measure the length of one of the shapes in the workbook. So, one of them asked the teacher, how can we use these cubes to measure something that is very long? Furthermore, the class observation revealed that some of the learners attempted workbook activities at home before it was explained in class with the teacher. Furthermore, there were some cases who expressed a lack of interest in the activities. They moved around, messing with other and had informal chatting with friends.

In terms of the learners’ interaction, some of the learners completed the assigned activities and submitted to the teacher to check. In all sessions, they tried to complete the workbook activities as fast as they could and those in the MG usually would ask about the time to play Mathletics. Those who had to continue using the workbook, i.e. those 19 learners in the Workbook Group, displayed signs of frustration at not being able to engage with Mathletics software and frequently tried to informally interact with those in the Mathletics Group. The WG learners frequently stopped working on the workbook activities, and would try to engage with the Mathletics activities. In all observed sessions, most of the WG learners were observed pulling the laptop with Mathletics from a learner in the MG in an attempt to complete the Mathletics mathematics practice activity. In Session 4, one of the MG learners was observed asking for help from WG learner and became frustrated when the WG learner clicked the correct option (instead of allowing her to do so). Other WG learners cried out on occasion out of frustration and upset at not being able to engage in Mathletics (observed in session 1, 2 and 3).

5.3.2.3 Grade 2 Mathletics Group: Pedagogy of Mathematics Practice in Mathletics Setting

Generally, the teacher allowed those learners using the Mathletics platform to engage in self-directed learning. She moved around to check on MG work and encouraged other learners to share and help their friends. The teacher also provided scaffolding when needed. For example, in one of the activities, some of the learners needed a little more help with the Mathletics practice activity, so they asked the teacher about how they can use the ruler in the game (the learners were taught to use the ruler from right to left to measure the length (Arabic mode), whereas Mathletics activities were presented to use the ruler from left to right (Western/ English mode). The teacher when interviewed re-iterated the importance of the teacher in technology-enabled settings, such as that supported through Mathletics. She said that '*This technology (Mathletics) never replaces the teacher, 'the teacher is like a key of the box' especially for this age'* [MT2].

The class observations revealed that the learners enjoyed playing and seemed enthusiastic with the Mathletics platform. It is interesting to note that their excitement did not appear to reduce during the overall period of the observation. Indeed, on many occasions the researcher had to shut-down the wi-fi connection to bring a close to the Mathletics sessions and/ or the teacher had to take each device from the MG learners, as learners simply refused to stop engaging with the Mathletics practice activities. The teacher in her interview noted that the level of the learners' interest towards mathematics increased when using Mathletics, '*Mathematics is one of the subjects that the learners like because it related to their life such as money, time, addition and subtraction. But the presence of the game has increased enthusiasm for Mathematics'*[MT2]. She therefore strongly recommended integrating this technology into mathematics classrooms, particularly for practising math-based activities, '*but it is good after I have explained the lesson as an additional course, so they can practice by using the game'*. The teacher however, suggested to have a separate class timetabled to use this technology because mathematics class time is not enough. The teacher stated that '*I suggested to integrate such technology as an additional course two to three time per- week* *because mathematics class is not enough. I take 20-30 mins to explain the new topic and the learners have to practice what they have learnt in the workbook. And also, learners need time to have access to the game'*[MT2]. So, she suggested to integrate this technology in school time, but this integration should be specifically planned, '*So, I suggest integrating this technology at school time because it really increases their enthusiasm in mathematics class. It should be integrated with clear plan.'* The teacher also highlighted the need for technology in-situ, stating that: *'It is necessary to have equipment in school such as devices, Internet and the game itself'* [MT2].

Also, the interviewed learners explained some of the benefits of using Mathletics in the classroom. Learner G2MC1 said: *'I like mathematics class, but when you bring Mathletics game, I became more concentrated when the teacher explains. I want the teacher to finish fast so I can practice by the game and understand more…The game also helps me to understand so when I have difficulty in understanding mathematics, I can play more and more'*. Learner G2MC2 stated that*:' I like mathematics class, but I became more focus with the teacher when she explains. Mathletics helps me to understand more and I became faster and smart in solving the problems because I solve them in my head and type the answers'*. Learner G2MC3 stated: '*I like mathematics class, but I like it more when we started playing Mathletics. The game makes me more focused and better at mathematics because I answer in my head and then type the answers. The most things that I like to play is addition and subtraction. These two topics were hard but now became easy because I play over and over again'*. This is in line with what one of the mothers said in the interview '*My daughter likes mathematics but this game (Mathletics) makes her better at math. She can solve the problems in head and then type the answer. Since this game introduced to the school, my daughter was so excited about mathematics class. She asked to charge the device before went to bed so it will be ready for the next day'* [M1].

Furthermore, the learners created challenge groups within various Mathletics activities, and expressed their enjoyment in competing and collaborating with their peers and used the activities as a chance for a challenge. The learners were observed self-organising into challenge groups in which the person who finishes first is the winner. The winner typically showed her happiness, such as by raising her voice, saying "*I won*". As previously mentioned, the learners in WG group were observed providing help to their friends so they can win the competition – sometimes this help was requested, other times it was volunteered by WG learners. During the interviews, the interviewed learners confirmed that they prefer to play at school because of the presence of their friends. Learner G2MC1 '*The most enjoyable thing is to play with my classmates'*, Learner G2MC3 *'I play at school and at home, but I like to play at school because of my friends'*. Sometimes, MG learners expressed frustration at WG interventions in their learning activity.

Additionally, the class observation revealed that the learners in this MG group exhibited a desire for collaboration. They were frequently observed explaining how to solve the problem to each other. This was confirmed by the learners in the interview. Learner G2MC1 said that '*At the beginning, I didn't know how to do the activity. When I have joined my friends, I have learnt how to play'*, Learner G2MC2 said that *'...But I like to play at school with my classmates. Because when I need help, I can ask them'*. However, there is evidence showing that there were some learners who preferred to work alone in the Mathletics activity. For example, one of the learners generally sat by herself in her seat and did the all the Mathletics activities by herself throughout the sessions [G2MC1].

The learners were also able to connect with global competitors within the 'Live-Mathematics', and this appeared to increase their excitement. This engagement was shown to be a fun learning experience for participants in this study. The learners were extremely happy when they found each other in the game 'Live-Mathematics'. The race winner showed her happiness by raising her hand, saying for example, "I won", moving around, and showing the teacher her achievement. The learners were able to move to the advanced level (second level) and challenge at this level within 'Live Mathletics'. However, in general learners played at the first level so that they could score more points and win more games.

Learners appeared to be motivated to stay on task by tracking their own progress and sharing this with their peers. The learners were also observed repeatedly returning to the activities to improve their final scores and respond with the correct answers. When the learners received their final feedback with only a few mistakes, they tried the activity again to see if they could get all correct answers. One of the mothers said in the interview, '*The game can provide the feedback so, she can play multiple times until gets the correct answers. For example, she had difficulty in one of the topics, I think 'Addition' but when she played the* *game it became easy because she repeated the activities over and over again and she can see her progress'* [M2]. The learners further demonstrated pride in their achievement when they completed the activity without help and without mistake - Learner G2MC1 '*Now I can play by myself – there is no need for anyone help me. But if I need help, I will ask my mother because I play most at home'*, learner G2MC2 *'I am proud of myself that I can play without help'*.

Moreover, the class observation reveals that the learners exhibited the desire to engage in the platform beyond the class. The leaners in the interview confirmed that they visited the activities at home. Leaner G2MC1 '*I played at home, I played the previous lessons such as Measurement, Geometry'*, G2MC2 *'I play Mathletics at school and at home'*. This confirmed by two different mothers interviewed: '*When my daughter came back home, she played about half an hour. she talked about the game with her siblings. She can play the game by herself, she never asks for help'* [M1], and '*Generally, my daughter is independent she never asks me for help unless she did not get the answer. But after the integration of this game (Mathletics) she never asks for help. She usually finished her homework and then played the game. She visited some of the activities that they took at the beginning of the semester and practiced something new. She talked with her brother about the excitement that she had when she played with her friends in the classroom and the activities that they played together and who won the competition. She encouraged her brother, who is a year older than her, to have an account and play the game'* [M2].

The Grade 2 learners in this group appeared to be motivated by some of the game elements such as points and certificates. They physically moved around the classroom to share with each other the number of points being earned. The learners in the interview confirmed that they enjoyed collecting points. Learner G2MC1 '*I like to play Mathletics to collect the points and to win the competition. I have 78 points that I have collected right now. I have only one certificate, so I have to play a lot to collect more points and have another certificate'*. Learner G2MC2 *'I have 400 points and one certificate. I have to play more to get more points'*, G2MC3 *'I like to collect points. I have 100 points and last week I had 1200 points. I have one certificate'*. So, this encouraged them to play more. Learner G2MC3 for example said that '*So, if I cannot receive a certificate, I have to play more'*. However, some of the leaners expressed sadness if they weren't able to collect points. Learner G2MC3 for example said that '*But if the week passed and I did not have a certificate, I will be so sad*'. Also, the interviewed mother supported this point, one of the mothers said that '*My daughter plays the game (Mathletics) at home because there is a challenging between her and her friends about the points that lead to the certificate. When she got a certificate at the first time, she was so excited. So, she played a lot to get more certificates'* [M2]. This mother also mentioned some of the benefits to learners when they bring their own device to school, she said that '*I am so excited about the integration of the iPads at school. This gives the kids confidence that they can take care of their own stuff. The kids are so happy to bring their own device and play with their friends at school. Also, I think bringing their own device at school will develop a good relationship between home and school. Our kids will be so excited to talk about the activities that they will do with their friends and the competition that they will make at school'* [M2].

Despite learners enjoying the Mathletics experience, some learners noted the importance of the teacher, mentioning the strategies that the teacher does to support them with more challenging questions. Leaner G2MC1 said: '*I have difficulties with the test and some of the activities. But the teacher helps us for example she re-explains when we need, she lets us to practice on the board, she lets us to help each other and sometimes she brings games. When we have difficulties in some of the questions such as higher order thinking question, the teacher writes the question on the board and explains it until we got it. So, the game the you gave us (Mathletics) is useful but the teacher is important because she teach us and take care of us*'. Learner G2MC5 noted: '*I had difficulties with some hard questions like higher order thinking questions, but the teacher help us. She re-explained for us individually, she lets to practice on the board, she lets us to practice the hard activities at home. So, I can say the teacher is important for us. So, the game that you gave us (Mathletics) is useful but it never replaces the teacher. We have to have a teacher to teach us reading, writing and mathematics and then practice in the game. But this game (Mathletics) helps me to revise the previous topic and I feel like I became smart because I answer in my head and then type the answer in the game'*. Learner G2MC6 further commented: '*In mathematics, there are some hard questions. but the teacher helps us. She lets us work in groups to help each other and she gives us real life examples. So, I agree with my friends that the game (Mathletics) is useful but could never replace the teacher. The game helps to practice more and revise the previous topic'*.

However, there were some learners who expressed a lack of interest of some of mathematics practice activities because of the aesthetic design of particular activities within the Mathletics platform. These learners therefore disengaged with these activities and tried to practice other activities. For example, the learners were asked to do Mathletics activity, ‘Adding Three Digit Number- Regrouping’. The learners did the first few questions using pencil and paper because they could understand how to complete the question within Mathletics, and subsequently they closed the activity and tried to do other activities. Another example was when they were asked to do Mathletics activity ‘Estimated Addition’, the learners tried the first question only. They found this question very hard, and there was a sign (≈) that the leaners did not understand. So, they disengaged with the activity and tried to do another activity and some of them moved to play ‘Live Mathematics’.

5.3.3 Grade 2 Comparison: Mathematics Dispositions within Control Group and Mathletics Group

As already explained, a survey instrument was used to gather data in relation to learners' dispositions towards mathematics pre- and post- intervention, in both the Control Group and Integrated/Mathletics Group for Grade 2 learners, and the findings are presented here under four headings: *Confidence*; *Interest*; *Satisfaction* and *Anxiety*. The Shapiro-Wilk test shows that the p-value for all variables were less than alpha level (not a normal distribution), therefore, the Wilcoxon signed-rank test was used. Anxiety for the Mathletics Group, on the other hand, was excluded from the Wilcoxon test, as the p value for this variable was bigger than alpha level (normal distribution). Instead, the Paired-sample t-test was used to examine Anxiety within the Mathletics Group. The paired-sample t-test is sensitive with outliers, hence, the outlier has also been checked to ensure not of significance.

5.3.3.1 Confidence. The Wilcoxon signed-rank test was performed to examine whether there was a significant difference in the score tests for learners' expressed levels of confidence in mathematics before and after the six-week intervention between the Control Group and Mathletics Group of Grade 2 learners. The CG exhibited no significant differences in their pre- and post-test confidence levels in mathematics education (Table 5.1). The same test was conducted to compare the effects of the online mathematics platform (Mathletics) on the learners' confidence in the MG. Table 1 shows no significant differences were observed in the pre- and post-test confidence levels for the Mathletics Group.

Table 5.1: Results of Wilcoxon Signed Rank Test of the differences between pre- and post-survey for both Control Group and Mathletics Group for the category "Confidence"

Category	Variables	Wilcoxon Signed Ranks Test Control Group N= 19		Wilcoxon Signed Ranks Test Mathletics Group N= 10	
		z	p	z	p
Confidence (C)	GM	-1.414	.157	.000	1.000
	WM	-.577	.564	-1.000	.317
	MM	.000	1.000	-1.414	.157
	EM	-1.732	.083	-.577	.564
	DM	-1.625	.104	-1.633	.102
	MH	-.577	.564	-.577	.564
	LU	-1.000	.317	-1.414	.157

Note. GM - Mathematics in general; WM - Written math problems; MM - Mental math; EM - Easy math tasks; DM - Difficult math tasks; MH - Math homework; LU - Listening and understanding in math class. P<.05

Therefore, the learners in both groups reported the same level of confidence regarding mathematics education (which included their confidence in: Mathematics in general, Written math problems, Mental math, Easy math tasks, Difficult math tasks, Math homework, and Listening and understanding in math class) in the pre- and post-intervention tests.

5.3.3.2 Interest. In order to test the Grade 2 learners' expressed interest in mathematics across the period of six weeks and compare the CG and MG, a Wilcoxon signed-rank test was performed (see Table 5.2). A statistically significant difference was observed in the pre- and post-test results in relation to the learners' interest in 'completing homework' (z value of -2.333 and significance at p=.020) in the Control Group. In this regard, the learners in the Control Group exhibited a **significantly decreased interest** in 'completing homework' in the post-test with a median score rating of 3.50. No significant changes were observed over time in the Control Group in the other mathematics education categories (Mathematics in general, Written math problems, Mental math, Easy math tasks, Difficult math tasks and Listening and understanding in math class).

Table 5.2: *Results of Wilcoxon Signed Rank Test of the differences between pre- and post-survey for both Control Group and Mathletics Group for the category "Interest"*

Category	Variables	Wilcoxon Signed Ranks Test Control Group N=19		Wilcoxon Signed Ranks Test Mathletics Group N=10	
		z	p	z	p
Interest (I)	GM	-.707	.480	.000	1.000
	WM	-1.732	.083	-1.414	.157
	MM	-.333	.739	-1.414	.157
	EM	-.187	.851	-2.000	.056
	DM	-1.133	.257	**-2.271**	**.023**
	MH	**-2.333**	**.020**	-.577	.564
	LU	-.647	.518	-.962	.336

Note. GM - Mathematics in general; WM - Written math problems; MM - Mental math; EM - Easy math tasks; DM - Difficult math tasks; MH - Math homework; LU - Listening and understanding in math class. P<.05

Regarding the effects of the online mathematics platform on the learners' interest in mathematics education in the Mathletics Group, a statistically significant difference was observed between the pre- and post-test scores towards 'difficult math problems', with z=-2.271. This value was significant at p=.023. Thus, the learners' interest in engaging with 'difficult math problems' **significantly increased** over time in the learners involved in the Mathletics Group (as shown in Appendix F), this result based on positive rank where the mean rank for Interest at post-test is more than the pre-test). However, no significant differences were observed in the Mathletics learners' interest in the other categories (Mathematics in general, Math Homework, Written math problems, Mental math, Easy math tasks, and Listening and understanding in math class).

5.3.3.3. Satisfaction. In order to test the Grade 2 learners' satisfaction in both conditions (CG and MG), a Wilcoxon signed-rank test was performed (see Table 5.3). No significant difference in satisfaction was observed between the pre- and post-intervention tests regarding mathematics education under both conditions. Therefore, both conditions achieved a similar level of satisfaction with mathematics education in all categories (Mathematics in general, Written math problems, Mental math, Easy math tasks, Difficult math tasks, Math homework and Listening and understanding in math class).

Table 5.3: Results of Wilcoxon Signed Rank Test of the differences between pre- and post-survey for both Control Group and Mathletics Group for the category "Satisfaction"

Category	Variables	Wilcoxon Signed Ranks Test Control Group N= 19		Wilcoxon Signed Ranks Test Mathletics Group N= 10	
		z	p	z	p
Satisfaction (S)	GM	-.730	.465	-1.000	.317
	WM	-.378	.705	-1.342	.180
	MM	-1.706	.088	-1.000	.317
	EM	-1.089	.276	-.368	.713
	DM	-.813	.416	-1.289	.197
	MH	-.541	.589	-1.000	.317
	LU	-.105	.916	.000	1.000

Note. GM - Mathematics in general; WM - Written math problems; MM - Mental math; EM - Easy math tasks; DM - Difficult math tasks; MH - Math homework; LU - Listening and understanding in math class.

5.3.3.4 Anxiety. A Wilcoxon signed-rank test was performed to test the Grade 2 learners' anxiety level in the Control Group (see Table 5.4). A **statistically significant difference** was observed between the pre- and post-test scores in the categories of mental math, and listening and understanding mathematics. The learners reported that their **anxiety** regarding both skills **increased over time** (Mental Math: $z = -2.139$, with significance at $p=.032$; Listening and understanding in mathematics class: $z =-2.525$, with significance at $p =.012$). Finally, the test showed no statistically significant differences between the pre- and post-test in the other categories, including Mathematics, Written math problems, Easy math tasks, Difficult math tasks and Math homework.

Table 5.4: Results of Wilcoxon Signed Rank Test of the differences between pre- and post-survey for Control Group for the category of "Anxiety"

Category	Variables	Wilcoxon Signed Ranks Test Control Group N= 10	
		z	p
Anxiety (A)	GM	.000	1.000
	WM	-.835	.404
	MM	**-2.139**	**.032**
	EM	-.421	.674
	DM	-1.261	.207
	MH	-1.698	.089
	LU	**-2.525**	**.012**

Note. GM - Mathematics in general; WM - Written math problems; MM - Mental math; EM - Easy math tasks; DM - Difficult math tasks; MH - Math homework; LU - Listening and understanding in math class.

As the data were normally distributed within the Mathletics Group, a paired t-test was also performed to test the effects of the online mathematics platform (Mathletics) on the learners' anxiety in those participating in the Mathletics Group. The differences between the pre- and post-tests in the MG in relation to anxiety were not statistically significant (see Table 5.5).

Table 5.5*:* Results of Paired t-test of the differences between pre- and post- survey for Mathletics Group for the category "Anxiety"

Category	Variables	Condition	Mathletics Group Paired t- test N= 10		
			Mean	Std. Dev.	P-value
Anxiety (A)	GM	Pre-test	4.8000	.91894	.574
		Post- test	4.4000	2.63312	
	WM	Pre-test	4.5000	2.22361	.271
		Post- test	5.4000	2.54733	
	MM	Pre-test	5.3000	1.82878	.842
		Post- test	5.5000	2.22361	
	EM	Pre-test	5.7000	2.49666	.927
		Post- test	5.8000	1.93218	
	DM	Pre-test	4.5000	2.59272	.588
		Post- test	5.1000	2.07900	
	MH	Pre-test	4.5000	2.75882	.428
		Post- test	5.3000	1.41814	
	LU	Pre-test	4.3000	2.71006	.718
		Post- test	3.8000	2.82056	

Note. GM - Mathematics in general; WM - Written math problems; MM - Mental math; EM - Easy math tasks; DM - Difficult math tasks; MH - Math homework; LU - Listening and understanding in math class.

Therefore, the participants in the Control Group exhibited increased anxiety levels regarding mental math and listening and understanding of the mathematics lesson. In contrast, no significant change was observed in the level of anxiety in any of the categories of Math Education (Mathematics in general, Written math problems, Mental math, Easy math tasks, Difficult math tasks, Math homework and Listening and understanding in math class) in the Mathletics Group.

5.3.4 Grade 2 Comparison of Academic Performance in Control and Mathletics Groups:

A paired-sample t-test was performed to compare the scores on the Mathematics Performance Test in the same group of Grade 2 learners pre- and post-intervention in both the Control Group and Mathletics Groups. The performance of the Mathletics Group was statistically significantly better (p=.002) at the post-test (mean 11.4) than at the pre-test (mean 8.75). In contrast, the Control Group exhibited no significant difference between the pre-test and post-test performance results (p= .63) (see Table 5.6).

Table 5.6: Results of Paired t-test of the differences between pre- and post- mathematics test for both groups.

	N	Pre-test		Post-test		t	p
		M	SD	M	SD		
Control Group	16	8.78	2.67	8.56	3.2	.492	.63
Mathletics Group	10	8.75	3.2.86	11.4	2.3	-4.441	.002

Furthermore, Table 5.7 shows that all learners (bar one who performed the same) in Mathletics Group gained better results in post-test by at least half mark, two learners (C1& C9) achieved highest result in their achievement of 14 out of 14 in the post-test.

Table 5.7: Summary results of pre- and post- mathematics for each learner in Grade 2 (Control Group and Mathletics Group).

Student's No.	**Mathletics Group**		**Student's No.**	**Control Group**	
	Pre- test (14)	**Post- test (14)**		**Pre- test (14)**	**Post- test (14)**
M1	11.0	14.0	C1	9.0	10.0
M2	8.0	9.0	C2	8.0	10.5
M3	10.0	12.5	C3	12.0	11.0
M4	4.0	9.5	C4	11.0	11.5
M5	9.0	13.5	C5	5.0	1.0
M6	9.5	9.5	C6	10.0	11.0
M7	6.5	11.5	C7	7.0	5.0
M8	12.5	13.0	C8	7.0	8.0
M9	12.0	14.0	C9	11.0	9.5
M10	5.0	7.5	C10	2.0	4.0
			C11	10.0	8.0
			C12	10.0	11.5
			C13	7.0	5.0
			C14	11.0	11.0
			C15	11.5	12.0
			C16	9.0	8.0

Only eight learners out of sixteen from the Control Group improved slightly their grades at the post-test compared to the pre-test, with 7 dis-improving their grade in this grouping. The highest mark was 12 (out of 14) and that was in case 15. Furthermore, the table shows that the academic performance of seven learners in the Control Group had decreased at the post-test (compared to pre-test), with one of these learners (C5) dropping from a mark of 5 out of 14, at pre-test to just 1 out of 14 at post-test.

5.3.5 Discussion of Findings from Grade 2 Tatweer School

This section summarises the findings relating to the performance of mathematics education, particular the dimension of mathematics practice, and also discusses the pre- and post-dispositions towards mathematics and academic performance, within the Grade 2 Control Group and Integrated/ Mathletics Group.

The manner in which mathematics was taught was mainly teacher-led, and involved the teacher primarily presenting the mathematics topic and process of problem-solving at the outset, inviting learners to engage in whole class question and answer, or discussion on how to solve the problem, scaffolding learning using resources like bricks and rulers, and organising learners into groups to facilitate opportunities for collaborative forms learning. In terms of the practice of mathematics, those assigned the workbook activities to practice mathematics, typically were also organised at least initially in groups and were encouraged to avail of support from peers and/ or the teacher, where necessary. Therefore, learners generally did help each other to complete the activities within their groups. However, there were some learners who disengaged with the collaborative group work, preferring to work by themselves on the assigned activities in both groups. Some of the CG learners further displayed a level of anxiety with more challenging mathematics questions, while others expressed a lack of interest in the new mathematics concept. Generally, learners in the Control Group did not exhibit high levels of interest or excitement while practising these mathematics activities in class. Furthermore, learners in the Mathletics Group who had been asked to complete at least one of the workbook activities, did so as fast as they could so that they could progress to using Mathletics platform.

In contrast, while the teacher was present for the Mathletics sessions, the Grade 2 learners took the lead in terms of self-directing their practice of mathematics, or self-organising themselves into pairs or groups to engage in friendly competition and also offer peer support in completing the mathematics practice exercises. The atmosphere among the Mathletics group was lively, with lots of engagement across the group, and oral and visual expressions of enjoyment. Indeed, the only challenge lay in the rather unfortunate situation of having those in the Workbook Groups being physically present but not able to formally engage with the Mathletics Group participants, and it was plainly visible that they were frustrated by having to engage in the workbooks, while their peers were allowed to engage with Mathletics. It is important to note here that the Integrated Model adopted here is not the model that is intended to be promoted within mathematics education, but rather the only one which could be used to research Mathletics in the Saudi public school context at that time.

In terms of Grade 2 learners' dispositions towards mathematics, the findings clearly show that the Control Group participants were negatively impacted by their experience within the traditional mathematics classroom setting, with the statistical analysis indicating decreased interest in mathematics homework, as well as increased anxiety levels towards engagement in mental math activity, as well as in listening and understanding of mathematics in class. The class observations also captured this, with revelations of Grade 2 learners across the sessions struggling with understanding certain concepts and/ or workbook questions in the Control Group, particularly reasoning ability-type questions, often verbally expressing frustration before asking teacher for assistance. In contrast, no significant change was observed in the levels of anxiety in any of the categories of math education (Mathematics in general, Written math problems, Mental math, Easy math tasks, Difficult math tasks, Math homework, and Listening and understanding in math class) in the Mathletics Group. In addition, the Mathletics Group showed a statistically significant result post-intervention in terms of increased interest in engagement in more difficult mathematics tasks, which was also captured in interviews with learners where they stated they preferred more challenging questions, and indeed spoke of their pride in completing the more difficult questions.

Finally, the analysis of academic performance showed a statistically significant improvement for the Mathletics group, and no improvement for the Control Group, and in drilling down on results for the Control group, it is a matter of concern to see over 50% of learners with dis-improved performance on the post-test for Grade 2 learners.

5.4 Grade 3: Findings Tatweer Group

This section opens with a short description of the teacher and cohort of learners in Grade 3 group, and then moves forward to summarise the findings on the general pedagogic approaches and nature of learner engagement in traditional mathematics and Mathletics sessions, with the conclusion sections comparing and contrasting findings relating to Grade 3 learner dispositions and performance in traditional mathematics sessions, with the Mathletics online mathematics practice sessions.

5.4.1 Grade 3 Control Group: Background Information

The teacher of Grade 3 Teacher [T3], had sixteen years' experience teaching at primary level, and only one-year teaching Arabic Language. The teacher was female and had a diploma-degree. The teacher indicated that she had undertaken ICT professional development, that was organised by Ministry of Education, and considered herself to have basic level of knowledge of integration technology in education. This teacher was mathematics teacher for both cohorts (Control Group and Mathletics Group). The mathematics sessions were taught through Arabic.

There were 31 learners (aged 8-9 years) in the Grade 3 Control Group of the Tatweer school. These learners were all female and came from Saudi Arabia and a range of Middle Eastern countries, with Arabic their main language. The learners engaged in five 40-45minute sessions of mathematics classes per week (including the observed session), and covered mathematical topics including Represent and Interpret Data and Fraction during the last part of the year. The learners in the Control Group and their teacher were observed during 12 separate mathematics sessions (while covering mathematical topics including Represent and Interpret Data and Fraction during the last part of the year) ranging for circa 40-45 mins over a 4-week period in 2015-2016 academic year.

5.4.1.1 Grade 3 Control Group: Pedagogy in Introducing Mathematics Concept/s.

Based on the class observation, the teacher used three techniques to revise the previous topic**.** On some occasions, the teacher provided individual feedback on homework. She moved around and check on individual homework and asked the learners if they had difficulties on homework. She also engaged the whole class on homework and previous topic. When the teacher started the new chapter, she usually started the lesson by doing the preparation activities. She read the questions out loud and asked the learners to answer. Sometimes, the teacher used peer assessment technique to check on homework, or on occasion she asked the group leader/s to check on group member's homework.

The teacher was observed on some occasions explaining the learning outcomes for the lesson and typing the learning objectives on the board. Following this, the teacher then moved to explain the new topic, using a variety of teaching strategies to explain the new topic. She generally used question and answer technique to stimulate learning thinking about on the new topic, sometimes integrating real world examples. In session 3 for example the topic was 'Probability', the teacher started the new topic by asking the learners these questions; '*What is the chance that you have taken a mathematics class yesterday?*' Then she asked, '*What is the chance that you will take a mathematics class today?*' Then she asked: '*What is the chance that you will take mathematics class tomorrow?*'

The class observation further revealed that the teacher facilitated group work and gave opportunities for the learners to discuss and share ideas. She frequently asked the learners to discuss real-world problem in their groups. Also, she actively encouraged learners to participate through invitation to individual learners to problem solve in front of class. For example, in the Probability topic, the teacher put balls with two different colours (1 blue and 7 reds) in a bag and invited one of the learners to take one ball out. The teacher then asked the learners some questions such as: 'What is the probability of your friend of getting a blue ball?'.

Furthermore, the class observation revealed that the teacher used different resources to display the new mathematics concept. The teacher used physical resources such as the aforementioned balls to help learners to understand mathematics concept and in how to solve the problem. She also used the whiteboard to explain the new topic and generally deployed digital resources such as the digital mathematics book. The teacher then talked about one of her experience using the iPads *'Once I did ask the learners to bring their own iPads in reading class because the topic was about 'Using New Technology', I chose only one learner from each group to bring her own iPad. The learners just read the topic from the iPads. The learners were really focus on the new topic and enjoyed reading by using the iPads. It was* *amazing class'*. The teacher in the interview further confirmed her perception that '*technology is useful for the teacher and the leaners alike',* but that a lack of technology resources impacted on her integration of technology in the classroom, '*I did not integrate technology in my class as much as I want because of the lack of the resources such as Smartboard, Desk-top and Internet*' [T3].

In terms of Control Group interaction, most of the learners in this group actively participated in the new topics, often volunteering answers in class. However, there were some learners who expressed a lack of interest in the new topic, and these learners didn't engage fully with the intended lesson activities. The learners in the interview confirmed that some lessons are hard, and the teacher took long time to explain, so they lost concentration. Learner G3CC1 said that '*I like mathematics, but some topics are hard such as Multiplication and division, so I got bored and I lose concentration*'. Learner G3CC2 '*I like mathematics so when the teacher explained I usually focus but sometimes I lose concentration because the teacher takes long time to explain the topic*'. Some learners were distracted by their friends. Learner G3CC3 for example stated: '*I like mathematics but sometimes, I lose concentration because my friends keep talking*'. Learner G3CC4 '*I lose concentration when my friends are talking'.* Learners did typically ask the teacher to re-explain the process of solving more difficult mathematics problems. For example, some of the learners had difficulties in one of 'Interpretation Representation by Symbols' activity, so one of the learners asked the teacher to do that activity on the board. A final point here is that some Grade 3 learners had attempted new topic questions at home before these were explained by the teacher, with varying levels of success.

The interviewed learners confirmed that they generally preferred topics that were visually appealing or interactive, with comments such as: '*I like Geometry lessons because the teacher usually brings model that help us to understand. So, the lessons became enjoyable'* [G3CC2], '*I like Geometry because the teacher brings some things to play with like balls, cubes…*' [G3CC3], '*I like mathematics. I like Multiplication and Division, but I like Fraction the most because the questions have shapes and colours*' [G3CC4].

The teacher was observed continually trying to encourage the learners' participation in the new topic. For example, some mathematics problems had a higher order component integrated within the session. The teacher therefore read the higher order thinking mathematics question out loud and asked for volunteer/s to explain how to solve the mathematics problem to class, and in some cases, offered a reward – 'I will give her [volunteer] a gift (e.g. a crown)'. The learners were observed listening and focusing on the teacher, and as soon as she finished reading, a large number of the learners screamed the answer. Some of the learners in the interview mentioned that when the teacher used a new strategy to explain a new topic, these methods can motivate them to be more active and participate in the lesson, '*I like when the teacher uses different strategies. Once the teacher is making strategies for us. Divided us into groups, who speaks goes out? At the end of the lesson. Who won is given lollipop but if there is no candy, she gives us a certificate'* [G3CC4].

5.4.1.2 Grade 3 Control Group: Pedagogy of Mathematics Practice in Traditional Setting

In terms of the Control Group's interaction with mathematics practice activities, some of the Grade 3 learners were observed working in the designated group and helping each other to find the answer. All learners completed the activity in the class time and asked the teacher to come and check on their work. In some cases, as in previous observations of other grades, some of the learners displayed levels of anxiety with more challenging questions. They however did generally ask the teacher for more explanation, who would assist directly by explaining to learner/s - For example, in session 1, one group were doing the activities in the group, and expressed frustration with the first question. One of the learners put down her pencil and said out loud that the question was hard and asked the teacher if it was compulsory to do that question because it was so difficult. The teacher did engage to reassure them and re-explained the question to that group. At other times, the teacher might engage the whole class in question and answer about the mathematics problem or ask one of the learners to write the textual question on the board and invite another learner to explain the way to solve the mathematics problem. The class observation further revealed that some leaners expressed lack of interest so, they tended to have informal chats with each other, sometimes asking loudly when the class would finish. The teacher had to discipline these learners for chatting informally or distracting others.

5.4.2 Grade 3 Integrated/ Mathletics Group: Background Information

There were 31 learners (aged 8-9 years) in this Grade 3 Integrated Group, with the same teacher as the Control Group. The whole group were taught the new mathematics concept together, with the class splitting for the mathematics practice elements. In this regard, a total of 19 learners of the 31 learners used the Mathletics platform for mathematics practice, thus formed the Mathletics Group [MG], and the other 12 learners used the workbook activities for mathematics practice, thus the Workbook Group [WG].

5.4.2.1 Grade 3 Integrated Group: Pedagogy in Introducing Mathematics Concept/s.

As the same Grade 3 teacher was involved in both the Integrated Group and the Control Group, and the same topics were explored in each of the observed sessions, the same pedagogic approaches were adopted in revising and explaining the topic. Furthermore, the same physical resources were utilised. Therefore, the focus here is not on re-visiting the pedagogy employed by the teacher but rather exploring learner interactions in this space.

In terms of the learners' interaction in the new topic, the learners in the Integrated Group generally actively listened to the teacher explaining the new mathematics topic. The learners were observed volunteering answers to questions posed by the teacher. For example, in the third session within the theme of Probability, the teacher asked: 'What is the chance for your friend to get a blue ball?' A large number of the learners provided answers. Furthermore, the class observation revealed that, at all observed sessions, the learners worked on the new mathematics concept in the groups that were created by the teacher, and helped each other to find the answer. Also, as in previous observations of other grades, some learners displayed levels of frustration in some of new mathematics topic and asked the teacher for more explanation. For example, in sessions 2, some learners had difficulties in reading the chart and outwardly expressed their frustrations. Also, in all sessions, there were some cases who expressed a lack of interest in the new topic, by messing with others and not paying attention to teacher.

5.4.2.2 Grade 3 Integrated Group: Pedagogy in Mathematics Practice in Traditional Setting

As explained already, this was an integrated session, which split in the latter part of the class to facilitate the Mathletics intervention for mathematics practice. All learners were asked to complete at least one question from the workbook, as this was a mandatory requirement within education system in Saudi Arabia. However, 19 of the learners were allowed to move away from the workbook and use the Mathletics software once this question had been completed, and the remaining 12 learners had to continue answering questions from the workbook. The section below describes what was observed during workbook activity across the Integrated Group.

Once the new topic was explained, the teacher typically engaged learners in mathematics practice activities from workbook. She generally asked the learners to do three to four questions from Workbook in class time. Generally, the teacher did not provide direct feedback on individual performance. She sometime asked them to drop the workbook on her desk or bring them after the class to check. The teacher in the interview confirmed that checking on learners' work and providing individual feedback takes time, and thus can't be completed within class-time.

Furthermore, the teacher was also observed on some occasions deploying digital resources to display some of mathematics activities. For example, in session 7 the learners had difficulties in the 'Equivalent Fractions' activity so, they did ask the teacher for more explanation. The teacher then projected the activities on the whiteboard and re-explained.

The teacher supported learners to work in groups or individually on the mathematics practice activities. She also encouraged cooperation by directing learners to help another group member. In sessions 7 for example, the teacher was busy with one of the groups, so she asked one of the learners to help her friends in the other group to explain one of the equivalent fractions' activity. She also encouraged peer assessment in practicing mathematics concept. In session 2 for example, the teacher asked the learners to open the workbook and work out the activities and then peer assess each other's work. Some learners exhibited initiative in attempting more advanced math practice activity, with quite a few learners trying advanced mathematics at home before the new topic was explained by the teacher.

In terms of the learners' interaction, the Grade 3 learners in the Mathletics Group completed the mandatory single mathematics activity in the workbook as fast as they could and dropped it to the teacher, and moved on to use Mathletics (reported in next section). The remaining learners in the MG were observed actively engaging in practicing the Mathletics activities. They cooperated with each other in explaining how to solve the problem. In session 8, one learner for example explained to her friends how to compare and order fractions. Also, some learners were observed disengaging with the group and working alone by themselves on the activity. Furthermore, some expressed anxiety with more challenging mathematics activity and asked the teacher for more explanation. The class observation further revealed that there were some learners who expressed a lack of interest in the activity. These learners moved around the class for informal chats with others, without having completed the assigned activities. The teacher generally reprimanded learners for informally chatting, and ensured they got back on task.

5.4.2.3 Grade 3 Integrated Group: Pedagogy of Mathematics Practice using Mathletics

Once the Mathletics Group learners completed the mandatory workbook activity assigned by the teacher, they moved quickly to engage with the Mathletics activity related to the new topic.

In terms of the Grade 3 learners' interaction, the general class observation revealed that the Mathletics Group seemed to be more engaged and have greater interest within mathematics class in all sessions using Mathletics. They waited with excitement to gain access to the platform 'Mathletics'. The teacher in the interview confirmed that after the presence of the game 'Mathletics' the leaners became so excited about mathematics class, 'the learners were *waiting with enthusiasm and ready for mathematics class. The learners were concentrated and more interest in mathematics class. They wanted to finish so they have time to practice by platform (Mathletics). They really understand the value of the game which is for learning not playing'* [T3]. During interviews with learners, the participants reported that they had fun when they were doing the activities in the platform, and they enjoyed answering the questions. The learners mentioned that they liked mathematics class, but after the integration of the game, they became even more excited about it. Learner G3MC1 said that '*I like mathematics, but I became enthusiastic about mathematics class*', learner G3MC2 '*I like mathematics, but I became so excited about mathematics class.'*. They also said that they were more focused and participated more with the teacher, because they wanted her to quickly finish teaching, giving them more time to play Mathletics with their peers in the classroom. Learner G3MC1, '*So, I focus with the teacher and try to finish fast so I can have time to play*', learner G3MC4 '*I like mathematics, but this game 'Mathletics' helps me to be concentrated in mathematics class. I try to answer with the teacher so I can save time to play'*. In line with this, the interviewed mothers confirmed that their daughters became very interested, excited, and enthusiastic about mathematics class, for example one mother stated: '*My daughter likes mathematics class but after the presence of this game 'Mathletics' she became so excited about mathematics*' [M1], another mother relayed that:'*My daughter is so excited about the game 'Mathletics'. This game added a new thing in mathematics learning' [M2].*

The learners believed that doing the mathematics practice activities using the platform made them more intelligent, as they could solve problems in their head (without the use of pencil and paper). For example, Learner G3MC1 stated: '*I understand the topic from the teacher, but I understand it more by the game. This game helped me to add faster and do the answer in head',* Learner G3MC2 noted: '*I am being good at math because I answer in head', and,* Learner *G3MC3 said: 'This game 'Mathletics' is useful because I can solve the problem in head'*. Furthermore, the learners in the interview mentioned that the game helps them to revisit previous topics to overcome any difficulties. Learner G3MC1 for example noted*: 'I had difficulties in some topics such as Division, but I try to play more until I understand it. Today we had a weekly test in Fraction, so yesterday I revised from the book then I played by the game 'Mathletics'. I understand the topic from the teacher, but I understand it more by the game'*, and Learner G3MC3 stated that Mathletics enabled her to engage in more revision of mathematics concepts - '*It helps to revise more'*. One learner further mentioned the role of Mathletics in building confidence in mathematics problem solving: '*I feel confident that when I have difficulties I can play more until understand'* [G3MC4]. In addition, some of the mothers noted that the learners expressed interest in revisiting the activity, especially with difficult topics. For example, one mother said: '*my daughter sometimes asks for help, but since she started the game, she never asks for help as she can play until she gets all the correct answers. The game helped her to understand more, review previous topic and explore a new topic.* [M1]. Another mother suggested that Mathletics-type technology should be integrated across all subjects, particularly the subjects that learners find difficult - '*So, I my opinion, we should integrate this technology to all subjects* *especially hard subject such as mathematics. At least our kids will invest their time in something useful'*[M2].

The Grade 3 learners created their own group to challenge each other within Mathletics, and orally expressed in class their enjoyment of the competition with their peers, using the mathematics practice activities within Mathletics as a chance to challenge themselves, and to boast about 'who will finish first without a mistake'. This behaviour encouraged the learners to continue to engage in such challenges, competing to see who could finish first. The interviewed learners confirmed that they liked to engage in friendly competition at school, for example, Learner G3MC2 stated: 'I *played at school and at home but at school is better because I compete my friends'.* Some of the learners confirmed that they like to play at school so when they have difficulties in solving problems, they could ask their friends for assistance. Examples in this regard include: Learner G3MC3 '*I like to play at school and at home but at school is better because I play with my friends. when I have difficulties, I asked my friends'*, and Learner G3MC4 '*At the first time to play the game I didn't know how I can play it, but I asked my friends then I know how'.* Moreover, it was observed that the learners were happy when they found each other within the online game 'Live-Mathematics' -a facility within Mathletics that allowed for global competition in mathematics problem solving. The learners were excited to race their classmates and to connect with competitors from around the world within the game. However, the learners mainly focused on completing activities at the most basic level within 'Live Mathematics', so it could be argued that their focus was only on winning rather than on quality of the learning experience.

The Grade 3 learners were observed continually checking on their own performance within Mathletics. As observed, when they finished the activity, they revisited the main interface and showed each other the 'Gold Bar' which indicated their progression through the series of mathematics problem activities. Furthermore, the learners were observed expressing pride in their achievement when they completed the activity without help and/or without mistake. For example, learner G3MC1 expressed pride in completing activity by herself - '*I can play by myself no one help me'*. Based on classroom observation, learners enjoyed collecting points as they moved around in the classroom and showed each other the number of points they had earned, comparing their scores. In the interview the learners confirmed that they enjoyed collecting points. Learner G3MC1 '*I have 200 points, last week I had 1200* *points and I had only one certificate'*. Learner G3MC2 '*The best things I like in this game is to collect points. I have 100 points right now. Last week I had 1100 points'.* Learner G3MC3 '*It is interesting to collect points'*. Learner G3MC4 '*I like to collect points, I collected 78 points right now*'. Also, the award of the certificate/s was another factor that motivated the leaners to play Mathletics. G3MC4 noted: '*I have two certificates. So, when I could not have certificate, I have to play more'*. The teacher in her interview also said that '*They enjoyed collecting points and had a certificate especially when one of them got a certificate. The others were so excited to play more and have one*'. Furthermore, one of the mothers said that '*My daughter is so excited about the game "Mathletics' she came to me and said that I collected this number of points at school. She competed her friends about the points that she had*'[M2].

The learners also exhibited a desire to revisit Mathletics activity beyond the classroom and completed additional mathematics practicing at home. The learners talked about the activities that they completed at home and the points that they collected. This finding is supported by the interview with mothers. They confirmed that their daughters played at home, they talked with their siblings about how many points they collected in the class and how they enjoyed challenging their peers. In this regard, one mother said that '*my daughter played Mathletics at home half to one hour. She talked a lot about the activities that she did at school and the points that she collected' [M1]*, another stated that '*When my daughter came back from the school, she played Mathletics at home about half an hour. She enjoyed the game 'Mathletics'. She talked about the game at home and encourage her sister to have an account'[M2].* The mothers also said that their daughters tried to finish daily homework as fast as they could so they would have time to play Mathletics, '*she tried to finish her homework as fast as she could so she can have time to play'* [M1]*, 'She usually finished her homework and then have a play'* [M2]. They also acknowledged their daughters' ability to solve problems more independently using Mathletics, one mother stated that '*she has no difficulties but if she needs help, she asked her brother. She had a weekly test and she revised from the game she did not ask for help'[M2].* The mothers further mentioned some of the benefits of the game, including its ability to connect within and beyond the class, and its role in motivating their daughters to engage in mathematics with their friends - '*Technology makes the life much easier and facilitated connection between home and school. For example, when she played at school, she came and said I did this game with my friends and* *talked about how they were excited while playing and shouting if someone won'[M1], and* '*One benefit of this game is to develop the connection between home and school. My daughter came from the school and talked about the activity that she played with her friends and how they were so excited. She talked about when one of her friends asked her for help and explained it for her. She talked about the points that she collected at school'[M2]*. This is supported by what the interviewed leaners said – for example, Learner G3MC1 said that '*Yes, I play at home, sometimes I play with my friends 'Live Mathematics',* Learner G3MC3 '*I played at home about half an hour',* Learner G3MC4 '*I play at home, I revised the previous topics such as Geometry and Measurement. So, if I have difficulties when I play at home, I ask my mom'*.

Despite the leaners have enjoyed the mathematics practice exercises within Mathletics by themselves, they did acknowledge the role of the teacher in learning mathematics. In this regard: Learner G3MC5 noted: '*Mathematics is important for us. We cannot learn mathematics without a teacher. The teacher corrects us, help us so we will be ready for fourth grade…'*. Learner G3MC6 similarly states: '*Mathematics is important for our life. So, we cannot learn mathematics without a teacher especially in hard topics. The teacher takes care of us all and she gave especial care for leaners who are not good at mathematics', and* Learner G3MC7 confirms: '*Mathematics is important, so we have to have a teacher. The game 'Mathletics' that you gave us is useful, but the teacher is important'.* The teacher similarly acknowledged the need for teacher presence in class for learners especially for this age, particularly to scaffold, provide feedback and caring. She said that '*Technology is used to increase leaners enthusiasm toward learning not to replace the teacher, the teacher remains teacher. Especially for this age (primary level) because leaners in this age do not need the teacher to understand mathematics concepts only. They have no enthusiasm and desire to learn, if there is no one follow up them, help them, support them and reward them. All that is a teacher job*'.[T3]

In terms of the pedagogic approach, the Grade 3 teacher facilitated a high degree of self-directed and independent learning during the Mathletics practice sessions. The teacher in the interview mentioned learners' enjoyment in the class after the integration of 'Mathletics'. She said that '*The learners enjoyed mathematics class especially for the days that they will bring their own devices'*. The teacher also noticed a decrease in the learners' recorded absence from school over the period of the Mathletics intervention - *'...even their absence decreases'*[T3]. Also, the teacher noticed improvements in the academic achievement and higher order thinking ability of the Mathletics Group, '*I notice an improvement in their academic achievement. They became more focus on paper- based test. Also, I notice an improvement in higher order thinking ability because when they practice by the platform [Mathletics] they answer in head and then write the answer, so this develop higher order thinking*'. The teacher mentioned another benefit of the game was its ability to facilitate learners moving at own pace, and to undertake advanced problem solving - '*The learners also worked out the activities that related to the lesson and sometimes they visited something new or practiced something from the previous lessons and this help them to understand more because they are going to take these lessons in deep next year'*[T3].

Finally, the Grade 3 teacher made three really interesting suggestions in terms of Mathletics integration for mathematics practice in Saudi Tatweer school contexts, as follows:

1) The Grade 3 Teacher suggested a 'bolt-on' Mathematics Practice model which would see Mathletics added at the end of class/ after class: '*surely, I support the integration of this technology in the classroom but with clear plan. I suggested to add additional classes for this technology (two to three times per-week) because in math class, I take 20-30 mins explaining the new topic and 25-15 mins for practicing' [T3].*
2) She advised that schools would need to have access to the technologies to support Mathletics (i.e. ipads, wifi, etc.) and/ or learners would need to be encouraged to bring their own devices (BYOD) would be appropriate – '*The school also should be well prepared for this technology for example, Internet and devices. The learners can be provided by the devices or are able to bring their own device.*'[T3].
3) She further suggested reducing the number of learners in-class for Mathletics interventions: *'Also, the number of the learners should decrease. I think 25 leaners in the class is fair enough*' [T3].

5.4.3 Grade 3 Comparison: Mathematics Dispositions within Control Group and Mathletics Group

The findings in relation to Grade 3 learners' dispositions towards mathematics are presented under four headings: *Confidence*; *Interest*; *Satisfaction* and *Anxiety*. The Shapiro-Wilk test shows that the p-value for all variables were less than alpha level (thus, not a normal distribution), therefore, the Wilcoxon signed-rank test was used. The variable 'Anxiety' for the Mathletics Group, on the other hand, was excluded from the Wilcoxon test, as the p value for this variable was bigger than alpha level (normal distribution), and thus, the Paired-sample t-test was used to examine 'Anxiety' with the Mathletics Group. The paired-sample t-test is sensitive with the outlier, hence, the outlier was checked and none existed.

5.4.3.1 Confidence

The Wilcoxon signed-rank test was used to examine whether there was a significant difference between the score tests before and after the six-week intervention for both the Control Group and Mathletics Group (Table 5.8) in Grade 3 context. The tests indicate that no significant difference in pre- and post-test confidence levels toward mathematics for the Control Group. The same test was conducted to compare the effects of the online mathematics platform (Mathletics) on the learners' confidence with the Mathletics group. The results also show that there was no significant difference in pre- and post-test confidence levels toward mathematics in Mathletics Group.

Table 5.8: Results of Wilcoxon Signed Rank Test of the differences between per and post survey for Grade 3 both group (CG) and (MG) for the category "Confidence".

Category	Variables	Wilcoxon Signed Ranks Test Control Group N=20		Wilcoxon Signed Ranks Test Mathletics Group N=19	
		z	p	z	p
Confidence (C)	MG	-.577	.564	-1.000	.317
	WM	-.816	.414	.000	1.000
	MM	-.378	.705	-2.000	.056
	EM	-1.633	.102	-1.000	.317
	DM	-.905	.366	-.264	.792
	MH	.000	1.000	.000	1.000
	LU	-.447	.655	-1.000	.317

Altogether, these results indicated that learners in both cases reported the same level of confidence in mathematics in pre- and post-intervention tests, across all categories which included: general mathematics, written mathematics problems, mental mathematics, easy mathematics tasks, difficult mathematics tasks, mathematics homework, and listening and understanding in mathematics class.

5.4.3.2 Interest

In the case of the **Control Group**, the results show that there was no statistically significant difference in pre- and post- test scores in relation to changes in pupils' interest over time for all categories bar one, the category of '**Mathematics in general'**, where there was a **statistically significant difference** in pre- and post-test for at Grade 3 level. The students reported that their interest at this latter skill decreased over time: z= -2.046 significant at p= .046.

Table 5.9: Results of Wilcoxon Signed Rank Test of the differences between per and post survey for both Grade 3 group (CG) and (MG) for the category "Interest".

Category	Variables	Wilcoxon Signed Ranks Test Control Group N=20		Wilcoxon Signed Ranks Test Mathletics Group N=19	
		z	p	z	p
Interest (I)	**MG**	**-2.046**	**.046**	-1.633	.102
	WM	.000	1.000	-1.000	.317
	MM	-1.231	.218	**-2.203**	**.028**
	EM	-.707	.480	-1.732	.083
	DM	-1.265	.206	-1.552	.121
	MH	-1.000	.317	-.447	.655
	LU	-1.134	.257	.000	1.000

For the **Mathletics Group**, the test shows that there is a **statistically significant difference** in pre- and post-tests toward '**mental math'** with z = -2.203, and this value is significant at p = .028. This finding shows that the interest in engaging with 'mental math' increased over time for the students involved in the Mathletics Group. However, the test shows no significant differences in the Mathletics students' interest across the other categories (mathematics in general, mathematics homework, written mathematics problems, difficult mathematics, easy mathematics tasks, and listening and understanding in mathematics class).

5.4.3.3 Satisfaction

The results from Wilcoxon signed-rank test for both Mathletics and Control Groups showed that there was no significant difference in satisfaction in pre- and post- intervention tests toward mathematic education for either at Grade 3 level.

Table 5.10: Results of Wilcoxon Signed Rank Test of the differences between per and post survey for both Grade 3 group (CG) and (MG) for the category "Satisfaction".

Category	Variables	Wilcoxon Signed Ranks Test Control Group N=20		Wilcoxon Signed Ranks Test Mathletics Group N=19	
		z	p	z	P
Satisfaction (S)	MG	-1.300	.194	-.447	.655
	WM	-1.081	.279	.000	1.000
	MM	-1.131	.258	-1.000	.317
	EM	-.604	.546	-.447	.655
	DM	-1.121	.262	-.722	.470
	MH	-.241	.809	-1.000	.317
	LU	-.730	.465	.000	1.000

It can be concluded that both conditions resulted in a similar level of satisfaction in mathematics education, in all categories.

5.4.3.4 Anxiety

In order to test pupils' anxiety, a Paired-sample t-test was administered to those participating in the Grade 3 Control Group. The results indicate that there were no statistically significant differences in pre- and post-test for all categories (Table 5.11) for Control Group.

Table 5.11: Results of Paired t-test of the differences between per and post survey for Grade 3 (CG) for the category "Anxiety".

Category	Variables	Condition	Paired t- test Control Group N= 20		
			mean	Std. Dev.	P-value
	MG	Pre-test	4.8824	1.83311	.186
		Post- test	4.0588	2.27680	
	WM	Pre-test	5.2353	2.04724	.633
		Post- test	4.9412	2.24918	

Anxiety (A)	MM	Pre-test	4.8824	1.36393	668
		Post- test	5.0588	2.01465	
	EM	Pre-test	5.2353	1.92124	.096
		Post- test	5.5294	2.21127	
	DM	Pre-test	4.5294	.71743	.632
		Post- test	4.4118	.87026	
	MH	Pre-test	4.8824	1.76360	.332
		Post- test	4.4118	.50730	
	LU	Pre-test	3.0588	2.04544	.140
		Post- test	3.9412	2.33106	

A Wilcoxon signed-rank test was also used to test the effect of the online mathematics platform (Mathletics) on the learners' anxiety for those participating in the Mathletics Group. The results indicated that the differences in the pre- and post-tests in Mathletics Group condition in relation to anxiety were not statistically significant (table 5.12).

Table 5.12: Results of Wilcoxon Signed Rank Test of the differences between per and post survey for Grade 3(MG) for the category "Anxiety".

Category	Variables	Wilcoxon Signed Ranks Test Mathletics Group N= 19	
		z	p
Anxiety (A)	MG	-1.117	.264
	WM	-1.365	.172
	MM	-.389	.697
	EM	-.373	.709
	DM	-.314	.753
	MH	-1.431	.152
	LU	-.158	.875

Therefore, we can conclude that the participants in both groups recorded no significant change in the level of anxiety in any of the categories at Grade 3 level.

5.4.4 Grade 3: Academic Performance Findings

A paired-sample t-test was run to compare the scores for Mathematics Performance Test for the same group of Grade 3 learners pre- and post-intervention. The results indicated that the **Mathletics Group** at post-test (mean 9.68) scored **statistically significantly higher** (p = .000) than in the pre-test (mean 6.21) for **academic performance in mathematics**. On the contrary, the Control Group reported no statistical difference between pre-test and post-test ($p = .8$) (see Table 5.13)

Table 5.13: Results of Paired t-test of the differences between pre- and post- mathematics test for both groups.

	N	Pre-test		Post-test		p
		M	SD	M	SD	
Control Group	13	8.19	2.26	8.38	2.4	.81
Mathletics Group	16	6.2	2.99	9.5	2.50	.000

Furthermore, as in Grade 2, all Mathletics Group in Grade 3 improved at post-test (Table 5.14), Some of them achieved significantly higher scores than their original mark at post-test compared to pre-test (C1, C5, C7, C8, C11).

Table 5.14: Summary results of pre- and post- mathematics for each learner in Grade 3 (Control Group and Mathletics Group).

Student's NO	**Mathletics Group**		**Control Group**	
	Pre- test	**Post- test**	**Pre- test**	**Post- test**
1	7.0	12.0	9.0	8.0
2	5.0	7.0	10.0	7.0
3	10.0	12.0	11.0	8.0
4	11.0	12.0	7.0	7.0
5	1.0	6.0	11.0	12.0
6	7.0	9.0	6.5	8.0
7	4.0	9.0	8.0	10.0
8	4.0	12.0	7.0	5.0
9	5.0	7.0	8.0	5.0
10	6.0	10.0	11.0	12.0
11	6.0	12.0	9.0	8.0
12	1.0	4.0	5.0	6.0
13	11.0	11.0	4.0	7.0
14	7.0	10.0		
15	8.0	8.5		
16	6.0	11.0		

Five learners C1, C3, C4, C8, C11 achieved the highest score (12 out of 13). Six learners in CG improved at post-test (C5, C6, C7, C10, C11, C13). Two of these learners (C5, C10) got the high score (12 out of 14), they improved by only one mark. Seven of learners' results in the Control Group decreased at the post-test (C1, C2, C3, C8, C9, C10, C11), one of them dropped from 8 at pre-test to 5 at post-test (C9).

5.4.5 Discussion of Findings from Grade 3 Tatweer School

This section summarises the findings relating to the performance of mathematics education, particular the dimension of mathematics practice, and also discusses the pre- and post-dispositions towards mathematics and academic performance, within the Grade 3 Integrated/ Mathletics Group and the Control Group.

As the same teacher taught both groupings (the CG and IG/MG groups) in Grade 3 in this Tatweer school, the same approaches to mathematics education were adopted by the teacher when introducing new mathematics concepts in both the CG and IG/MG mathematics sessions. As in Grade 2, the manner in which mathematics was taught was mainly teacher-led, and involved the teacher primarily engaging in a 'show and tell' to explain the mathematics topic and process of problem-solving at the outset. There was evidence of attempts to engage learners within question and answer, and through invitation of learners to demonstrate their understanding in whole-class discussion. In terms of the practice of mathematics, those assigned the workbook activities to practice mathematics, typically were also organised at least initially in groups and were encouraged to avail of support from peers and/ or the teacher, where necessary. They used physical resources (cubes, balls, etc.) that were provided by the teachers to explore the new concept or to solve a mathematics problem. In the traditional setting, the teachers directed learners to use textbooks and created groups and actively encouraged the learners to collaboratively work in these groups to solve the mathematics practice activities. Therefore, learners generally did help each other to complete the activities within their groups. The results also showed that in both groups, some of the learners displayed a level of anxiety with more challenging mathematics questions, while others expressed a lack of interest in the new mathematics concept.

As was the case for Grade 2 learners, while the teacher was present for the Mathletics sessions, the Grade 3 learners took the lead in terms of self-directing their practice of mathematics, or self-organising themselves into pairs or groups to engage in friendly competition and also offer peer support in completing the mathematics practice exercises. The atmosphere among the Mathletics group was positive, with lots of engagement across the group, and oral and visual expressions of enjoyment. Indeed, again as was the case with Grade 2 learners, the only challenge lay in the rather unfortunate situation of having those in the Workbook Groups to be physically present but not able to formally engage with the Mathletics Group participants, and it was plainly visible that they were frustrated by having to engage in the workbooks, while their peers were allowed to engage with Mathletics.

In terms of Grade 3 learners' dispositions towards mathematics, the findings clearly show that the Control Group participants were somewhat impacted by the traditional mathematics classroom setting, with the statistical analysis indicating decreased interest in 'mathematics in general' across this cohort. [In contrast to Grade 2 CG learners, there was no significant change in anxiety levels pre- and post- intervention within Control Group participants]. Interestingly, the Mathletics Group showed a statistically significant result post-intervention in terms of increased interest in engagement in more 'mental mathematics'. There was no significant change in the levels of confidence, satisfaction or anxiety in any of the categories of math education (Mathematics in general, Written math problems, Mental math, Easy math tasks, Difficult math tasks, Math homework, and Listening and understanding in math class) for either the Mathletics Group or the Control Group.

Finally, the analysis of academic performance showed a statistically significant improvement for the Mathletics group, and no improvement for the Control Group. In drilling down on results for the Grade 3 Control group, it is a matter of concern to see over 50% of learners with dis-improved performance on the mathematics post-test, with only marginal increases in mathematics performance for the majority of the remaining members of the Control Group.

5.5 Conclusion from Phase 2 in Tatweer Setting

In the context of teaching mathematics in Tatweer setting, the results indicated that teachers across both grade levels typically followed a prescribed route in mathematics education, using primarily teacher-led and directed approaches, thus strictly adhered to pathway for learning mathematics concepts as outlined in textbook and workbook. The textbook and mathematics instructional materials provided by the Ministry of Education were the main resources used at both grade 2 and 3 levels. The teachers also made use of CD materials accompanying the textbook, but were not seen to make use of other online materials.

Usually, at the beginning of the class, they checked on homework or engaged in the preparation activities. Following explanation of the key concept, the teachers usually provided learners with opportunities to work independently and/ or collaboratively (in groups/ pairs) on mathematics problem solving and invited learners to engage in solving the problem. They further integrated opportunities for whole class discussion, where appropriate. It was notable that there was widespread use of group/ paired work, and peer assessment therein, to facilitate collaborative forms of learning with the traditional delivery of mathematics education. Furthermore, the teachers generally provided physical resources to stimulate and increase learner engagement in understanding and solving problems. They further used Question-and-Answer approaches to stimulate learners' thinking about the new mathematics concept. They also attempted to make the task/s relevant by connecting these with real-life problems. They also tried to support mathematics literacy development in mathematics class, through inviting learners to read information on new topic and placing key words (mathematics language literacy) on board. The learners typically were encouraged to practise the new mathematics concept using the prescribed workbook, during which time the teachers played the role of facilitator and offered scaffolding by supporting learners who needed assistance. The teachers also encouraged learners to cooperate in groups and peer-assess progress during the practice dimension of the class. However, the learners typically did not receive any feedback from the teachers on their progress or performance in completing the mathematics practice activities until later in the day. Therefore, the teachers did not provide individual feedback on the learners' performance in their mathematics practice session during the class time.

In terms of the learners' interaction with the new topic, the findings from the intervention with learners at Grade 2 and Grade 3 levels showed that most of the learners actively participated in new topic/s being introduced each week. They worked well in groups and were seen to help each other to solve problems. They used physical resources (cubes, balls, etc.) that were provided by the teachers to explore the new concept or to solve a mathematics problem. However, the results also showed that some of the learners displayed a level of anxiety with more challenging mathematics questions, while others expressed a lack of interest in the new mathematics concept. This was particularly evident in the traditional mathematics practice setting at each grade level, where while the learners did complete the mathematics practice activities by pencil and paper, generally they did not exhibit high levels of interest or excitement while practising these mathematics activities in class. Even during group activity, there were some learners who disengaged with the collaborative group work, preferring to work by themselves on the assigned activities.

In contrast, within the Mathletics setting, the results revealed that learners in both Grade 2 and Grade 3 exhibited high levels of excitement and engagement throughout the sessions. Learners further demonstrated high levels of motivation to complete the mathematics practice activities both in-school time and also completed additional mathematics activities at home. This is reflected in the improved Mathletics learners' performance at both Grade 2 and Grade 3 levels as is evidenced by the statistically significant increased academic performance at the post- test compared to the pre-test at each grade level. Even though individual and group engagement could be facilitated entirely through online Mathletics platform, Grade 2 and Grade 3 learners created their own groups and did appear to enjoy solving the Mathletics problems in a physical class-based setting and were frequently observed calling out to friends for support within the class. Furthermore, the 'Live Mathematics' part of Mathletics that facilitated competitive completion of mathematics practice exercises, really appeared to enthuse and engage learners – they appeared to really enjoy connecting with and challenging their classmates (and peers in other countries) in the online competition environment. The teachers were observed facilitating a high degree of self-directed and independent learning during the Mathletics practice sessions. Learners generally asked peers for assistance on those occasions that they had difficulty solving problems in Mathletics, and only rarely sought support from teachers to complete the Mathletics activity.

The findings also indicated that the learners appeared to be motivated by their own performance in Mathletics, with learners re-visiting the activities multiple time to improve their final score and visiting the main interface page to see their level of completion as displayed on the Mathletics progress bar. Overall, the findings from this research at these grade levels indicated that combining particular game elements such as points, certificates, progress bars, a friendly 'competitive' environment, direct feedback on progress and performance in completing mathematics and practice activities development have positive effects on increasing the learners' interest in mathematics, and in keeping them on task. Furthermore, the aesthetic design of the game was one of the factors influencing learners' engagement, in that when the design of the interface was not intuitive, the learners expressed a lack of interest and disengaged the activity.

In terms of learners' dispositions toward mathematics the results show that altogether, learners within the Control Group and Mathletics Group across both grade levels indicated no change in their confidence or satisfaction levels with mathematics education across all categories (which included: Mathematics in general, Written math problems, Mental math, Easy math tasks, Difficult math tasks, Math homework, and Listening and understanding in math class). Furthermore, the findings indicated that learners in the Grade 2 Control Group had increased anxiety regarding 'Mental Math skill' and 'Listening and understanding mathematics skill' in the post-test. Interestingly, the comparison of pre- and post-dispositions revealed that the learners in the Grade 1 Mathletics Group exhibited an increased interest in engaging with 'Difficult math problems', and learners in Grade 3 Mathletics Group exhibited an increased interest in engaging with 'Mental math'. However, the learners in the Grade 2 Control Group exhibited a significantly decreased interest in 'Mathematics homework' in the post-test. Furthermore, the results of from the Grade 3 Control Group showed decreased interest of learners in 'Mathematics in general' skill. In contrast, no significant change was observed in the level of anxiety in any of the categories of mathematics for Grade 2 or Grade 3 Mathletics Groups. The implications of these findings from phase 2 will be further examined in the context of mathematics education within the discussion in the final chapter.

Chapter 6: Findings - Readiness of Saudi Teachers for Technology Integration

6.1 Introduction

This chapter presents the findings from a survey sent to primary teachers in Tatweer schools and International schools to explore the level of ICT experience, access to technology, professional development and confidence in technology-enabled learning of primary school teachers and to identify factors affecting the integration of ICT in primary schools in Saudi Arabia. The initial part of this chapter opens by recapping on the methodology for phase 3. The findings are then presented, beginning with a general profile of the respondents, and followed by an overview of the findings relating to ICT integration at the teacher-level (which includes discussion of: Teachers' experiences with ICT, Material used with the aid of a computer and/or the Internet, Teachers' ICT-based activities with the class, Pedagogic approaches with or without ICT, Teachers' professional development and confidence, and Teachers' attitudes and opinions). The next section presents the findings from the review of provision at school-level (which includes discussion of: Access to ICT infrastructure, ICT provision, and, Obstacles to the use of ICT). The final section presents a summary of the key findings and conclusions from this phase of the study.

6.2 Recap on Phase 3 Methodology

This third and final phase of the multi-phase mixed method set out to explore *the state of readiness of Saudi teachers for technology integration in their practice of mathematics education at primary level in this district of Saudi Arabia.* This led to a quantitative investigation of the levels of ICT experience, access to technology, professional development and confidence of Saudi primary teachers, as well as their attitudes towards ICT integration in education. The primary tool used in this aspect of the study was a survey tool, comprising of 27 closed questions, deployed using an online survey platform (Survey Monkey) in January and February 2018. An overview of the research approach in phase 3 of the research is extracted from Figure 3.2, as follows:

Research Phase 3

Data Collection Time - Dec 2017-April 2018

Research Approach: Quantitative Research

Focus of Research - Build a profile of teachers' access to, skills in, professional learning opportunities and dispositions towards using technology in education in primary settings in Saudi Arabia

Cohort - Teachers in 20 Public Primary Schools & 3 private schools

Particpants' Numbers- 24 Tatweer's Teachers and 17 International schools' Teachers.

Data Collection Tools - Survey instrument

Data Analysis: Descriptive statistics, t-test & Mann Whitney U test

The survey tool devised for this study was based on an EU survey tool (used periodically to assess and compare ICT integration in countries across Europe), and included questions examining the level of ICT experience, access to technology, professional development in technology enabled learning, and their integration of technology-enabled resources and/ or practices of school teachers. An edited version of the survey containing 27 closed questions was used in the current study. The survey was divided into ten categories. The first five questions asked for 'information about the target learner cohort', followed by two questions about teachers 'experience with ICT for teaching', four questions about 'ICT for teaching', four questions about 'support to teachers for ICT use', and two questions about 'ICT-based activities and material used for teaching'. The next section focused on exploring 'obstacles to using ICT in teaching and learning', and the subsequent section on 'learning activities with the target class'. This was followed by a question about 'teacher skills'. The subsequent two questions probed 'teacher opinions and attitudes', and the last five questions asked for 'personal background information' of each teacher.

The edited survey was piloted, and Cronbach's alpha values were checked before using it for the main part of the study. The survey was administered in two different types of primary schools in Saudi Arabia, Tatweer schools and International schools. All primary teachers from 20 Tatweer schools and the three International schools in the eastern area of Saudi Arabia were invited to participate in this survey. In terms of responses, 19 teachers (out of

24) from Tatweer schools and 15 (out of 17) from the International Schools answered all 27 questions in the survey, with the remainder only answering 15 questions of specific relevance to their context/level of ICT experience. The results from the survey presented here in the form of descriptive statistics were analysed and are discussed in next section. The items relating to teachers' ICT competencies were grouped into two categories: Teachers' operational skills and Teachers' social media skills. Operational skills are foundational skills (e.g. Word, Excel, Outlook, PowerPoint) and also include computer and Internet skills. Social media skills enable users to collaborate and interact with other. In the current survey, social media skills are defined as those that enable users to participate in online discussion forums, create and maintain blogs or websites, and participate in social networks. The descriptive statistics were used to describe the frequency of integration, or level of agreement with particular ICT practices or statements, and furthermore in comparisons between respondents from Tatweer and International school contexts. Moreover, the Mann-Whitney U Test was used to explore any potential gender differences between the opinions and attitudes of male and female teachers across these contexts

6.3 Findings from the Survey:

The following sections present the findings from the survey. The findings are presented in three sections: General information about the teachers, Teachers-Level of ICT Integration and School-Level ICT Integration.

6.3.1 General information about the teachers.

There was a total population of 130 teachers in ten all-girls schools and ten all-boys schools within the primary Tatweer school system, and a further 90 teachers in the three International schools, in the eastern district of Saudi Arabia. In terms of this study, 24 (out of 130) respondents to the survey came from the Tatweer schools and 17 (out of 90) from the International schools. It was not possible to accurately determine the exact number of schools who responded to the survey because the survey was anonymous, and therefore neither schools nor teachers could be individually identified. It can be definitely stated that there were at least two different types of Tatweer schools, as there were both male and female teachers represented in the respondents. In terms of gender, 13 of the teachers from the International School were female and the remaining 4 were male, with equal division in the number of male/ female respondents from Tatweer schools (12 of each). The majority of respondents in both settings were aged in categories of 31 years of age or more (19 out of 24 in Tatweer schools and 13 out of 17 in the International Schools). In terms of years of teaching, respondents from the Tatweer school context were almost equally divided in terms of experience teaching, with 11 respondents with ten years or less teaching experience, and 13 respondents with greater than ten years teaching experience. The International School had 10 respondents with ten years or less teaching experience, and 7 with more than ten years teaching experience.

It should be noted that in International Schools in Saudi Arabia, all lower level learners (Grades 1, 2 and 3) are taught by female teachers, but higher grades are separated by gender and taught by teachers of the same gender. In the Public school system (which includes Tatweer schools), children are separated from Grade 1 by gender and similarly their teachers. Therefore, as one would expect from the gender mix of participants from the Tatweer schools, 12 respondents indicated that they taught all-boys classes and 12 taught all girls classes in the Tatweer school. In the International schools, 11 respondents indicated they taught all-boys and the remaining indicated they taught only girls in their classroom, which meant that a high percentage of the female teachers were most likely teaching all-boys classes at the lower grades within the International schools. Furthermore, a review of size of class cohorts indicated that more than half of Tatweer teachers (around 54%) had more than 20 learners in each class, whereas the majority of teachers in the International schools (around 58%) had from 11 to 20 students. The majority of respondents from Tatweer schools (50%) had 12 to 18 teaching hours per week, while the majority in the International schools (around 52%) had 19 or more teaching hours per week.

In terms of experience teaching at grade levels, more than 50% of respondents had experience teaching at more than one grade level within both the Tatweer and International school settings (only class teachers teach one grade – specialist teachers in subjects like Mathematics generally are assigned to teach more than one grade level). Furthermore, the respondents in both settings had experience across a range of teaching subjects including: Language, Mathematics, Science, Social Studies, Other – Arts, Sport (for boys), Islamic Studies.

6.3.2 Teacher-Level of ICT Integration

The following section presents the current teacher-level of ICT integration. This section is structured as follows: Teachers' experience using ICT, Material used with the aid of a computer and/or the Internet, Teachers' ICT-based activities with the class, Pedagogic Approaches (with or without ICT), Teachers' professional development and confidence in ICT, and Teachers' attitudes and opinions to ICT integration.

6.3.2.1 Teachers' experience using ICT.

Within the survey, the teachers were asked about the number of years using computers and/or the Internet at school, experience using computers and/or the Internet in the last 12 months for teaching purposes, and their experience using computers and the Internet in their daily life. The results showed that the majority of respondents (around 64%) from Tatweer schools had under 6 years experience, whereas the majority from the International school (around 66%) had 6 years or more experience, using computers and the Internet at school. Just one teacher in a Tatweer school had less than one year of experience using computers and the Internet at school. The results further showed that 91% of Tatweer teachers, and all teachers in the International school, had used computers and/or the Internet for preparing lessons in the last 12 months. Furthermore, around 79% of Tatweer teachers and 88% of the International school teachers had used computers and/or the Internet for teaching purposes in the previous 12 months.

In terms of the teachers' use of computer and the Internet at home, the teachers were asked two questions relating to the use of a computer and the Internet for activities at home. Around one third of the Tatweer teachers reported that they made daily use (and a further 37.5 % made weekly use) of a computer for activities other than work e.g. shopping, organising photos, socialising, entertainment, booking a hotel, contacting family and friends. The majority of the International schools' teachers (around 83%) made daily use of the computer and the Internet for these activities. Furthermore, the vast majority of teachers in both schools (around 92% of Tatweer teachers and all the International school teachers) use the computer and the Internet to update their knowledge and/ or to undertake professional development.

6.3.2.2 Material used with the aid of a computer and/or the Internet.

Teaching materials are important to support and scaffold learning in the learning environment, and therefore, within the survey teachers were asked to respond to a question on ICT-enabled resources being utilised in Tatweer and International school contexts.

As shown in Figure 6.1a, a high percentage of respondents from Tatweer school context (around 84%) used existing online materials from established educational sources and around 80% further used the Internet to search for educational material. Likewise, as shown in Figure 6.1b, the vast majority of respondents from the International school context (more than 90%) used the Internet to search for materials, and also used existing online materials from established educational sources. More than 63% of the Tatweer respondents further used ICT-enabled offline materials located on the school's computer or provided within the Ministry of Education's resource pack. With respect to the former, more than 50% of the respondents from the International school context also used offline materials such as those are found in a school database, and/ or CD-ROM. However, the resource materials provided by the Ministry of Education were less commonly used (less than 47%) in the International school context, when compared to the Tatweer schools. Online games were less commonly used by respondents (less than 50%) from both Tatweer and International school contexts, when compared with other types of online resources.

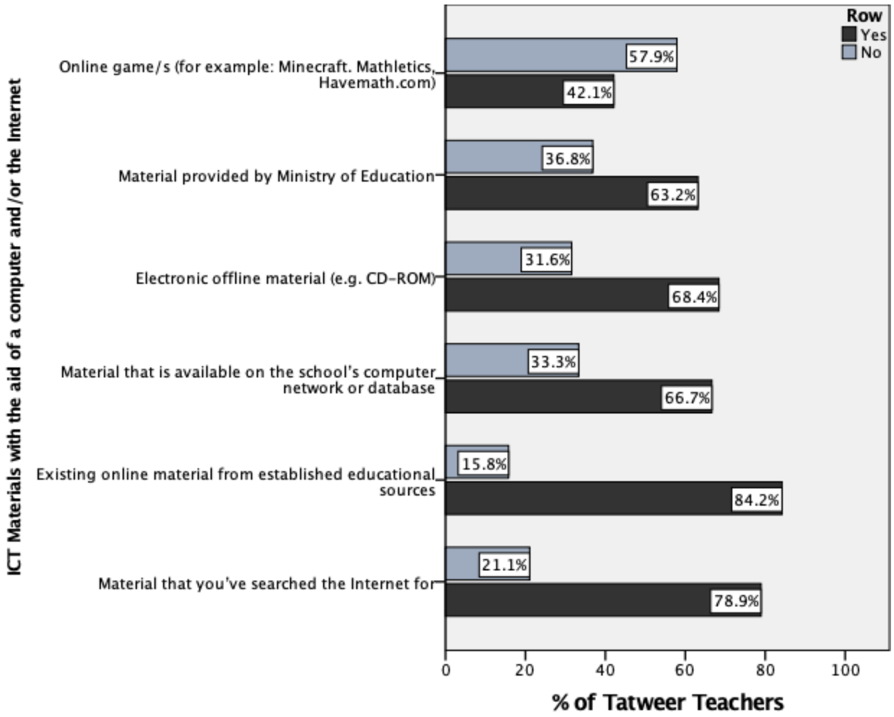


Figure 6.1a*:* Materials used by Tatweer teachers with the aid of a computer and/or the Internet.

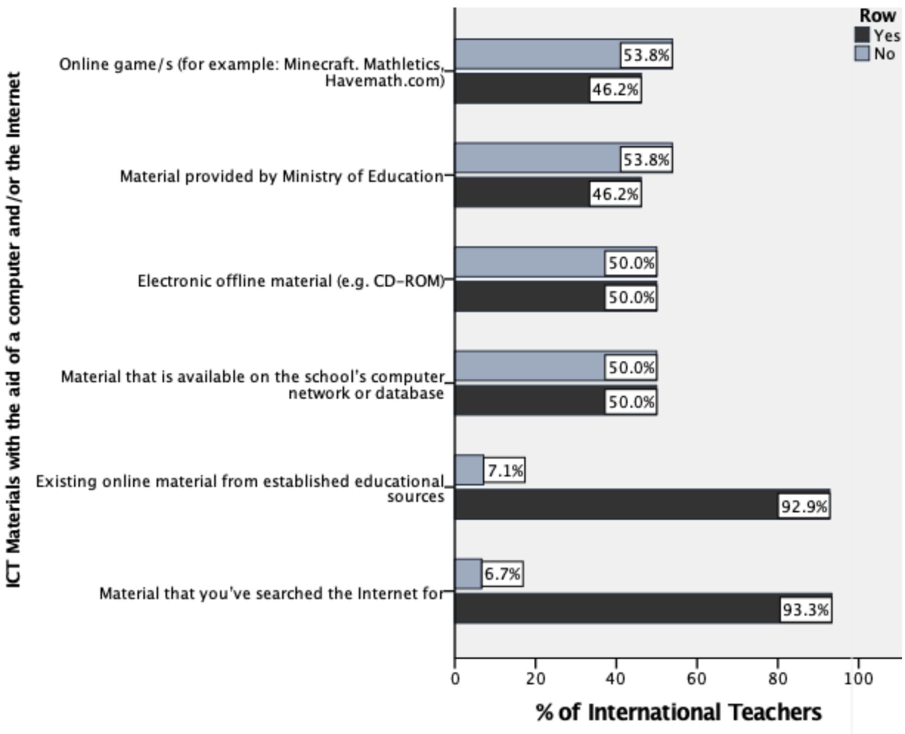


Figure 6.1b: Materials used by the International school teachers with the aid of a computer and/or the Internet.

6.3.2.3 Teachers' ICT-based activities with the class.

The frequency of teacher engagement and use of ICT-based activities in the class was explored in this study, and are illustrated in Figure 6.2a and Figure 6.2b. The findings showed that teaching preparation activities (browsing the Internet to prepare for lessons, preparing presentations, preparing tasks for students) were the most frequently declared ICT-based activities across both school contexts. However, the use of ICT in the preparation of teaching was more frequently used by respondents from the International school context, with around 40% of these teachers engaging in this on a daily basis, compared to 21% of Tatweer respondents. Similarly, the findings indicated that 40% of respondents from the International school context made daily or weekly use of ICT to provide feedback and/ or assess learner performance, with just over half of this number (21%) of respondents from Tatweer schools doing likewise.

The findings further indicated that more than treble the number of respondents from the International school context created digital learning materials on a daily basis for their learners (46% daily from International compared with less than 15% of teachers Tatweer school). The school website/virtual learning environment was less frequently used in Tatweer school context, with around 57% of respondents from Tatweer schools never using it, but conversely, 73% of respondents from the International school used these facilities, with only 6.7% never used it. Finally, more than 60% of the respondents from the International schools used technology daily or weekly for posting homework for students and communicating online with parents. Conversely, a high percentage of Tatweer respondents never used technology to post homework for learners (68%) and/ or communicate with parents (57%).

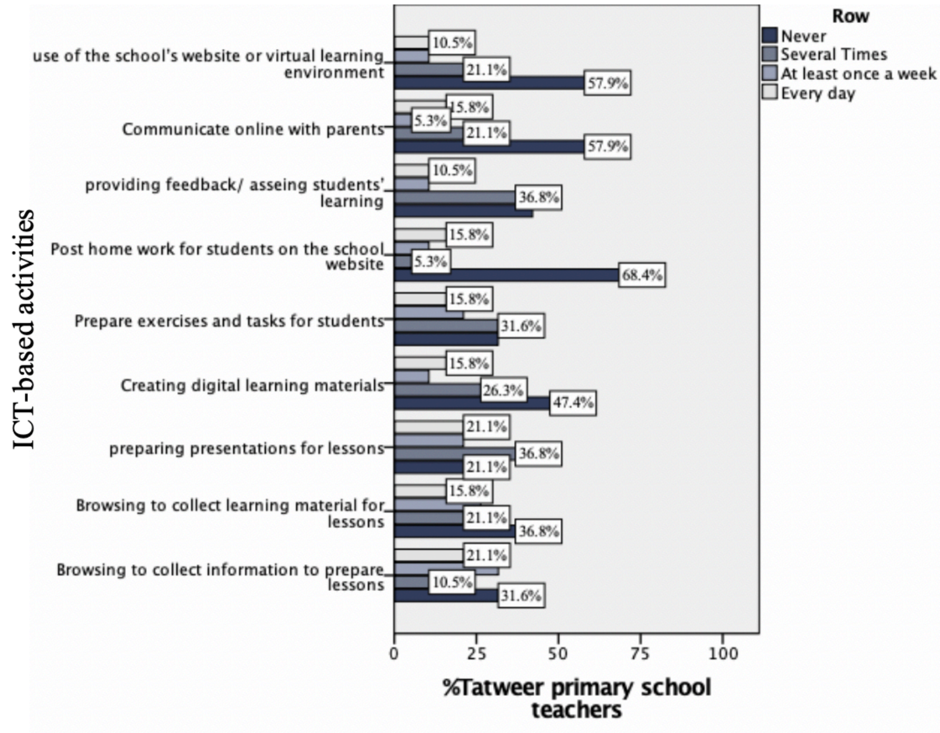


Figure 6.2a: Tatweer primary school teachers' ICT-based activities with their classes.

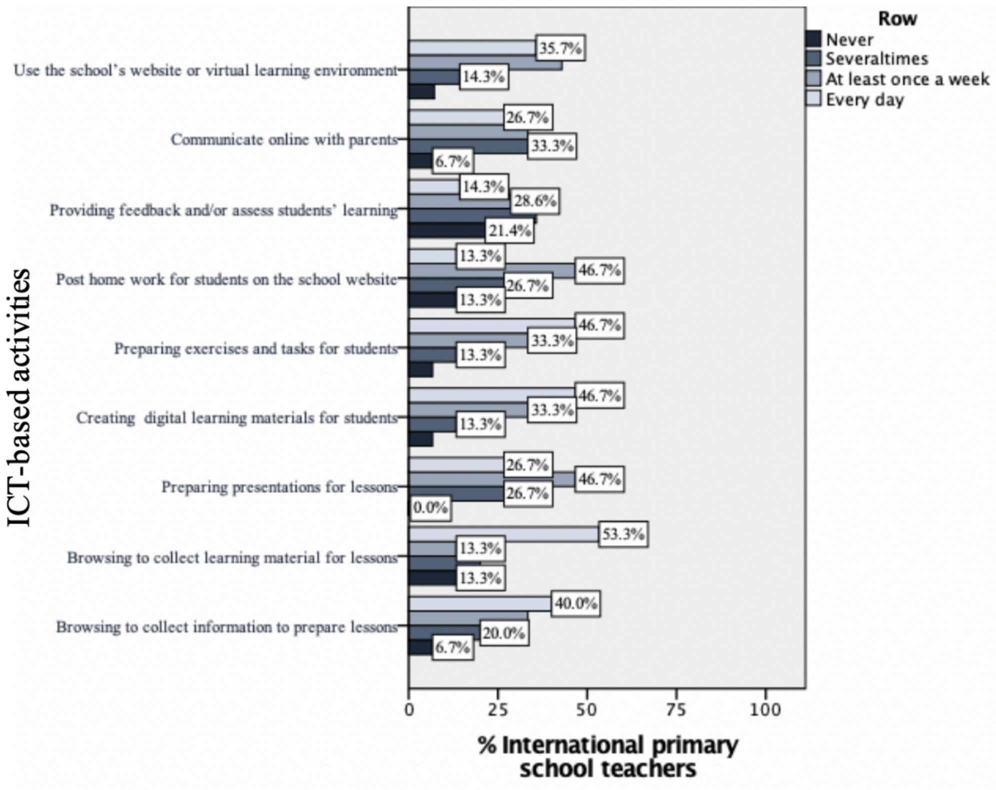


Figure 6.2b: International primary school teachers' ICT-based activities with their classes.

6.3.2.4 Pedagogic approaches (with or without ICT).

The participants in this study were asked to indicate the frequency with which they adopted particular pedagogic approaches in their practice with learners (with or without the use of ICT), and the findings are summarised in Figure 6.3a and Figure 6.3b. The findings indicated that the majority of teachers from both the Tatweer and International school contexts very frequently used modes of presentation and/ or demonstration to explain concepts etc. to the whole class (58% in Tatweer context, and 61% in International context), and also over half of respondents from both settings indicated that they provided individual feedback to learners (with results indicating slightly higher numbers of teachers providing feedback in International school context). The findings further showed that group-work among learners was actively encouraged by teachers in both settings (58% in Tatweer context, 68% in International context). Moreover, the findings from both settings indicated that opportunities for discussion of ideas between learners and with their teacher and self-directed work is not as frequently supported as other modes of teaching and learning. With respect to the former, just 50% of respondents from the International school context and 41% from Tatweer school context facilitated learner discussion of ideas with peers and teachers ‘a lot’, and in terms of the latter, self-directed work by learners was less frequently supported by teachers with just 29% in Tatweer context, 44% in International context indicating frequent engagement in this. Interestingly, enquiry-based activities were highlighted as being used a lot by 50% of respondents in Tatweer school context and 61% by those in International school context. Learner engagement in assessment of own/ others work was rated relatively strongly within the International school context (55% engaging in this practice a lot), but was less strongly practiced within Tatweer school context (41% of respondents rated doing this ‘a lot’). The practice of allowing learners to present to whole-class was less well supported in general across both school contexts, with 50% of those in International school context facilitating this regularly and only 37% of those in Tatweer school context doing likewise. Similarly, opportunities for learners to engage in reflection was not as frequently used - with around 44% of respondents from International school context and around 37% of those from frequently providing opportunities to reflect on their own learning.

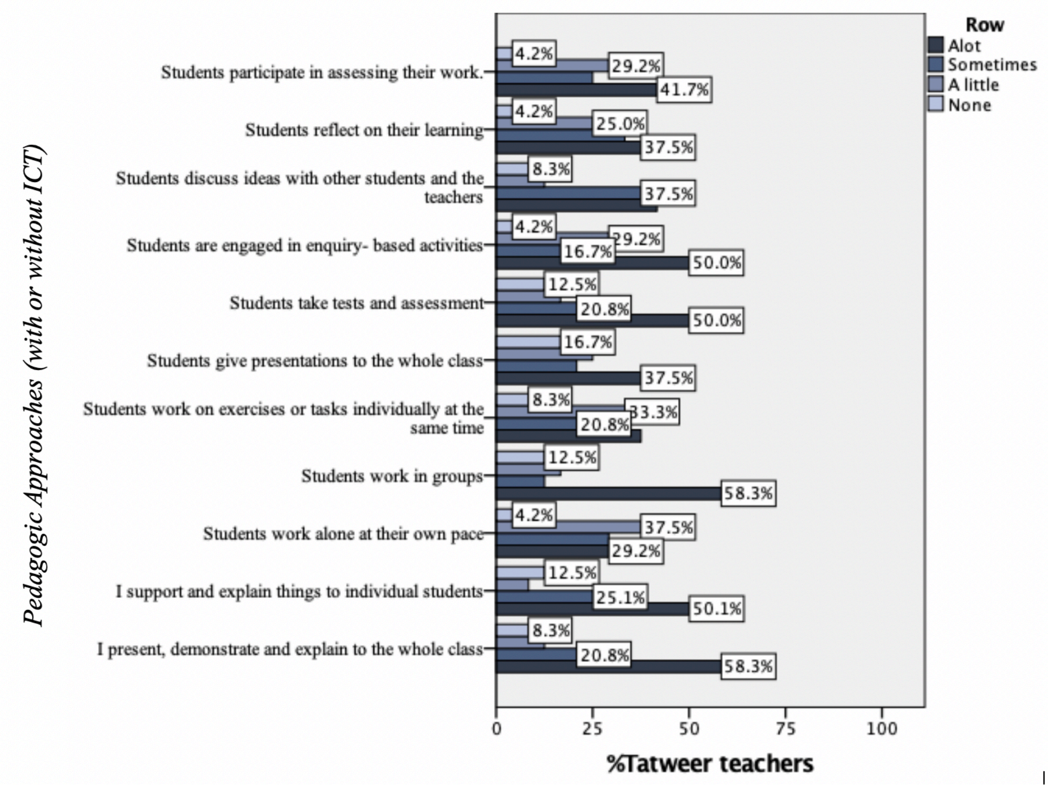


Figure 6.3a: Pedagogic Approaches (with or without ICT) in Tatweer schools.

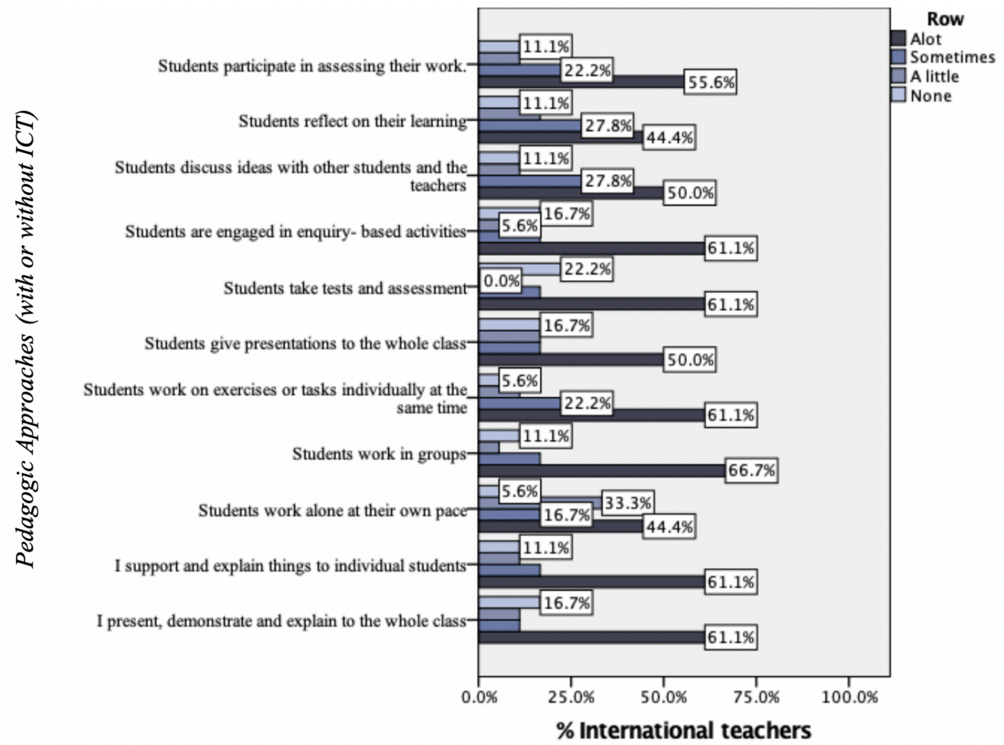


Figure 6.3b: Pedagogic Approaches (with or without ICT) in International schools.

6.3.2.5 Teachers' Professional Development and Confidence.

The teachers were asked about training and professional development in this part of the study, and furthermore were asked to gauge their confidence in using ICT in their practice.

The findings indicated that ICT training was **not** compulsory for teachers in either Tatweer or International school contexts, as self-reported by respondents with only 36% of the Tatweer teachers and 60% of the International teachers reporting mandatory participation in ICT training for their own subject. However, the findings further indicated that around three quarters of respondents from the Tatweer school context and all from the International school context, engaged in ICT training opportunities in the previous two school years. It was also interesting to report that most of Tatweer respondents (around 63%) had undertaken ICT training through the government training unit and the remainder through a private company, while the vast majority of the respondents (80%) in the International schools were trained by a private company with the remainder undertaken training provided by a government body.

The findings further indicated that most of the Tatweer respondents had engaged in personal learning about ICT in their own time (around 73%), and more than 57% of them also had both engaged in ICT training provided by school and participated in online communities for professional discussion with other teachers (as shown in Figure 6.4a). Similarly, in the context of the International school as shown in Figure 6.4b, a very high number of respondents indicated they had engaged in personal learning about ICT in their own time (87%), in ICT training provided by school staff (71%) with somewhat lesser percentage participating in online communities to exchange professionally with other teachers (53%).

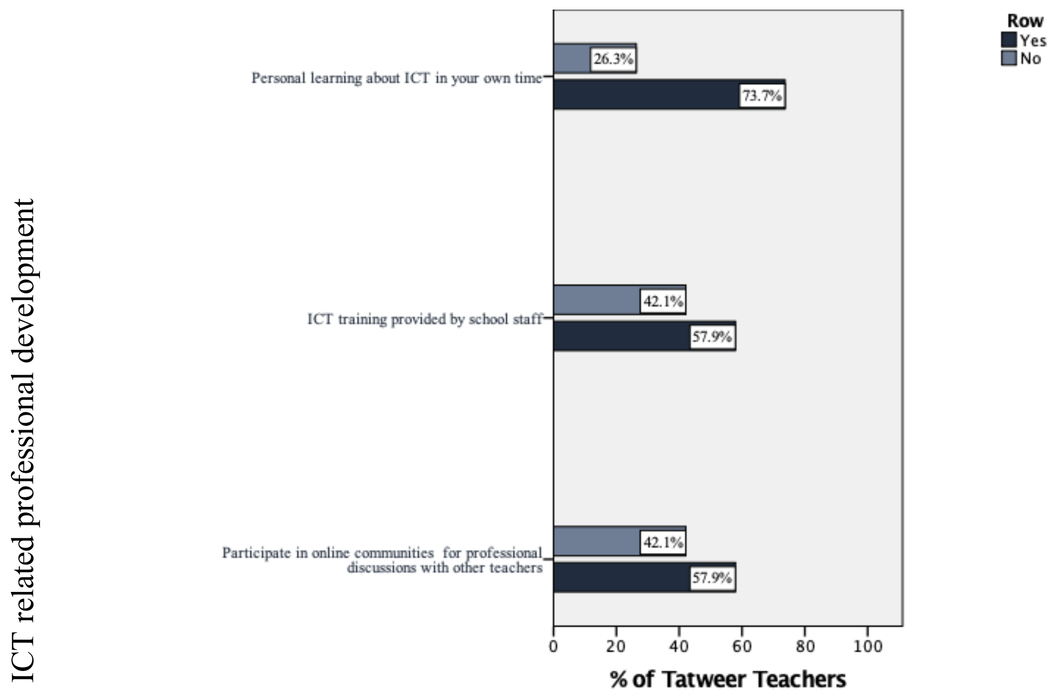


Figure 6.4a*:* Tatweer teachers engagement in ICT related professional development.

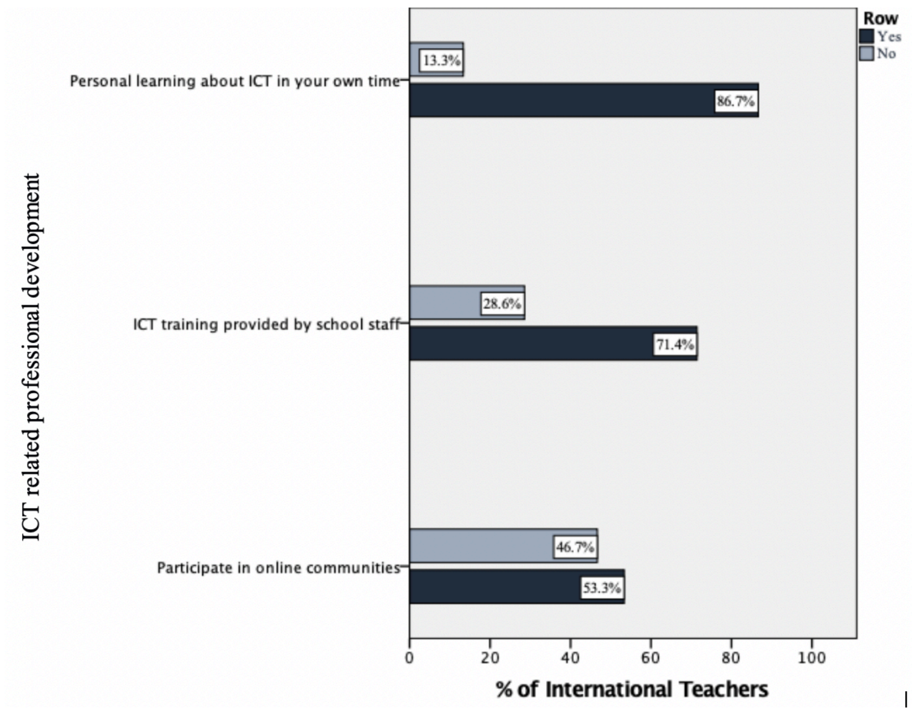


Figure 6.4b*:* International teachers' engagement in ICT related professional development

In terms of types of training as shown in Figure 6.5a, around 63% of Tatweer respondents had participated in training on basic and advanced use of Internet, basic applications (e.g. basic word processing, spread sheets, presentations), equipment-specific training (interactive whiteboard, laptop, etc.), and ICT training related to their subject, in the previous two school years. Similarly as shown in Figure 6.5b, but at a much higher level of participation, over 87% of the respondents from the International school context had participated in introductory training courses on the use of the internet and general applications (e.g. basic word processing, spread sheets, presentations etc.), equipment-specific training and subject-specific training in ICT. Furthermore, respondents from both settings engaged on courses on using ICT as a pedagogic tool, with a higher level of participation in such courses by those in the International school context (53%) than in Tatweer school context (42%). Finally, there was evidence of engagement by respondents in both settings with courses on multimedia (42% in Tatweer school context; 66% in International school context) and advanced courses in specific applications (with similar levels of participation 52%/53% for the latter).

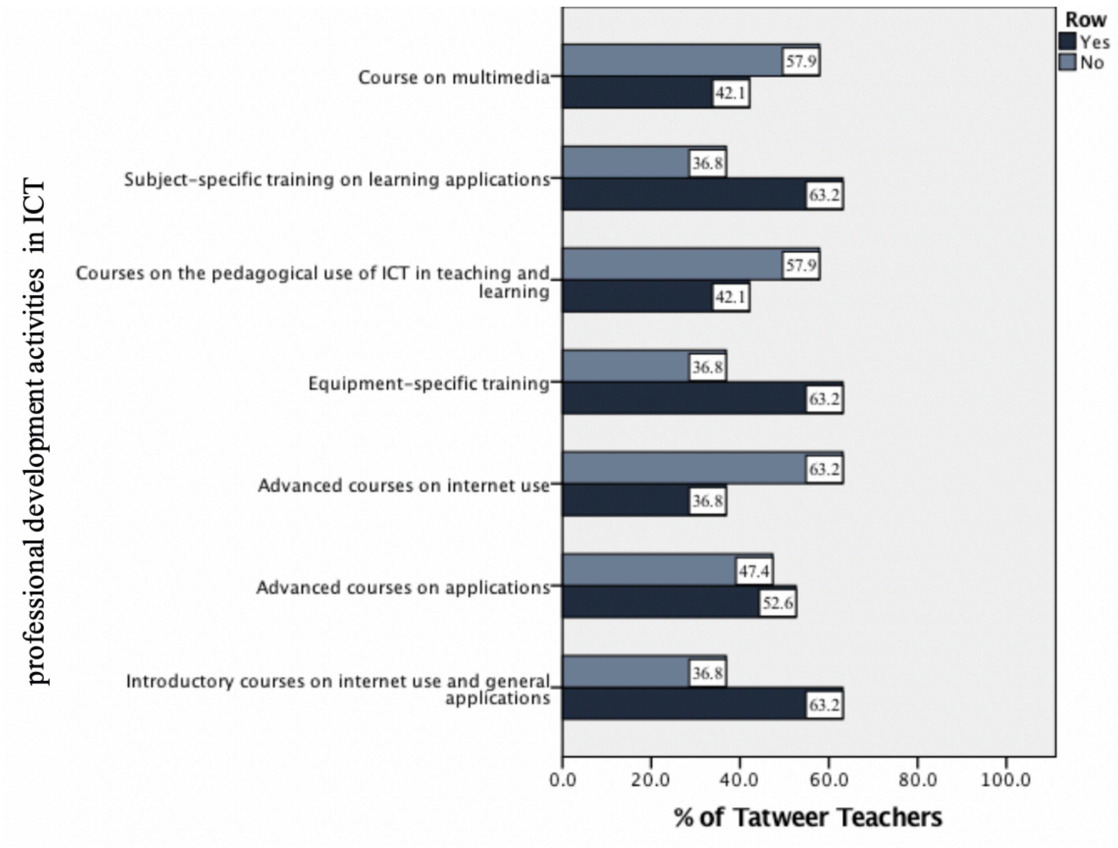


Figure 6.5a: Tatweer teachers' types of professional development in ICT

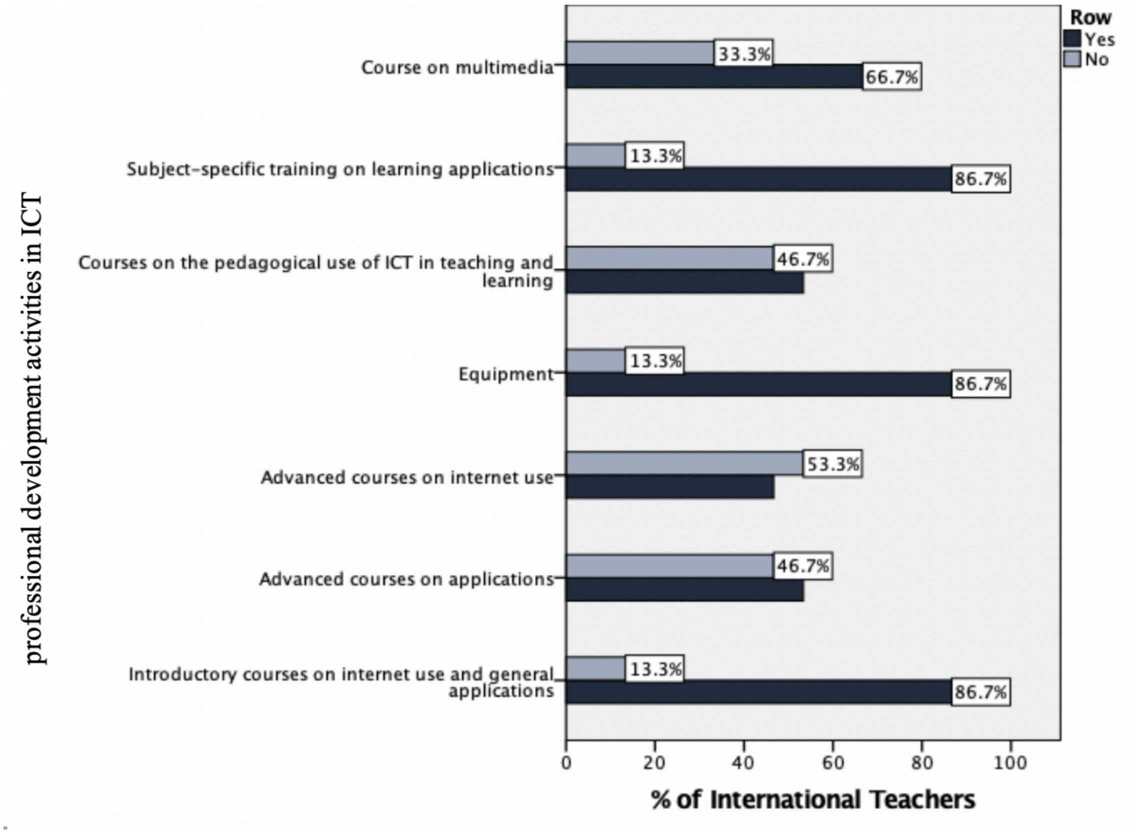


Figure 6.5b: International teachers' types of professional development in ICT

This section summarises the findings from respondents' self-reported levels of confidence in their operational ICT skills (Figure 6.6a and Figure 6.6b), their social media skills (Figure 6.7a & Figure 6.7b), and their ability to enable learners to behave ethically and safely when using online technologies (Figure 6.8a and Figure 6.8b).

The findings indicated that the respondents in both types of schools had good levels of confidence in operational ICT skills but the respondents from the International school context expressed higher levels of confidence overall compared to those from the Tatweer context.

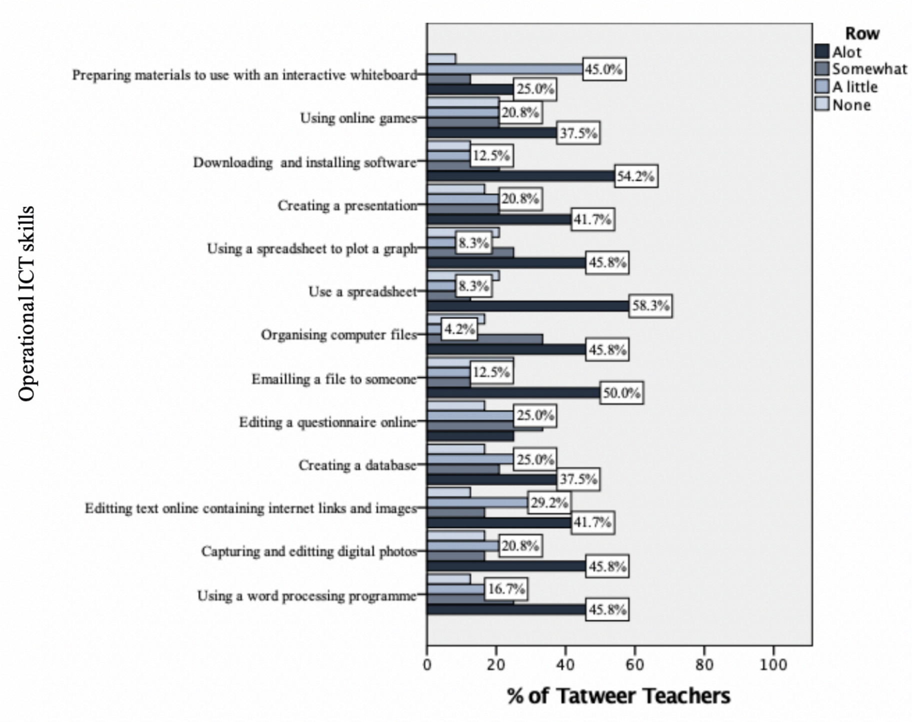


Figure 6.6a: Tatweer Teachers' confidence in operational ICT skills.

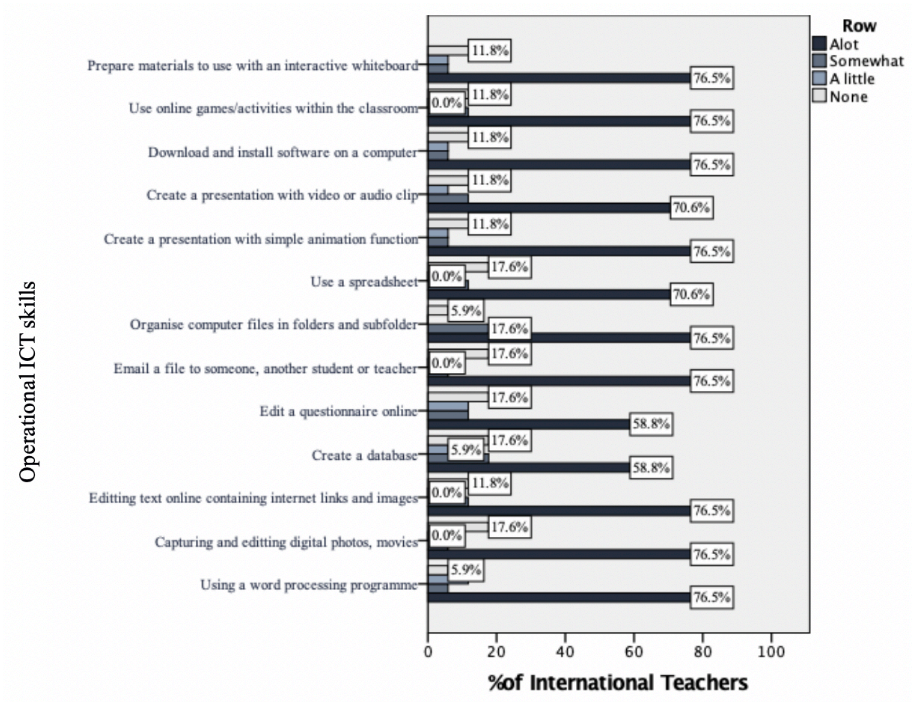


Figure 6.6b: International Teachers' confidence in operational ICT skills.

In the Tatweer context, respondents indicated having high confidence levels working with spreadsheets (58%), downloading files & installing software (54%), and using emails (50%), but had less confidence in their use of online games, databases or in preparing materials for use with interactive whiteboard. In comparison, within the International school context, the majority of respondents recorded high levels of confidence in operational type activities confidently, with over 70% self-reporting high confidence levels across the range of operational skills, with the exception of just two items, namely, creating databases and editing online surveys.

In contrast in the context of social media skills across both contexts, the findings indicated that fewer respondents had high levels of confidence across 3 of the 4 specific social media skills (engaging in social networking, blogging and online discussing forum), with the respondents from the International school context expressing higher levels of confidence overall compared to those from the Tatweer context. The respondents in the International context demonstrated a very high level of confidence in emailing (82%), with less respondents (50%) indicating confidence in this skills in the Tatweer context. .

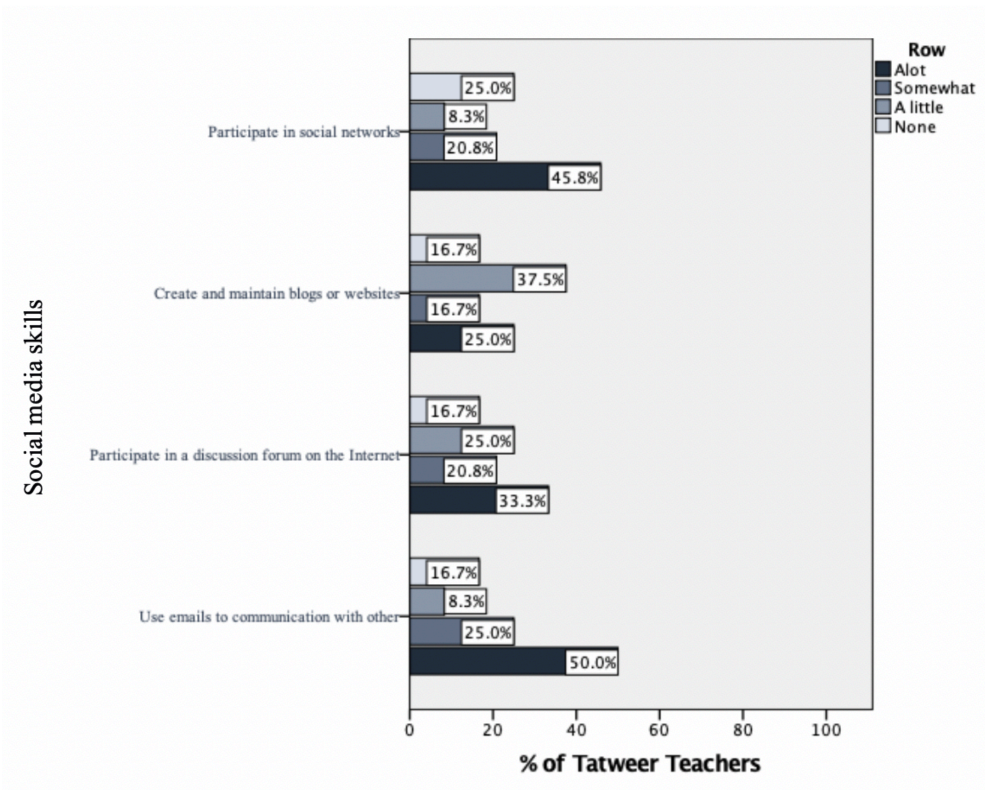


Figure 6.7a: Tatweer Teachers' confidence in social media ICT skills.

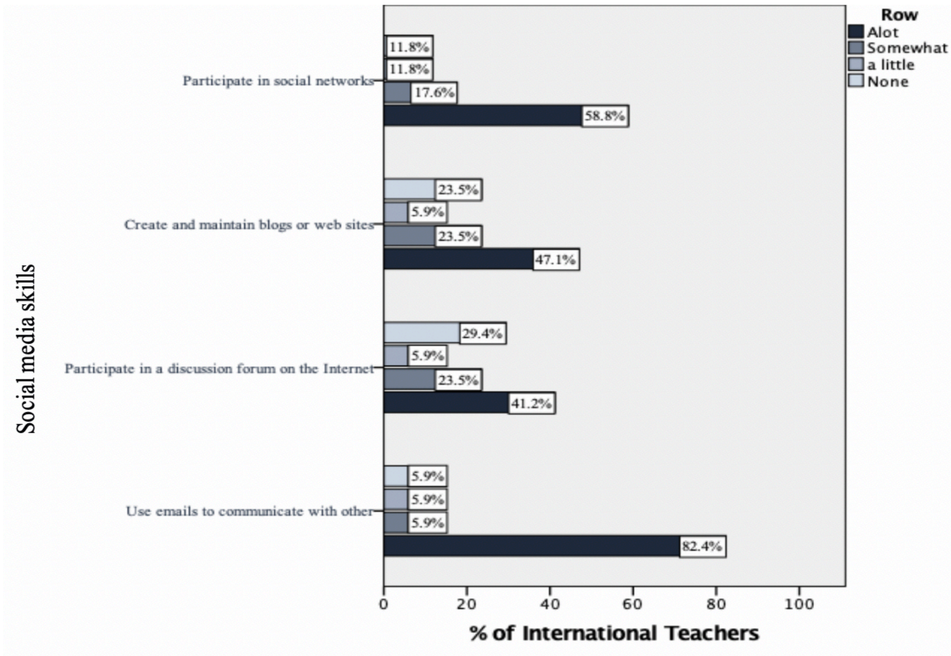


Figure 6.7b: International Teachers' confidence in social media ICT skills.

Finally, in terms of confidence in teaching learners how to behave ethically and safely online, the respondents from the International school context indicated high levels of confidence in doing this (with over 81% expressed high confidence levels), whilst the respondents from the Tatweer school were considerably less confident in facilitating this (circa 37.5% expressed high confidence levels).

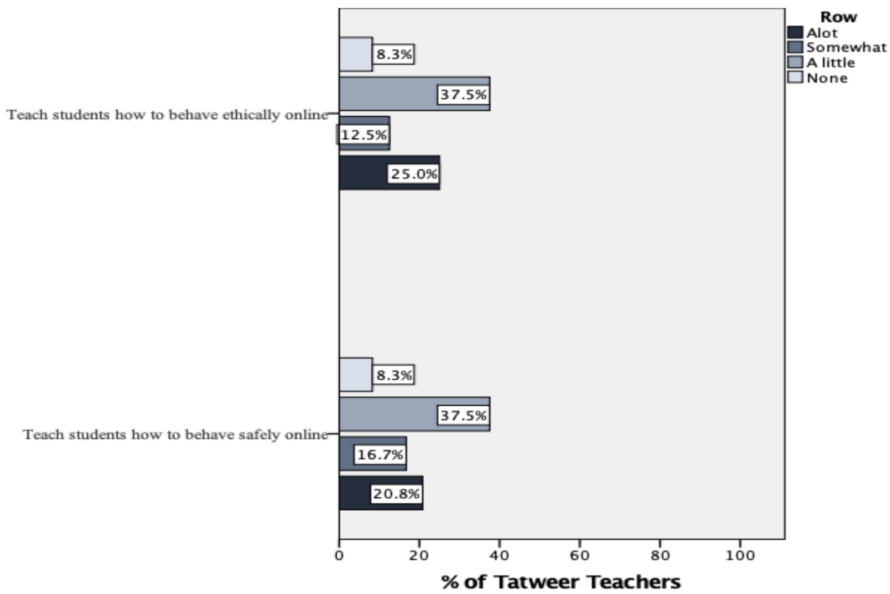


Figure 6.8a: Tatweer teachers' confidence in using ICT ethically and safety

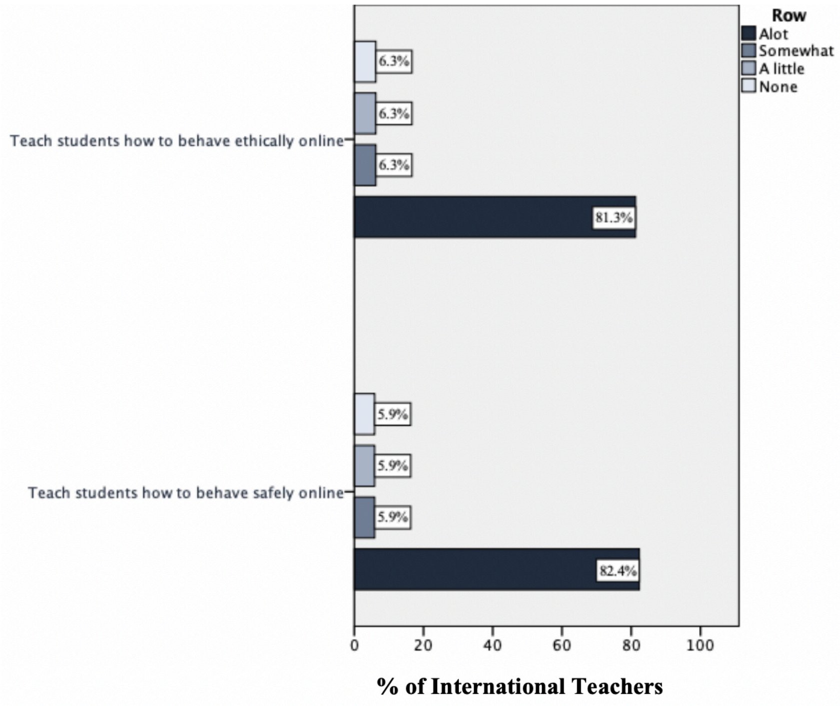


Figure 6.8b: International teachers' confidence in using ICT ethically and safety.

6.3.2.6 Teachers' attitudes and opinions to ICT integration.

The survey contained several questions investigating respondent's opinions about the impact on learners of integrating ICT in teaching and learning, which were rated on a scale of mattering 'a lot' to 'not at all'. The participants were also asked about their attitudes toward the challenges of twenty-first-century education, the readiness of schools to fully exploit ICT's potential in teaching and learning, the relevance of ICT use in different learning processes, and ICT's impact on students' skills, motivation and achievement. The latter items were rated on a 4-point Likert scale from 'strongly disagree' to 'strongly agree'. The effect gender on their attitudes was also explored.

Overall the findings indicated that the very large majority of respondents appeared to be very positively disposed towards integration of ICT and perceived positive outcomes for learners in doing so. The teachers in the International schools were more positive about benefits of technology integration compared to those in Tatweer schools. In terms of the Tatweer school context, respondents considered ICT-use during lessons as having a very positive impact through improving learners' understanding (50%), their perseverance in learning (54%), facilitation of collaborative work (54%) and improved class climate (54%). In the International context, respondents similarly noted ICT-integration leading to improvement in class climate (83%) in learners' understanding (83%), but interestingly, also recognised its value in enabling improvement in learner autonomy (83%) and in enhanced memory capacity (88%).

Moreover, the majority of respondents in both contexts recognised the value of ICT integration in supporting self-directed work as well as collaborative learning, with those in International context expressing more strongly their agreement of the value of ICT in supporting completion of exercises and practical sessions (77% in International context compared to 45% in Tatweer context strongly agreeing on this). The respondents from both contexts further agreed that ICT had positive impacts on learners' achievement, motivation, transversal skills but respondents from the International school context did not hold as strongly the belief that students' higher order thinking skills would be improved (as those in the Tatweer school context).

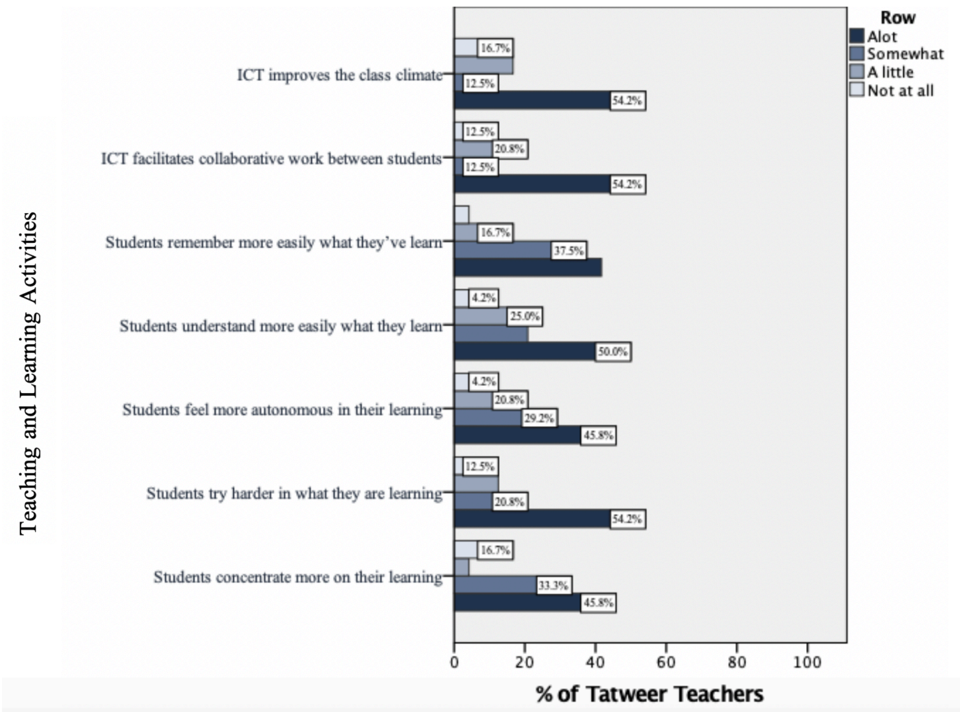


Figure 6.9a: Tatweer Teachers' opinions and attitudes on the impact of ICT on teaching and learning.

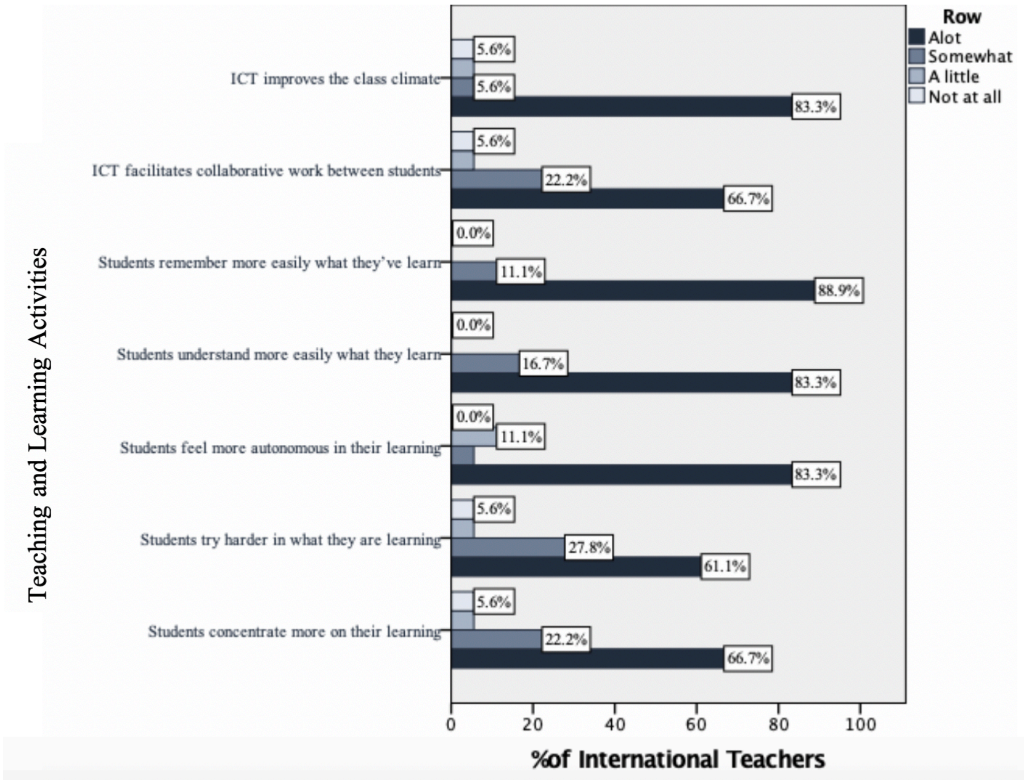


Figure 6.9b: International Teachers' opinions and attitudes on the impact of ICT on teaching and learning.

Finally, the results showed that both respondents from Tatweer and International school contexts were positively disposed towards ICT integration, and agreed that radical changes were needed in education to successfully re-orient towards technology integration. In the Tatweer context, the respondents wholly agreed that ICT integration was essential to prepare students to live and work in the 21st century, and 91% also agreed that radical changes in schools needed for ICT to be fully exploited for teaching and learning. Moreover, more than 84% of respondents in the International school context agreed that ICT was essential for students in 21st century (77% of these strongly agreed), with over 90% agreeing that radical changes in schools were needed for ICT to be fully exploited for teaching and learning.

6.3.2.7 The Gender Factor

The gender of respondents was examined to see if it was a factor influencing respondents' attitudes toward the integration of ICT in teaching and learning. The Mann-Whitney U Test was chosen to test differences between male and female participant' responses to survey, as the variables were not normal distributed (see Appendix H). The overall findings indicated that there were some differences between the male and female respondents from the Tatweer school context, in terms of level of agreement on the impact of ICT on some activities/ aspects of learning, but there was no significant statistical difference recorded between respondents of different gender from the International school context. Within the context of the International schools, the number of female respondents greatly exceeded the number of male respondents, so the Fritz et al. formula was used to study whether this had an effect on the result – the outcome is that there was a small size effect as the value of Fritz et al. formula for all statements varied between 0.00 and 0.12.

The analysis of the possible impact of respondents' gender differences is presented in Table 6.1a (Tatweer school context) and in Table 6.1b (International school context), in the context of questions relating to the impact of ICT on: i) learners' concentration on their learning, ii) learner perseverance with learning, iii) feeling more autonomous, iv) understanding and remembering more easily, v) whether ICT facilitates collaborative work, and vi) whether it improves the class climate. The results clearly indicated that there were no significant statistical differences between the male and female teachers in both type of schools, therefore, it has been concluded that the gender factor played no role in the overall findings from this set of questions, as the p values for all these variables are bigger than .05.

Table 6.1a*:* Mann-Whitney U Test between Tatweer teachers' opinion and attitudes on the impact of ICT on teaching and learning and Tatweer teachers' gender.

	i)Students concentrate more on their learning	ii)Students try harder in what they are learning	iii)Students feel more autonomous in their learning	iv)Students understand more easily what they learn	v)Students remember more easily what they've learnt	vi)ICT facilitates collaborative work between students	vii) ICT improves the class climate
Mann-Whitney U	55.500	53.000	54.000	54.000	51.000	62.000	45.000
Wilcoxon W	133.500	131.000	132.000	132.000	129.000	140.000	123.000
Z	-1.025	-1.204	-1.113	-1.126	-1.299	-.634	-1.710
Asymp. Sig. (2-tailed)	.305	.228	.266	.260	.194	.526	.087
a. Grouping Variable: What is your gender?							

Table 6.1b: Mann-Whitney U Test between the International School teachers' opinion and attitudes on the impact of ICT on teaching and learning and teachers' gender.

	i)Students concentrate more on their learning	ii)Students try harder in what they are learning	iii)Students feel more autonomous in their learning	iv)Students understand more easily what they learn	v)Students remember more easily what they've learnt	vi)ICT facilitates collaborative work between students	vii) ICT improves the class climate
Mann-Whitney U	25.500	25.000	16.500	16.500	18.000	12.000	16.500
Wilcoxon W	116.500	35.000	22.500	22.500	24.000	18.000	22.500
Z	-.071	-.135	-.702	-.703	-.480	-1.240	-.702
Asymp. Sig. (2-tailed)	.943	.893	.483	.482	.631	.215	.483
a. Grouping Variable: What is your gender?							

The analysis of the possible impact of respondents' gender differences has also been presented in Table 6.2a (Tatweer school context) and in Table 6.2b (International school context), in the context of questions relating to the impact of ICT use within activities such as: i) doing exercises and practice, ii) retrieving information, iii) collaboration and iv) self-directed learning. The analysis of data indicated that there was no significant statistical differences between male and female teachers in both types of schools (the p values for all these variables are bigger than .05).

Table 6.2a: Mann-Whitney U Test between Tatweer teachers' opinion and attitudes on the relevance of ICT use in different learning processes and the teachers' gender.

	i)Do exercises and practice	ii)Retrieve information	iii)Work in collaborative ways	iv)Learn in autonomous ways
Mann-Whitney U	57.000	59.500	55.500	49.500
Wilcoxon W	135.000	137.500	133.500	104.500
Z	-.950	-.784	-1.072	-.801
Asymp. Sig. (2-tailed)	.342	.433	.284	.423
a. Grouping Variable: What is your gender?				

Table 6.2b: Mann-Whitney U Test between the International School teachers' opinion and attitudes on the relevance of ICT use in different learning processes and the teachers' gender.

	i)Do exercises and practice	ii)Retrieve information	iii)Work in collaborative ways	iv)Learn in autonomous ways
Mann-Whitney U	22.500	24.000	16.000	25.500
Wilcoxon W	113.500	115.000	107.000	116.500
Z	-.597	-.306	-1.528	-.071
Asymp. Sig. (2-tailed)	.551	.760	.126	.943
a. Grouping Variable: What is your gender?				

The analysis of the possible impact of respondents' gender differences has also been presented in Table 6.3a (Tatweer school context) and in Table 6.3b (International school context), in the context of questions relating to the students i) motivation, ii) achievement, iii) higher order thinking and iv) competence in transversal skills. Interestingly, the results in Table 6.3a shows that there was a statistically significant difference between male and female Tatweer teachers' opinion of the use of ICT to improve the *students' motivation* (Mann Whitney is 42, p= .028) where female teachers scored higher mean rank (15) compared to male teachers mean rank (12). Furthermore, there was a statistically significant difference between male and female Tatweer respondents' opinion on use of ICT to improve *academic achievement* (Mann Whitney is 36 and p= .015) where female mean rank (15.5) is higher compared to male mean rank (9.5). Table 6.3b shows that there is no statistically significant difference between male and female respondents' opinion in the International schools on the impact of ICT on these activities as p values are bigger than .05. Finally, the analysis confirmed that as the p values for the impact of ICT on higher order thinking and competence in transversal skills in Tatweer context, are bigger than alpha level .05, there are no significant statistic differences between male and female teachers in Tatweer schools in these. The analysis in the International school context showed no significant statistical difference between male and female teachers' opinion on the impact of ICT on any of these aspects (all p values are bigger than .05).

Table 6.3a: Mann-Whitney U Test between Tatweer teachers' opinion and attitudes on the impact of ICT on students' skills, motivation, and achievement and teachers' gender.

	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Motivation	female	12	15.00	180.0	42.000	120.000	-2.198	.028
	male	12	10.00	120.0				
Achievement	female	12	15.50	186.0	36.000	114.000	-2.432	.015
	male	12	9.50	114.0				
Higher order thinking skills	female	12	14.00	168.0	54.000	132.000	-1.238	.216
	male	12	11.00	132.0				
Competence in transversal skills	female	12	13.38	160.5	61.500	139.500	-.676	.499
	male	12	11.63	139.5				
a. Grouping Variable: What is your gender?								

Table 6.3b: Mann-Whitney U Test between the International Schools teachers' opinion and attitudes on the impact of ICT on students' skills, motivation, and achievement and teachers' gender.

	i)Motivation	ii)Achievement	iii)Higher order thinking skills	iv)Competence in transversal skills
Mann-Whitney U	22.500	10.500	20.500	23.000
Wilcoxon W	32.500	16.500	30.500	33.000
Z	-.213	-1.441	-.684	-.387
Asymp. Sig. (2-tailed)	.831	.150	.494	.699
a. Grouping Variable: What is your gender?				

The analysis of the possible impact of respondents' gender differences has also been presented in Table 6.4a (Tatweer school context) and in Table 6.4b (International school context), in the context of questions relating to the perceived i) benefit of ICT in preparing students to live and work in the 21st century and in consideration of whether ii) radical changes are needed in schools to respond to ICT integration.

The results in Table 6.4a showed that there was a significant statistical difference between male and female Tatweer teachers' opinion in the use of ICT in preparing students to live and work in the 21st century (Mann Whitney is 30 and p = .004) where female teachers scored higher mean rank (16) as compared to male mean rank (9). Moreover, the test shows that there was a statistically significant difference between male and female Tatweer teachers' opinion in whether radical changes were needed in schools (Mann Whitney is 39 and p value is .032). where female teachers scored higher mean rank (15.25) as compared to male mean rank (9.75). These results indicate female Tatweer teachers have more strongly agreed than male teachers on the role of ICT in preparing learners for 21st century and of the need for more radical changes within education to accommodate ICT integration. On the other hand, the results (Table 6.4b) showed that there was no significant statistical difference between the International male and female teachers' opinion on the impact of ICT on these aspects (p value for all these statements are bigger than .05).

Table 6.4a: Mann-Whitney U Test between Tatweer teachers' opinion and attitudes about general issues, 21st century education challenges, ICT potential in teaching and learning and teachers' gender.

	Gender	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
i)ICT is essential for students in 21st century	female	12	16.00	192.00	30.000	108.000	-2.889	**.004**
	male	12	9.00	108.00				
ii)Radical changes for ICT in schools	female	12	15.25	183.00	39.000	117.000	-2.145	**.032**
	male	12	9.75	117.00				

Table 6.4b: Mann-Whitney U Test between the international School teachers' opinion and attitudes about general issues, 21st century education challenges, and the potential of ICT in teaching and learning and teachers' gender.

	ICT use is essential to prepare students to live and work in the 21st century	ICT to be fully exploited for teaching and learning radical changes in schools are needed.
Mann-Whitney U	22.500	21.000
Wilcoxon W	113.500	31.000
Z	-.597	-.622
Asymp. Sig. (2-tailed)	.551	.534

a. Grouping Variable: What is your gender?

6.3.3 School-Level ICT Integration

The following section presents the respondents' perceptions of the existing school-level ICT integration. This section discusses school-level of ICT integration in terms of: Access to ICT infrastructure, ICT provision and obstacles to the use of ICT.

6.3.3.1 Access to ICT infrastructure and ICT provision.

Figure 6.10a presents Tatweer participants' responses to their access to ICT at a school level. It shows that almost all such equipment could be accessed (on demand or permanently in situ) by most of Tatweer teachers. Specifically, more than 47% of teachers reported that they had access to computers with or without Internet and around 42% of Tatweer teachers had access to mobile phone through their schools. The majority of teachers in Tatweer Schools (around 52%) have access to E-readers on demand. Furthermore, most teachers indicated that they had permanent access to Interactive whiteboards.

In contrast, the teachers in the International school contexts had permanent access to most devices with the exception of e-readers, mobile phones and digital cameras (53% of the International School teachers have no access). Figure 6.10b shows that 80% of the teachers had access to an interactive whiteboard, followed by computers with and/or without internet connection. Around 59% of respondents in the International school context had access to computers including: desktop computers or any devices whether connected to the Internet or not, and 60% of the teachers had permanent access to computer labs. The respondents in the International Schools indicated that they had no mobile phone access, which indicated that mobile phones were prohibited in these schools (the latter was confirmed as being true in a later section).

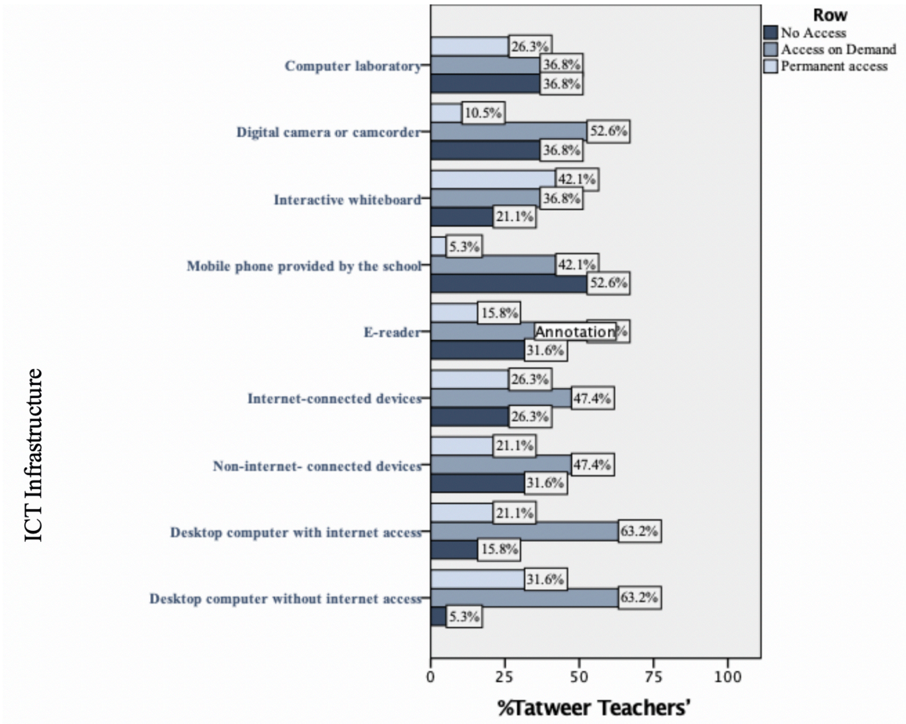


Figure 6.10a: Tatweer Teachers' access to ICT Infrastructure.

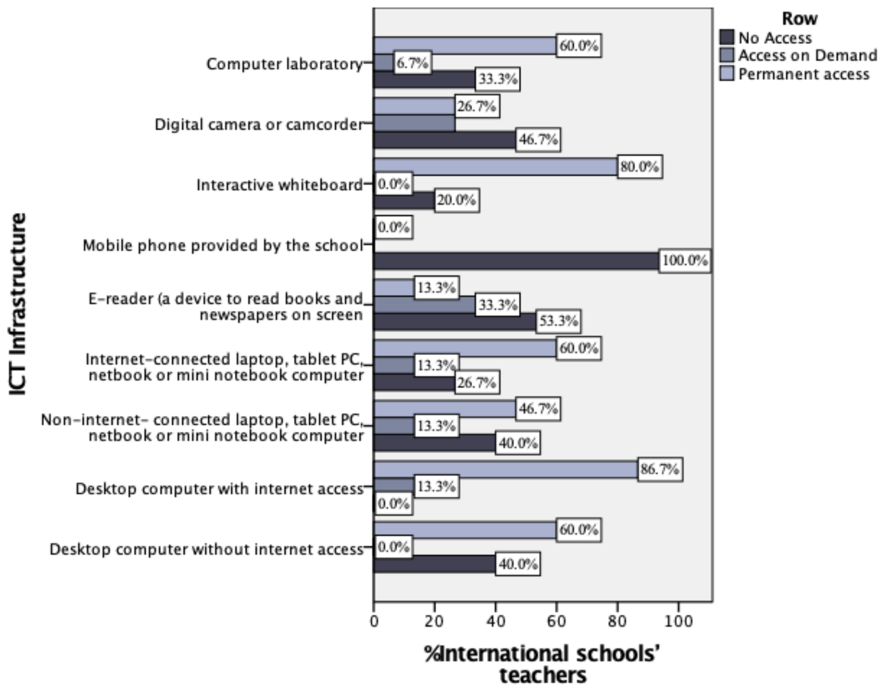


Figure 6.10b: International teachers' access to ICT infrastructure

The respondents were further asked about the ICT provision for learners and for personal use of teachers within their school. The overall findings indicated that both types of school settings did not directly provide the students with the essential equipment. In the case of Tatweer school (see Figure 6.11a), about 79% of Tatweer respondents reported that their schools had no initiatives for providing learners with laptops, tablets, or notebooks. Additionally, around 90% of Tatweer respondents reported that learners were not allowed to use their mobile devices or smartphones at all. The findings further showed that most Tatweer teachers reported that there was no direct provision of laptops, tablets, or notebooks for sole use by the teacher in the school.

Moreover, more than 73% of the teachers in the International schools reported (see Figure 6.11b) that the school did not provide the learners with laptop, tablet and notebook to use in the school, and that the students were not allowed to use their personal devices such as laptops, tablets, notebook and netbook. Furthermore, all respondents indicated that the learners in the International school were not allowed to use mobile or smartphones. However, the International school did provide a majority of respondents with sole use of a computer (laptop/ tablet, etc.).

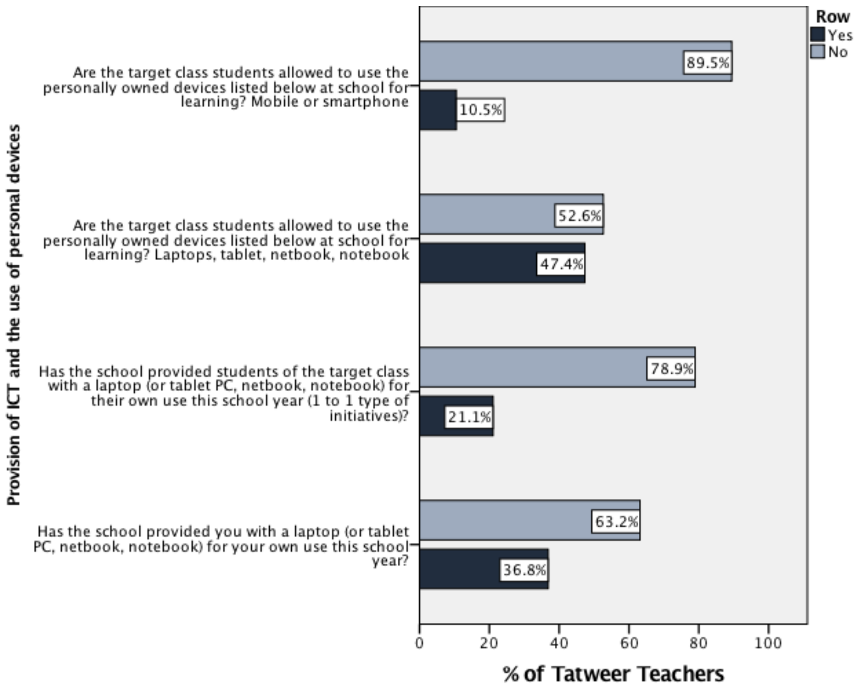


Figure 6.11a: Provision of ICT and the use of personal devices in Tatweer Schools.

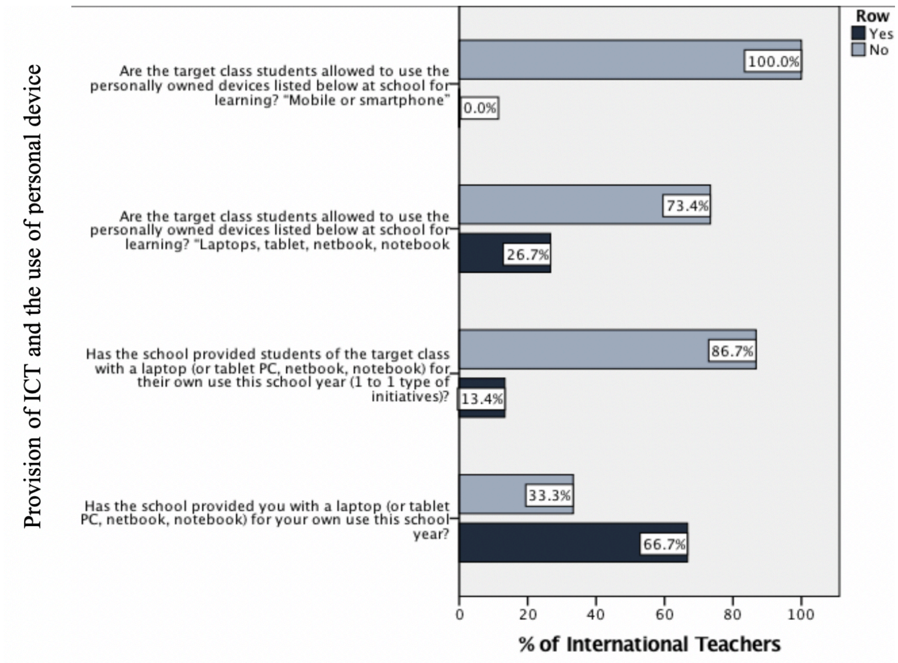


Figure 6.11b: Provision of ICT and the use of personal devices in the International Schools.

6.3.3.2 Obstacles to the use of ICT.

The factors impacting teachers' use of ICT in teaching and learning were also explored in this study. It was challenging to engage in a Factor Analysis with this data-set because factor analyses require a large number of observations, at least 100. A rule of thumb is that the number of observations should be at least 8 times the number of variables. The survey contained questions with about 20 items asking about the factors that inhibit teachers' use of ICT in teaching and learning. In the original EU study that inspired these survey questions, the survey items were divided into four factors as follows:

- *Equipment:* Insufficient or out of date/faulty computers, lack of laptops, No interactive whiteboards, and Slow Internet connection.
- *Pedagogy*: Lack of teacher skills, technical and pedagogical support, and/ or content (including in the local language), Difficulty of integration of ICT, and Lack of models for using ICT in teaching, Lack of ability to monitor learners' safe usage of the Internet.
- *Goal*: Parental and teacher opposition to the use of ICT, Benefits of ICT not clear, and the Use of ICT not being a goal in the school.

- *Other Factors*: Four items did not fall into any of these scales: Poor school time organisation, Weak space organisation, Pressure to prepare students for tests, and Students' safety online. These were categorised as other factors.

The same categorisation of factors was therefore followed for the factor analysis in this study, and the results are presented in Figures 6.12a to 6.15b. The results in general seemed to show that around 50-60% of the respondents in the International school context generally perceived each of the possible obstacles to impact to a lesser degree to the integration of ICT in teaching and learning (when compared with those in the Tatweer school context), with many of the potential barriers being rated as 'not at all' or 'a little' impactful by most of the respondents in the International context. In contrast, almost all possible barriers were perceived to have some impact or a lot of impact by 50% of respondents from the Tatweer school context

The findings for the first factor 'Equipment' for Tatweer respondents are presented in Figure 6.12a, and for International school context in Figure 6.12b. The findings generally show that lack of school ICT equipment especially lack of interactive whiteboards, low Internet speed or connectivity, and lack of computers were the barriers that respondents perceived as most impactful to ICT use in both schools, with teachers in Tatweer schools rating the impact of these being more impactful on ICT integration, when compared by those in the International schools. The data in Figure 6.13a reveals that insufficient numbers of interactive whiteboards and insufficient number of laptop/ notebook/desktop were the highest rated equipment factors that were perceived by participants to adversely affect ICT use, around 33% rated this element as impacting 'a lot' in Tatweer schools followed by insufficient Internet speeds, and insufficient number of computers, whether or not they were connected to the Internet.

Moreover, the analysis of data in Figure 6.13b shows that the biggest inhibiting factor reported by the respondents in the International schools with respect to equipment, were lack of Internet bandwidth or speed, and lack of interactive whiteboard and laptops/ notebooks, which were perceived to impact 'a lot' by around 25% of the teachers.

The data shows that respondents in both types of schools were relatively unconcerned with the existing school computers, as more than 50% of the respondents rated this factor as 'not at all' or 'a little' in terms of impacting on their integration of ICT in teaching and learning. Figure 6.14a and Figure 6.14b present the findings on respondents' perceptions of pedagogical and related factors for the Tatweer school context and the International school context respectively. Insufficient technical support was the most common factor identified by respondents as affecting their integration of ICT in education across both contexts. Interestingly, in the case of Tatweer schools, participants identified the lack of adequate content in the national language as a key factor impacting their use of technology, followed by the lack of adequate content/material for the teacher, with insufficient pedagogical support for teachers and lack of pedagogical models also concerns. In contrast, the biggest inhibitors of ICT integration in the International schools (Figure 6.13b) was insufficient pedagogical support for teachers and technical support to the teachers, with far less concern about content in national language, or teacher resources, or indeed pedagogical models for ICT integration.

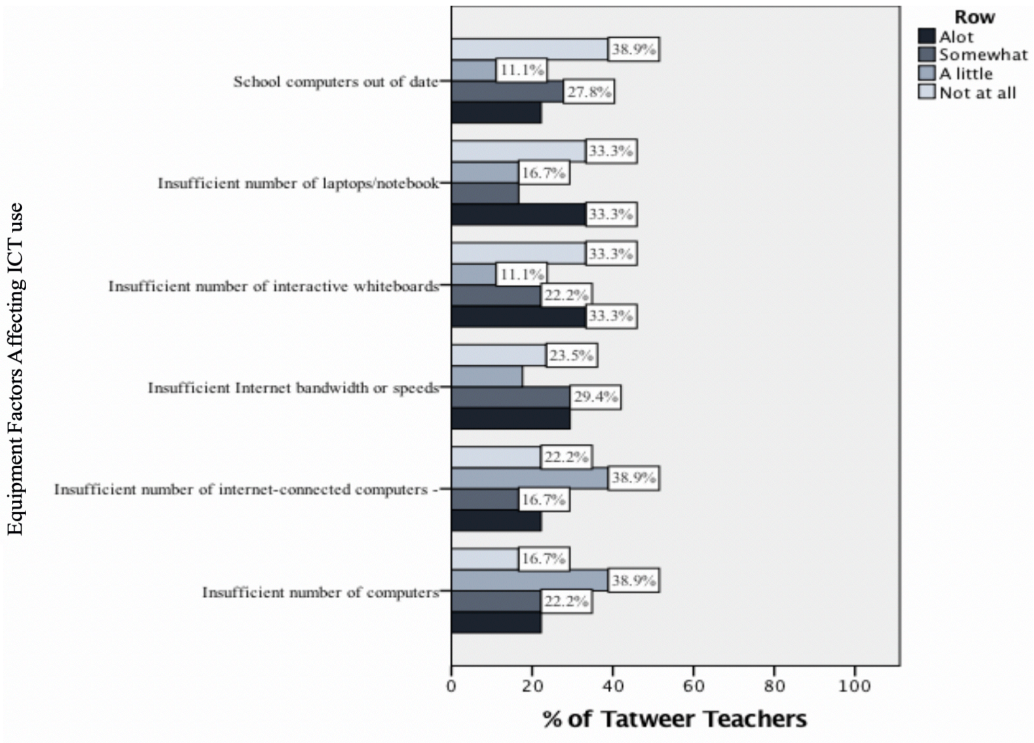


Figure 6.12a: Teachers' perceptions of equipment factors affecting ICT use in Tatweer primary schools.

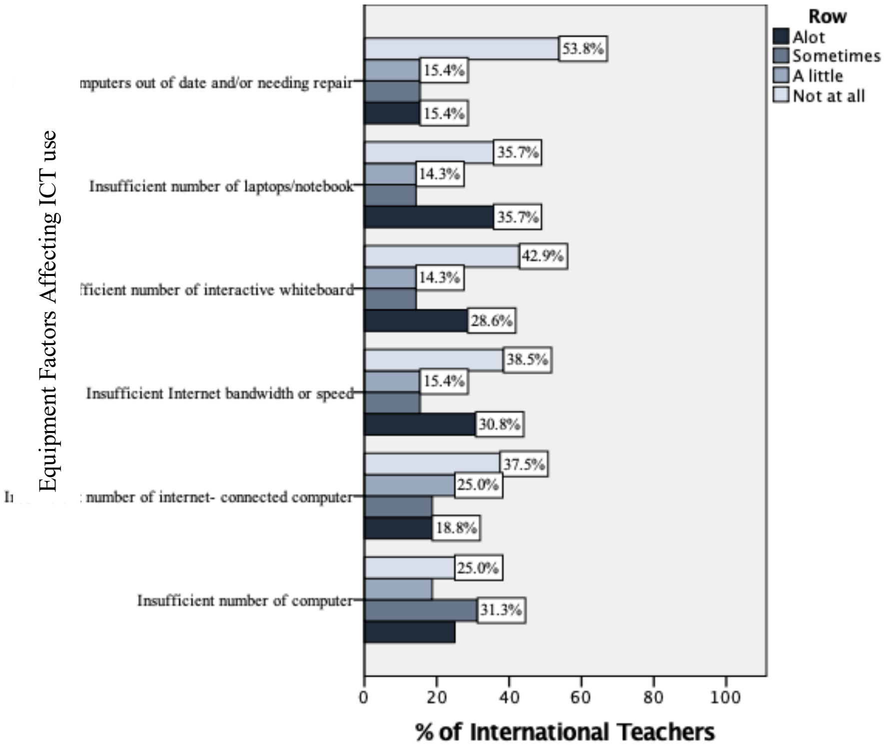


Figure 6.12b*:* Teachers' perceptions of equipment factors affecting ICT use in International primary schools.

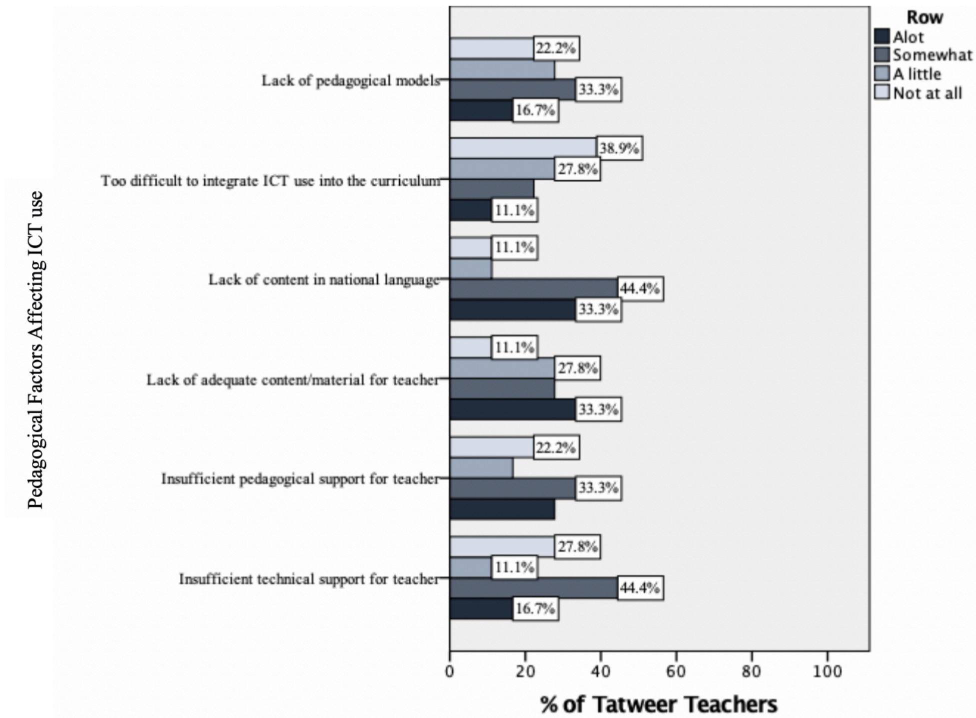


Figure 6.13a: Teachers' perceptions of pedagogical factors affecting ICT use in Tatweer primary schools.

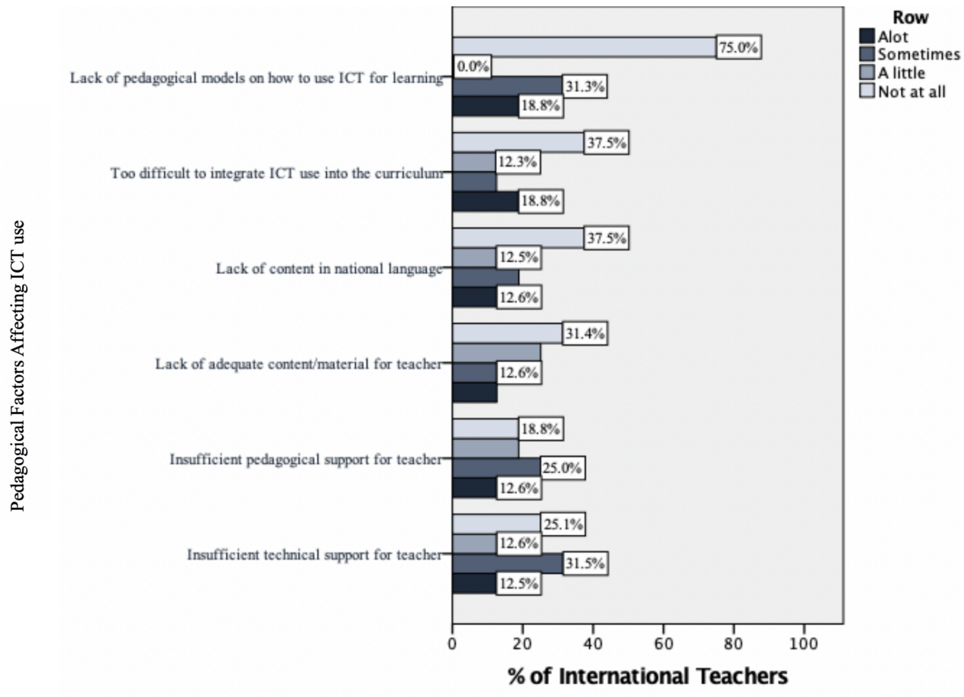


Figure 6.13b: Teachers' perceptions of pedagogical factors affecting ICT use in International primary schools.

Figures 6.14a and Figure 6.14b present the analysis of data with respect to whether specific goal factors would impact on a teacher's decision to integrate ICT in Tatweer/ International school contexts. Overall, respondents from the International school context felt that the lack of interest of teachers in ICT, or lack of interest by parents in ICT integration at school, or indeed lack of awareness of benefits of ICT integration, wouldn't strongly impact on its integration by them. In contrast, the Tatweer respondents strongly indicated that the lack of interest of teacher in ICT would impact on their integration of ICT and, following close behind, was that the lack of clarity on how using ICT benefited teachers/ learners would also impact on their integration of technology.

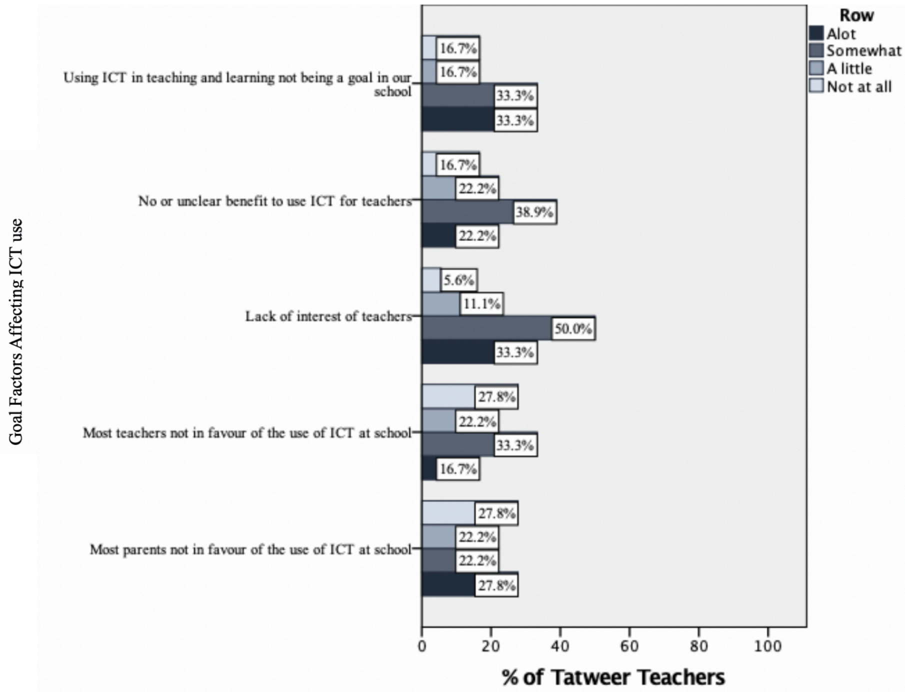


Figure 6.14a: Teachers' perceptions of goal factors affecting ICT use in Tatweer primary schools.

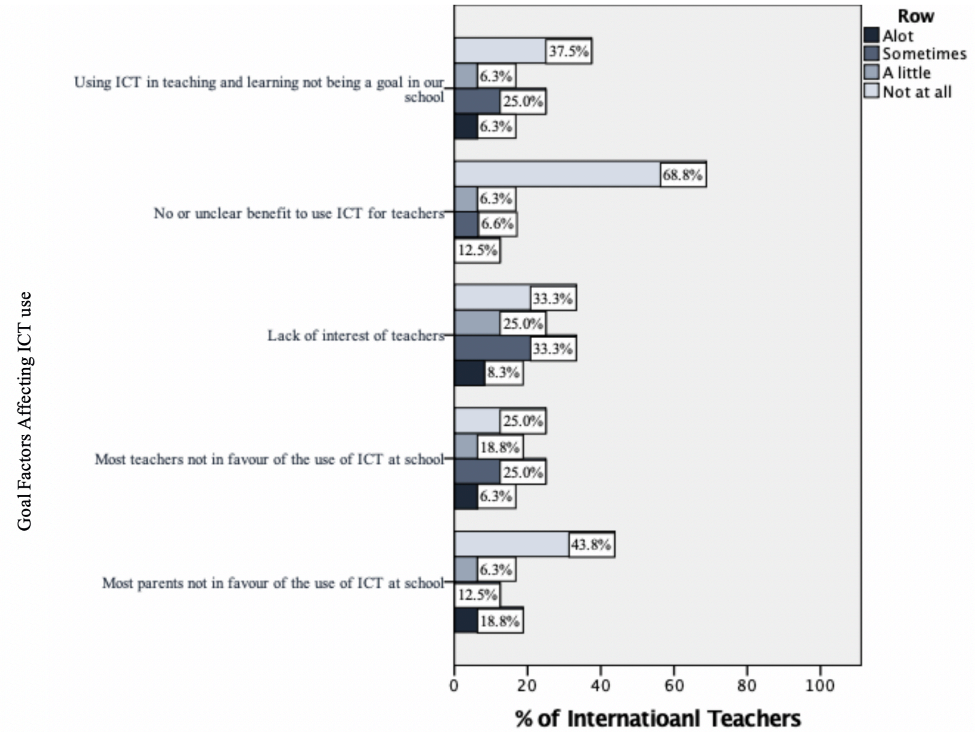


Figure 6.14b: Teachers' perceptions of 'goal factors' affecting ICT use in International primary schools.

In terms of other factors impacting ICT integration, concerns relating to safety of learners online, time-pressures with respect to preparations for examination, timetabling issues and need for allocation of physical spaces were factors identified by respondents as impacting to similar levels on ICT integration across both settings (as shown in Figure 6.15a and Figure 6.15b).

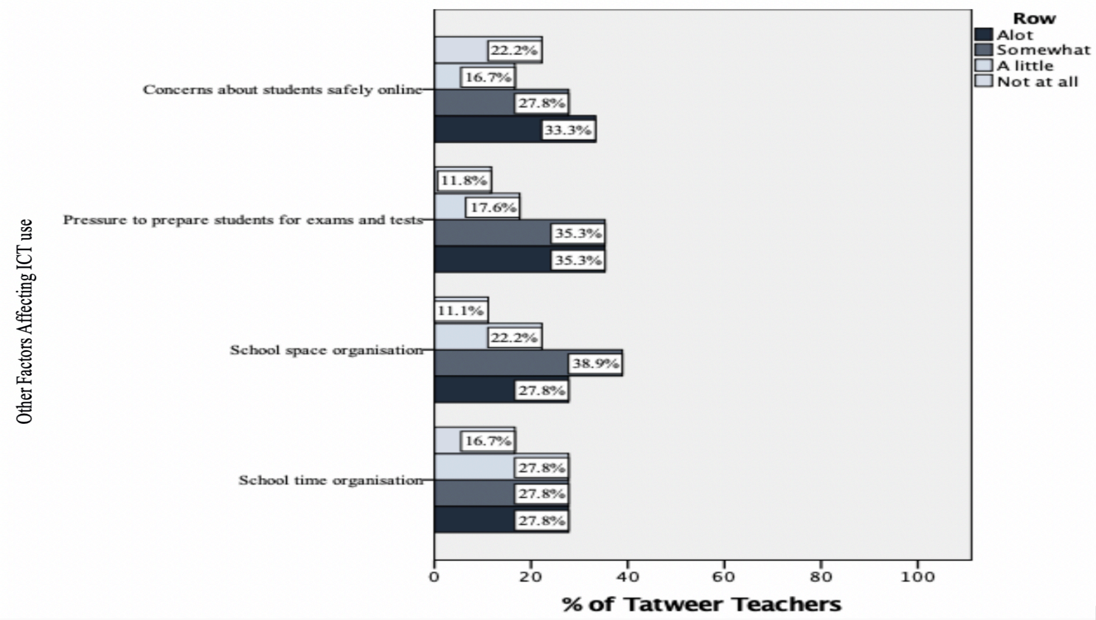


Figure 6.15a: Teachers' perceptions of 'other' factors affecting ICT use in Tatweer primary schools.

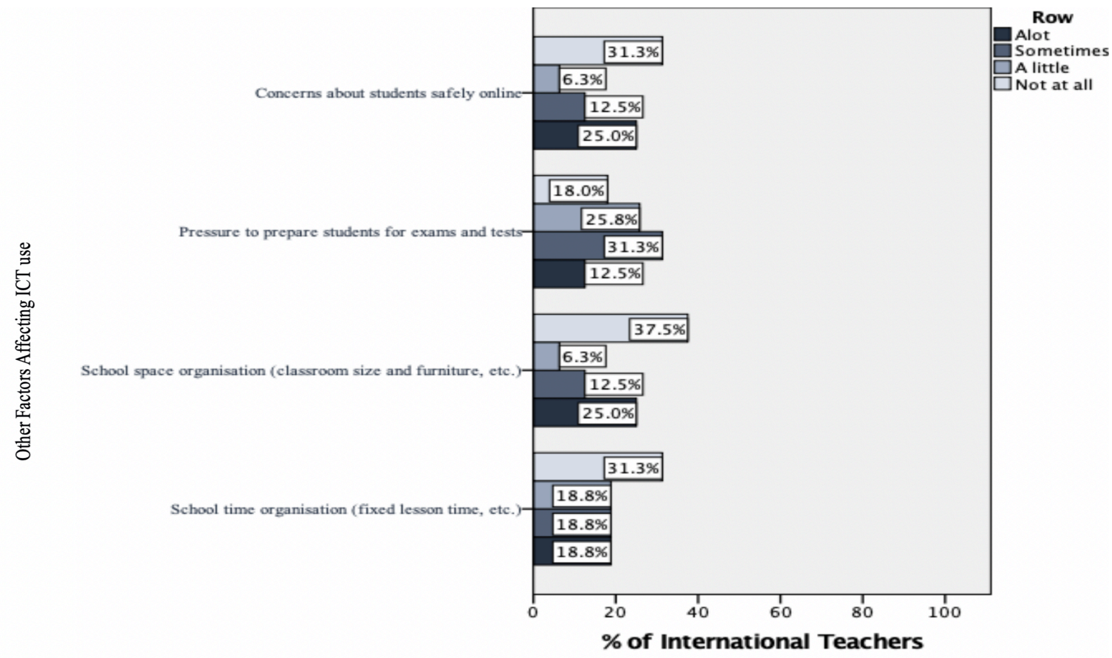


Figure 6.15b: Teachers' perceptions of 'other' factors affecting ICT use in International primary schools.

6.4 Discussion of findings from Phase 2

This third phase of the study set out to explore teachers' readiness to integrate technology in their teaching and learning practices in the Saudi primary school context. The findings indicated that teachers across both settings broadly recognised the importance of ICT integration in terms of enhancing 21st century skills-sets, and furthermore acknowledged the need for radical changes with the school system to do so.

The results in general showed that while teachers across both contexts broadly had good levels of ICT training and good levels of ICT integration for class preparation and teaching practice, the teachers in the International schools more frequently used ICT-based activities when compared to Tatweer teachers. In addition, the findings indicated that teacher-centred approaches were being promoted within both Tatweer and International schools, with a significant percentage of the teachers confirming that they frequently presented, demonstrated, and/ or explained materials to the whole class. It further showed that while online media were used for parental contact in International school, most Tatweer teachers never used technology to communicate with parents.

In terms of the current state-of-play with respect to access to technology in schools, the findings showed that concerns still existed across both settings with respect to access to technical and pedagogical support, and furthermore in terms of the lack of provision of essential equipment (such as laptops, tablets, or notebooks and mobile devices) for both the personal use of teachers and classroom use by learners. At school level, the results showed that Tatweer teachers had less access to the broader range of possible ICT infrastructure than those in International schools, with the interactive whiteboard being the main equipment that was widely available to Tatweer teachers. Furthermore, neither the Tatweer nor International school contexts had initiatives to directly supply the teachers and the students with essential equipment such as laptops, tablets, notebooks, mobile devices or smartphones. This equipment would be critical for supporting the integration of technology in education. It is interesting to note that the findings here were similarly identified in phase 2 of the study in the Tatweer public school, where although Grade 2 and Grade 3 teachers confirmed having successfully completed continued professional development courses in ICT provided by the Ministry of Education and/ or private companies, they still considered themselves to have basic level of technology know-how, and furthermore mainly used Powerpoint-type presentations in classroom practice due to the lack of technological infrastructure to support more innovative technology integration in the public school system. In contrast, the teachers in the International school setting (in phase 2 of this research study) considered themselves to have advanced level of ICT know-how, and spoke about creatively using technology in-class (although this wasn't directly observed by the researcher).

With regards to their skills levels, teachers across both settings self-reported reasonable levels of confidence in their ability to integrate a range of technology-enabled activities. The Tatweer teachers further indicated low levels of confidence in using technology for some activities, namely, preparing materials to use with an interactive whiteboard or creating and maintaining a blog or a website. This could have resulted from their lack of the professional training opportunities in these areas, as the results further showed that more than 58% of Tatwer respondents had never taken advanced courses on Internet use, or multimedia development. Furthermore, many teachers across both settings indicated that they lacked training on the pedagogical use of ICT. Moreover, many teachers across both Tatweer and International settings indicated low levels of confidence in teaching students how to behave safety and ethically online.

6.5 Conclusion

This chapter of the study presented the findings from a review of teachers' readiness to integrate technology in teaching and learning practices across Tatweer and International school contexts. The implications of the findings will be discussed further in the final chapter within the context of wider developments in the Saudi Education Plan, specifically plans with respect to the professional development of teachers in ICT integration, and the promotion of 21st century learner competencies.

Chapter 7: Conclusions and Recommendations

7.1 Introduction

This multi-phase mixed methods research study set-out to explore the integration of online gamified practice activities, within the context of mathematics education, specifically focusing on primary grade levels 1 to 3 in an International school and a Tatweer school in the eastern area of Saudi Arabia. This chapter presents the overall conclusions and makes recommendations for the future. It also includes the researcher's reflections on the research journey, and plans for further research.

7.2 Responding to Research Questions

There were three overarching research questions in this multi-phase mixed methods research study, the first of which was: *How is mathematics education presently being performed by teachers and learners in Grades 1 to 3 in two Saudi primary school contexts?;* the second question being, *What impact, if any, does the integration of online gamified mathematics 'practice activities' have on learning* in Grades 1 to 3 *in these Saudi schools?*, and finally: *What is the state of readiness of Saudi teachers for technology integration in their practice of mathematics education at primary level in this district of Saudi Arabia?* The ensuing discussion summarises the key findings from exploration of each question, in the context of developments relating to mathematics education and technology integration within and beyond Saudi Arabia.

7.2.1 Performance of Mathematics Education in Grades 1, 2 & 3 in Saudi Contexts

How is mathematics education presently being performed by teachers and learners in Grades 1 to 3 in two Saudi primary school contexts?

This research study found that Saudi teachers in both the public school (Tatweer) and the private (International) school settings typically followed a prescribed route in mathematics education, using primarily teacher-led and directed approaches, thus adhering to pathways for learning mathematics concepts as outlined in textbook and workbook. The textbook and mathematics instructional materials provided by the Ministry of Education were the main resources used at both grade 2 and 3 levels in Tatweer school setting, and very similar resources were used across all grade levels in the International school setting. The teacher-led approaches to learning involved a significant amount of teacher *demonstration* of problem-solving strategies. Following explanation of the key concept, the teachers usually provided learners with opportunities to work independently and/ or collaboratively (in groups/ pairs) on mathematics problem solving and invited learners to engage in solving the problem. They further integrated opportunities for whole class discussion, where appropriate. It was notable that there was widespread use of group/ paired work, and peer assessment therein, to facilitate collaborative forms of learning with the traditional delivery of mathematics education. Furthermore, the teachers generally provided physical resources to stimulate and increase learner engagement in understanding and solving problems. They further used question-and-answer approaches to stimulate learners' thinking about the new mathematics concept. They also attempted to make the task/s relevant by connecting these with real-life problems. Some teachers supported mathematics literacy development in mathematics class, through inviting learners to read information on new topic and placing key words (mathematics language literacy) on board. The teachers in both settings also made use of CD materials accompanying the textbook but were not seen to make extensive use of other online materials. It was good to see the utilisation of physical resources to help learners understand key concepts in mathematics across both settings. The learners used physical resources (cubes, balls, etc.) that were provided by the teachers in a form of game-play to explore the new concept or to solve a mathematics problem. In terms of the learners' interaction with the new topic, the findings from the intervention with learners showed that most of the learners actively participated in new topic/s being introduced each week. They worked well in groups and were seen to help each other to solve problems. In addition, learners were regularly invited to present or explain their understanding to peers in groups and in whole class discussion. However, there was evidence of some learners disengaging with the collaborative group work across all grade levels, preferring to work by themselves on the in-class mathematics activities, or disrupt the learning for others in their group or in class.

In terms of the *practicing* of mathematics concepts within the traditional context, there was a heavy reliance on textbook for guidance and workbooks for practicing mathematics. The learners typically were encouraged to practice the new mathematics concept using the prescribed workbook, during which time the teachers played the role of facilitator and offered scaffolding by supporting learners who needed assistance. The teachers also encouraged learners to cooperate in groups and peer-assess progress during the practice dimension of the class. However, the learners typically did not receive any individual feedback from the teachers on their progress or performance in completing the mathematics practice activities until later in the day. Therefore, the teachers did not generally provide individual feedback on the learners' performance in their mathematics practice session during the class time. This absence of individual feedback on mathematics practice activities during class was a cause of concern across both settings. Furthermore, the results also showed that some of the learners displayed levels of anxiety with more challenging mathematics questions, while others expressed a lack of interest in the new mathematics concept. This was particularly evident in the traditional mathematics practice setting at each grade level, where, while the learners did complete the mathematics practice activities by pencil and paper, generally they did not exhibit high levels of interest or excitement while practising these mathematics activities in class. Even during group activity, there were some learners who disengaged with the collaborative group work, preferring to work by themselves on the assigned activities.

Moreover, this research showed that the way in which mathematics education is being performed had a negative impact on dispositions of learners towards certain aspects of mathematics. The statistically significant results from the Tatweer setting showed that learners in the Grade 2 Control Group (who were taught in mainly teacher-led manner) had increased anxiety regarding ‘Mental Math skill’ and ‘Listening and understanding mathematics skill’ and a decreased interest in ‘Mathematics homework’ in the post-test. Furthermore, the results from the Grade 3 Control Group showed decreased interest of learners in ‘Mathematics in general’ skills.

Finally, there was considerable evidence across phases one and two of this study, of teachers using technology to present or introduce key concepts, but a dearth of evidence of technology being used to scaffold learners within the learning experience across all grades in the traditional settings. Furthermore, while online media was reportedly used for parental contact in the International school, most Tatweer teachers never used technology to communicate with parents.

7.2.2 Impact of Integrating Online Gamified Mathematics Practice Activities

What impact, if any, does the integration of online gamified mathematics ‘practice activities’ have on learning in Grades 1 to 3 *in these Saudi schools?*

The research highlighted the effectiveness of online gamified practice activities in enhancing learners' engagement, motivation, and performance in mathematics education at primary levels in Saudi Arabia.

This research study found that the integration of the online practice activities through the Mathletics platform in all grades across both settings resulted in high levels of engagement and collaboration in completing the online mathematics practice activities. The findings also indicated that the learners appeared to be motivated by their own performance in Mathletics, with learners re-visiting the activities multiple time to improve their final score and visiting the main interface page to see their level of completion as displayed on the Mathletics progress bar.

Moreover, the findings from this research at these grade levels further indicated that combining particular game elements such as points, certificates, progress bars, a friendly 'competitive' environment, direct feedback on progress and performance in completing mathematics practice activities had positive effects on increasing the learners' interest in mathematics, and in keeping them on task. Furthermore, learners demonstrated high levels of motivation to complete the mathematics practice activities both in-school time and also completed additional mathematics activities at home. This observation is consistent with the findings from studies by Tüzün et al., 2009 and Kuo, 2007, who also found that the learners were motivated to visit game environments after school time (even where there was no homework requirement).

Even though individual and group engagement could be facilitated entirely through the online Mathletics platform, learners in both settings did appear to enjoy solving the Mathletics problems in a physical class-based setting and were frequently observed calling out to friends for support within the class. Furthermore, the 'Live Mathematics' part of Mathletics that facilitated competitive completion of mathematics practice exercises, really appeared to enthuse and engage learners – they appeared to really enjoy connecting with and challenging their classmates (and peers in other countries) in the online competition environment. The teachers were observed facilitating a high degree of self-directed and independent learning during the Mathletics practice sessions. Learners generally asked peers for assistance on those occasions that they had difficulty solving problems in Mathletics, and only rarely sought support from teachers to complete the Mathletics activity.

Moreover, the aesthetic design of the Mathletics interface was one of the factors influencing learners' engagement, in that when the design of the interface was not intuitive or there existed redundancy in design, the learners expressed a lack of interest and avoided use of the feature, or disengaged from the mathematics practice activity. The case studies with the six learners in the International school context further highlighted areas for improvement in terms of the pedagogic and aesthetic design of Mathletics, including but not limited to: the framing of textual questions on-screen, promotion of textual literacy alongside numeracy within mathematics practice activities, removal of redundant scaffolds such as Hint box and unused features like the Avatar, and deeper consideration of the implication of cultural habituations in language acquisition (such as reading from right to left in Arabic contexts) in the design of graphical/ visual activities.

The results from the Mathletics intervention also showed that the inclusion of game elements such as points, certificates, progress bars, a friendly 'competitive' environment, and immediate feedback were factors that positively impacted on learners' engagement and motivation. These findings are in line with studies by Costu, Aydın & Filiz, 2009 and Hwang et al., 2012, who found that the inclusion of competition features within game-based learning contexts increased levels of engagement by participants. However, it contradicts the conclusions from other studies reported by Ronimus et al, 2014; Tüzün et al, 2009 and Filsecker & Hickey, 2014, that found the inclusion of reward system could decrease levels of motivation, engagement and. or interest, in addition to findings from the study by Ronimus et al. that found feedback features had contributed to lower participation levels within an online game.

In terms of academic performance, the findings from the Tatweer public school context indicated enhanced academic performance at both Grade 2 and Grade 3 levels for those groups using Mathletics to practice mathematics. Interestingly, the comparison of pre- and post- dispositions revealed that the learners in the Grade 2 Mathletics Group exhibited an increased interest in engaging with 'Difficult math problems', and learners in Grade 3 Mathletics Group exhibited an increased interest in engaging with 'Mental math', so the integration of the online gamified mathematics practice activities positively impacted on learner dispositions across both grade levels in the Tatweer school context. The overall results suggest that learners using Mathletics to practice mathematics, developed more positive dispositions toward mathematics and achieved statistically significant improved academic performance. This finding aligns with findings from prior research that learner engagement in gamified learning and/ or game-based learning improved learners' outcomes (Ke & Grabowski, 2007; Hwang et al., 2012; Sung & Hwang, 2013; Dourda et al., 2014; Su & Chengt, 2014; Bakker et al., 2015). This improvement comes from learners' enjoyment and engagement within the online gamified leaning environment.

Finally, this study utilised a 'bolt-on' Mathematics Practice model to integrate technology in mathematics education, through which the traditional mode of practicing mathematics using a workbook was replaced by online gamified mathematics practice activities (within the Mathletics platform). This model respected the expertise of the teacher in fostering conceptual knowledge building within mathematics education, and in this regard, it was necessary for the teacher to engage directly with learners in explaining the key concepts and engaging them in related learning activities. The model differs from others in mathematics education in that it integrates online gamified activities to support the *practice* dimension of mathematics education. Therefore, within the 'bolt-on' Mathematics Practice model, learners initially engage in learning about the concept with the teacher, but progress to complete mathematics practice activities individually, collaboratively and/ or competitively within an online gamified platform, such as Mathletics, with teacher acting as guide on the side.

This 'bolt-on' Mathematics Practice model may be useful in transitioning from traditional modes of mathematics education to more progressive models that seek to integrate technology to transform learning engagement, as it requires low levels of ICT skills, so even those teachers with low levels of technology skills and/or negatively disposed towards technology integration, may be won over by this model. In terms of infrastructure and equipment to support this Model, learners would need access to iPads, laptops or desktops with Internet access at the school level, and teachers ideally would have access to a personal computer to monitor learners' progress. There would also need to be broadband access to Internet at school, and at home if participation in online mathematics practice activities beyond school is to be promoted. This is particularly timely given the Saudi government commitment to support learning within and beyond the classroom, as articulated within the Tatweer educational initiatives. However, platforms such as Mathletics used in this research study require payment of subscription fees, so this would need to be taken into consideration. Furthermore, the stipulation of the need for completion of all mathematics practice activities from the prescribed workbook would need to be amended by the Ministry of Education, to include recognition of online mathematics practice activities.

7.2.3 State of Readiness of Saudi Teachers for Technology Integration

What is the state of readiness of Saudi teachers for technology integration in their practice of mathematics education at primary level in this district of Saudi Arabia?

This research study found that teachers across the Tatweer and International school contexts broadly recognised the importance of ICT integration in terms of promoting 21st century skills-sets, and furthermore broadly acknowledged the need for radical changes with the school system to do so. The findings indicated that teacher-centred approaches were being promoted within both Tatweer and International schools, with a significant percentage of the teachers confirming that they frequently presented, demonstrated, and/ or explained materials to the whole class, which was also observed to be the case in practice across all grade levels during interventions in phases one and two of this research study.

The results further showed that while teachers across both contexts self-reported good levels of ICT training, the teachers in the International schools had more confidence in using ICT-based activities when compared to Tatweer teachers. Furthermore, while teachers across both contexts reported good levels of ICT integration for class preparation and teaching practice there was little evidence of meaningful technology integration within the observed sessions in either setting. With regards to their skills levels, teachers across both settings self-reported reasonable levels of confidence in their ability to integrate a range of technology-enabled activities. The Tatweer teachers further indicated low levels of confidence in using technology for some activities, namely, preparing materials to use with an interactive whiteboard or creating and maintaining a blog or a website. This could have resulted from their lack of the professional training opportunities in these areas, as the results further showed that more than 58% of Tatweer respondents had never taken advanced courses on Internet use, or multimedia development. Moreover, many teachers across both settings indicated that they lacked training on the pedagogical use of ICT. This was supported in studies such as that undertaken by Dodeen et al. (2012), which pointed to deficits in teacher professional development for mathematics education, particularly in terms of technology integration. Moreover, many teachers across both Tatweer and International settings indicated low levels of confidence in teaching students how to behave safety and ethically online, which may have impacted on their willingness to engage with online technologies. The need for inclusion of more active teaching methodologies in teacher professional development was highlighted in a study by Albalawi and Alrajeh in 2012.

In terms of the current state-of-play with respect to access to technology in schools, the findings showed that concerns still existed across both settings with respect to access to technical and pedagogical support, and furthermore in terms of the lack of provision of essential equipment (such as laptops, tablets, or notebooks and mobile devices) for both the personal use of teachers and classroom use by learners. At school level, the results showed that Tatweer teachers had less access to the broader range of possible ICT infrastructure than those in International schools, with the interactive whiteboard being the main equipment that was widely available to Tatweer teachers. Moreover, neither the Tatweer nor International school contexts had initiatives to directly supply the teachers and the students with essential equipment such as laptops, tablets, notebooks, mobile devices or smartphones. This equipment would be critical for supporting the integration of technology in education.

7.3 Contributions of Research

As outlined in chapter one, this thesis makes the following contributions to knowledge and research:

7.3.1 The study provides evidence of the need to re-orient Saudi teachers' professional development on general pedagogies, with a focus on enabling teachers to foster learner-centred approaches and learner autonomy, including the affordances of more motivating pedagogic approaches such as: active learning methodologies, project-based, and/ or discovery learning.

7.3.2 This study provides an evidence base for utilising the Bolt-on Mathematics Education model to enable teachers and learners transition towards integration of technology in classrooms, a key objective of Saudi Arabia's Vision 2030.

7.3.3 This study presents evidence of (both aesthetic and pedagogic) design issues within the interface of the online mathematics platform, which would need to be addressed to enable fuller learner engagement within the online activity.

7.3.4 Finally, this study identified key issues that need to be addressed in improving teachers' readiness for technology integration in education across the eastern area of Saudi Arabia. This is of particular significance in the context of current plans for education outlined within the Saudi National Development Plan and the National Transformation Programme, and thus, will be of particular interest to policy makers and governmental departments tasked with progressing reforms within the education system that focus on developing specific teacher and learner competencies that enable new directions for economy and society outlined in the Saudi 2030 Vision.

7.4 Discussion of Recommendations.

This study highlights the need to revise or re-orient Saudi teachers' professional development on general pedagogies, with a focus on enabling teachers to foster learner-centred approaches and learner autonomy, including the affordances of more motivating pedagogic approaches such as: active learning methodologies, project-based, and/ or discovery learning, and of technology-enabled learning.

This study further identified a 'Bolt-on Mathematics Education' model that could be used to fast track technology adoption in mathematics education by teachers, and, in this regard, has the potential to contribute to broader transitions towards deeper integration of technology in education, a key objective of Saudi Arabia's Vision 2030.
Moreover, the study contributed to new knowledge within the domain of human-computer interface design in that it identified some redundancy in the pedagogic framing of activities and in the aesthetic design of the Mathletics interface.

This study has particular significance in terms of educational policy and practice in Saudi Arabia and the recommendations are as follows:

- **The first recommendation** is for the provision of additional training on pedagogies for technology integration and ICT skills development within continuous professional development programmes for Saudi primary teachers. This matter will be presented for consideration to the Ministry of Education in Saudi Arabia.
- **The second recommendation** is for more resourcing to support the ICT integration in schools, as a large number of teachers indicated limited access to technology for use in classroom practice, even within those schools targeted for technology integration. Furthermore, this support may include payment of subscription fees for online mathematics platforms like Mathletics that can readily support online gamified practice activities. Alternatively, it may call for the development of new online platforms designed to support gamified learning within mathematics education across the Saudi context, such as the iEn initiative being implemented by the Ministry of Education.
- **The third recommendation** is for further research to be undertaken to ascertain the effectiveness of the 'bolt-on' Mathematics Practice model in supporting transitions towards technology integration in mathematics education within the broader Saudi education context. The research would need to take account of the effect of such environments on primary level learners of both genders.
- **The fourth recommendation** is for the findings relating to improvements in the aesthetic design of online gamified activities (such as: need for careful consideration of textual literacy, avoidance of redundancy in design features, and cultural factors), to be disseminated in academic publications, conferences and any other academic or industry forum for game designers, instructional designers and educational technologists.
- **The fifth recommendation** is for an amendment by the Ministry of Education to the stipulation that all mathematics practice activities from the prescribed workbook must be completed, to one that recognises mathematics practice activities can be completed from either the workbook or online platform, such as Mathletics.

7.5 Researcher's Final Reflections on the Research Journey

It is difficult to fully capture the learning at both personal and professional levels from engagement in this research journey. I came to Ireland for the first time to engage in this research study, and the immersion into Irish culture was something with which I had to speedily come to terms. A secondary challenge was that all interactions in Ireland were conducted through my second language, English.

On the academic front, I started this research as a novice researcher and realised fairly early on that no amount of reading would adequately provide the complex skills-set needed to engage in this form of a mixed methods study, which was multi-phase, across different settings, using diverse sets of qualitative and quantitative tools, across different periods of time. Therefore, in the first year of study I undertook DCU training courses and attended Summer schools on qualitative and quantitative methods and complemented these with ongoing attendance at graduate training workshops on research methods throughout my time in DCU. In the first year of study, I also completed the (first draft) literature review, and progressed to frame and gain ethical approval from DCU's Research Ethics Committee (REC) for the study. The ethical approval process was complicated by the need to gain approval for each aspect of the study, data collection tools and the proposed schools, from the Ministry of Education, in advance of application to DCU's REC, which involved the translation of a myriad of data collection tools, Informed Consent form and Plain Language statement from English to Arabic.

My first encounter with learners, and thus in data collection, was in the second year of study, where I re-located to my home country of Saudi Arabia. I found the initial foray into researching the enactment of mathematics education and the integration of online mathematics practice activities using Mathletics, really stimulating. In previous research projects, I had used survey type instruments and engaged in interviews, so had some familiarity with the deployment of these tools – however, in this study, I also embraced the opportunity to use creative forms of data collection, such as using the eye tracker software to collect data on learner interactions within Mathletics during the first phase of the research in the International setting. However, huge tracts of data were gathered using the eye tracking software with Mathletics, and the challenge came in terms of analysing this data-set, which involved many multiples of months of pain-staking work which eventually was captured in just a sub-section of chapter 4 – so much work for seemingly small (but vital) coverage of the impact of the aesthetic design of Mathletics in the final thesis.

In the second half of my year collecting data in Saudi Arabia, the research moved to a public setting, the Tatweer school. I had chosen the Tatweer setting as these schools were purportedly at the forefront of technology integration, having received dedicated funding from the government. However, this was not the case in practice, and thus the nature of the intervention had to be amended to allow for fewer learners, many of whom had to bring their own devices and/or were supplemented by devices provided by me and the school. I learned that whatever the research plan, it needs to be adaptable and responsive to unforeseen difficulties, as was the case here. The data collection in the second phase involved the deployment of two different quantitative tools, one examined academic performance (in the form of a mathematics test for each Grade level) and the other involved the use of a survey instrument adapted from a German context that was used to examine learners' dispositions towards differing aspects of mathematics education, pre- and post- intervention. In terms of the latter, a significant amount of energy was expended in terms of its deployment across the two grade levels in the public school, and while there were some significant findings in terms of learners' levels of anxiety and interest, the tool itself really didn't highlight any significant outcomes with respect to motivation and confidence of learners over time across six of the eight other items relating to mathematics education. This made me think about the design of instruments more generally, and whether in some cases there are attempts to unnecessarily 'over-capture' data across multiple domains, when instead more focused instruments simply looking at for example 'learner anxiety' across one or two aspects of mathematics education would be more effective (and less time-consuming). A second challenge in phase two of the research was the need to translate all interviews with pupils, teachers and parents from Arabic into English, which again added to the time taken to complete the analysis of this context.

I spent most of the third year and part of the fourth year in data analysis of data-sets gathered in the first two phases of this study. From this process, a question arose about the teacher context – specifically, the extent to which Saudi teachers were ready for technology integration in their practice. This culminated in a third phase of data collection, this time using a survey adapted from one used by the EU to assess teachers' ICT skills, professional development and integration of technology in education. For this part of the study, assistance was provided again by the Ministry of Education in terms of deployment of surveys to schools in the eastern area of Saudi Arabia. The main challenge in this phase was in encouraging participants to respond – the survey had been made anonymous, but it still took multiple rounds of requests by email to get a reasonable degree of engagement from teachers across public and private schools in this area. The final year of study involved analysis and reporting of the findings from the teacher survey, and the final framing of the thesis as presented here. I have learned much about research studies and myself from this journey, and look forward to progressing further research in this area, as described in the next section.

7.6 Future Research & Dissemination Opportunities

In terms of future research, the intention is to progress post-doctoral research as follows:

- This study examined the role of gamified learning specifically in supporting mathematics practice activities. Further research will seek to extend this by exploring the effectiveness of online gamified learning in supporting the development of conceptual knowledge and understanding, (rather than solely exploring the domain of mathematics practice).

- The 'bolt-on' Mathematics Practice model utilised within this study has the potential to support the transition towards increased integration of technology to support mathematics practice across Saudi Arabia. This model (along with key findings from the research) will be presented at local conferences in Saudi Arabia and to Ministry of Education, with a view to establishing an inter-University research team to investigate its potential in enabling transitions towards technology integration in mathematics education across Saudi schools.

- This study was conducted within an all-girls school context at lower grade levels within Saudi Arabia. Therefore, future research would need to address this by exploring the effectiveness of this practical model within boys' school contexts, and upper boys' and girls' grade levels in primary school context.

- There has been one publication from this thesis during the period of study. It is anticipated that a further three papers will be submitted for review to high quality journals such as: Teaching and Teacher Education, Irish Educational Studies, Policy Futures in Education, Computers in Education, in the following areas: Gamified Learning in Mathematics Practice; Teachers' Readiness for ICT Integration in Saudi education context; and, Comparative review of ICT policies and practice in Saudi Arabia and Ireland.

7.7 Conclusions

This research journey began with the initial intent of solely exploring how gamified learning could be integrated in mathematics education, but instead the study moved towards a deeper exploration of the way in which mathematics education was being enacted across public and private school settings in Saudi Arabia, the effectiveness or otherwise of gamified learning in supporting mathematics practice, and teacher's readiness to integrate technology in their practice more generally. The Saudi education system is undergoing significant changes in terms of supporting the integration of technology at all levels in education. This improvement will continue under the Saudi National Transformation Program 2020 which will progress the goal of having high levels of technology integration, and ICT skills and competency development among both teachers and learners, in line with the overall Saudi vision for 2030. This study hopefully will contribute to these wider plans for technology integration through offering a means (via the 'bolt-on' mathematics practice model) of integrating technology within mathematics education in a way that motivates and engages learners, whilst allowing for competency development in both technology and mathematics for both learners and their teachers.

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Appendices

Appendix A: Saudi National Education Plan 2020

وزارة التعليم
Ministry of Education

Ministry of Education

Strategic Objective (1)	Provide education services for all student levels				
Relevant Vision 2030 Objectives	Establish positive values and build an independent personality for citizens Provide citizens with knowledge and skills to meet the future needs of the labor market				
Key Performance Indicators	**Baseline**	**2020 Target**	**Unit**	**Regional Benchmark**	**International Benchmark**
Percentage of children enrolled in kindergarten (3 to 6 years)	13	27.2	Percentage (%)	79	81
Percentage of illiterate adults (15 years and over - Saudis)	5.32	2.5	Percentage (%)	2	1
Percentage of students utilizing school transportation services (in public schools)	28	43	Percentage (%)	59	83
Percentage of students with disabilities utilizing the students' disability support program (6-18 years)	58,600 / number of Saudi kids 6-18	200,000 / number of Saudi kids 6-18	Percentage (%)	12	12

Strategic Objective (2)	Improve recruitment, training and development of teachers				
Relevant Vision 2030 Objectives	Establish positive values and build an independent personality for citizens Provide citizens with knowledge and skills to meet the future needs of the labor market				
Key Performance Indicators	**Baseline**	**2020 Target**	**Unit**	**Regional Benchmark**	**International Benchmark**
Average number of professional development hours completed by teachers	10	18	Number of hours	25	100
Average number of hours of professional development in educational leadership completed by school leaders	5	20	Number of hours	39	21
Percentage of Teachers passed (Qyas) test	48	65	Percentage	Not Applicable	

Strategic Objective (3)	Improve the learning environment to stimulate creativity and innovation				
Relevant Vision 2030 Objectives	Establish positive values and build an independent personality for citizens Provide citizens with knowledge and skills to meet the future needs of the labor market Develop youth skills and leverage them effectively				
Key Performance Indicators	**Baseline**	**2020 Target**	**Unit**	**Regional Benchmark**	**International Benchmark**
Number of medals and honors achieved in international competitions	86	133	Number	5	Under Study
Percentage of students benefiting from special gifted programs	87.3	100	Percentage	Under Study	6-10

Strategic Objective (4)	Improve curricula and teaching methods				
Relevant Vision 2030 Objectives	Establish positive values and build an independent personality for citizens Provide citizens with knowledge and skills to meet the future needs of the labor market				
Key Performance Indicators	**Baseline**	**2020 Target**	**Unit**	**Regional Benchmark**	**International Benchmark**
Average student results in international TIMSS tests (eighth grade: Math and Science)	394 (Math), 436 (Science)	450 (Math), 480 (Science)	Number	452, 483	611, 590
Average student results in international TIMSS tests (fourth grade: Math and Science)	410 (Math), 429 (Science)	460 (Math), 470 (Science)	Number	469, 463	606, 583
Average student results in international reading tests (PISA)	Not Applicable	460	Number	475	542
Average student results in international reading tests (fourth grade – PIRLS)	430	460	Number	439	567

Strategic Objective (5)	Improve students' values and core skills				
Relevant Vision 2030 Objectives	Establish positive values and build an independent personality for citizens Provide citizens with knowledge and skills to meet the future needs of the labor market				
Key Performance Indicators	**Baseline**	**2020 Target**	**Unit**	**Regional Benchmark**	**International Benchmark**
Percentage of students involved in extra-curricular activities outside the school program	15	55	Percentage	60	57
Percentage of students utilizing the Community Clubs Services	5	25	Percentage	Under Study	25

Strategic Objective (6)	Enhance the educational system's capability to address national development requirements and to meet labor market demands				
Relevant Vision 2030 Objectives	Provide citizens with knowledge and skills to meet the future needs of the labor market				
Key Performance Indicators	**Baseline**	**2020 Target**	**Unit**	**Regional Benchmark**	**International Benchmark**
Percentage of graduates who secured employment within (6) months of graduation	Under Study		Percentage	Under Study	90

Strategic Objective (7)	Develop creative financing methods and improve the educational system's financial efficiency				
Relevant Vision 2030 Objectives	Achieve budgetary balance				
Key Performance Indicators	**Baseline**	**2020 Target**	**Unit**	**Regional Benchmark**	**International Benchmark**
Students to teacher ratio	1:09	1:17	Ratio	1:15	1:25

Strategic Objective (8)	Increase Private Sector Participation in the Education Sector				
Relevant Vision 2030 Objectives	Provide citizens with knowledge and skills to meet the future needs of the labor market Expand privatization of governmental services Create an attractive environment for both local and international investors and enhance their confidence in our economy				
Key Performance Indicators	**Baseline**	**2020 Target**	**Unit**	**Regional Benchmark**	**International Benchmark**
Percentage of students in non-government higher education	6	15	Percentage (%)	40	26

Appendix B: Research Ethics

Section B.1: RCE letter confirming approval from DCU

Ollscoil Chathair Bhaile Átha Cliath
Dublin City University

DCU

5th May 2015

Jawaher AlGhamdi
School of Education Studies

REC Reference: **DCUREC/2015/133**

Proposal Title: Exploring the use of online gamified learning activities in mathematics education at primary level in Saudi Arabia

Applicant(s): **Jawaher AlGhamdi, Dr Charlotte Holland**

Dear Jawaher,

This research proposal qualifies under our Notification Procedure, as a low risk social research project. Therefore, the DCU Research Ethics Committee approves this project.

Materials used to recruit participants should state that ethical approval for this project has been obtained from the Dublin City University Research Ethics Committee.

Should substantial modifications to the research protocol be required at a later stage, a further submission should be made to the REC.

Yours sincerely,

Dónal O'Mathúna

Dr Dónal O'Mathúna
Chairperson
DCU Research Ethics Committee

DCU
Research & Innovation

Taighde & Nuálaíocht Tacaíocht
Ollscoil Chathair Bhaile Átha Cliath,
Baile Átha Cliath, Éire

Research & Innovation Support
Dublin City University,
Dublin 9, Ireland

T +353 1 700 8000
F +353 1 700 8002
E research@dcu.ie
www.dcu.ie

Section B.2: Informed Consent Forms.

Informed Consent Forms (Parent)

Research Title: Exploring the use of online gamified learning activities in mathematics education at primary level in Saudi Arabia.

Principal Investigator/ Researcher: *Jawaher AlGhamdi/ Dr. Charlotte Holland*

This aim of this study is to explore the use of online gamified learning activities within mathematics education at primary level in schools in Saudi Arabia. The participants in this study are primary level pupils, aged 6 to 9, and their teachers. The research study will primarily focus on examining engagement of these pupils with online community mathematics software (such as Mathletics) in school-based settings moderated by teachers.

Participant – please complete the following (Circle Yes or No for each question)

I have read the Plain Language Statement (or had it read to me). *Yes/No*

I understand the information provided. *Yes/No*

I have had an opportunity to ask questions and discuss this study. *Yes/No*

I have received satisfactory answers to all my questions. *Yes/No*

Please be advised that your participation in this study is completely voluntary. Should you wish to withdraw at any stage, you are free to do so without prejudice. The data gathered in this study will only be used for the purposes of for research. The privacy of the participants will be protected by the anonymisation of all data – hence, none of the participants or work places will be identifiable. Data will be securely stored in a password-protected computer file, with access limited to the researcher and supervisor. The data will be kept securely in School of Education Studies, Dublin City University, Ireland, for two years from the date of award of doctorate, before being securely disposed of by system administrator in DCU. The data gathered in this study is subject to legal limitations of Data Protection (Amendment) Act (2003) of Ireland.

Participant – please complete the following (Circle Yes or No for each question)

I am aware that my child can withdraw from this study at any time. *Yes/No*

I give permission for my child to be observed while in mathematics classes. *Yes/No*

I give permission for my child to participate in an interview/s. *Yes/No*

I give permission for my child to be audiotaped in interview/s. *Yes/No*

I give permission for my child to complete survey. *Yes/No*

The researchers would like to use eye-tracking and/or pulse-rate monitoring tools with up to six children to ascertain what attracts or stimulates their interest within online mathematics activities. These tools will provide us with valuable information about how learners can be motivated when participating in educational games. Please indicate by circling Yes or No below, whether you give permission for your child to be engaged in this.

I give permission for use of eye-tracking/ pulse-rate monitoring tools with my child. *Yes/No*

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I consent for my child's participation in this research project.

Name of Child: ---

Parents/ Guardians: ---

Parents/ Guardians Signature: ---

Witness Name & Signature :---

Date: ---

Informed Consent Forms (Teacher)

Research Title: ***Exploring* the *use of online gamified learning activities in mathematics education at primary level in Saudi Arabia.***

Principal Investigator/ Researcher: *Jawaher AlGhamdi/ Dr. Charlotte Holland*

This aim of this study is to explore the use of online gamified learning activities within mathematics education at primary level in schools in Saudi Arabia. The participants in this study are primary level pupils, aged 6 to 9, and their teachers. The research study will primarily focus on examining engagement of these pupils with online community mathematics software (such as mathletics) in school-based settings moderated by teachers.

Participant – please complete the following (Circle Yes or No for each question)

I have read the Plain Language Statement (or had it read to me). *Yes/No*

I understand the information provided. *Yes/No*

I have had an opportunity to ask questions and discuss this study. *Yes/No*

I have received satisfactory answers to all my questions. *Yes/No*

Please be advised that your participation in this study is completely voluntary. Should you wish to withdraw at any stage, you are free to do so without prejudice. The data gathered in this study will only be used for the purposes of for research. The privacy of the participants will be protected by the anonymisation of all data – hence, none of the participants or work places will be identifiable. Data will be securely stored in a password-protected computer file, with access limited to the researcher and supervisor. The data will be kept securely in School of Education Studies, Dublin City University, Ireland, for two years from the date of award of doctorate, before being securely disposed of by system administrator in DCU. The data gathered in this study is subject to legal limitations of Data Protection (Amendment) Act (2003) of Ireland.

Participant – please complete the following (Circle Yes or No for each question)

I am aware that I can withdraw from this study at any time. *Yes/No*

I give permission to be observed while in mathematics classes. *Yes/No*

I agree to participate in interview/s. *Yes/No*

I give permission to be audiotaped in interview/s. *Yes/No*

I agree to complete survey. *Yes/No*

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I consent to participate in this research project.

Teacher Name: --

Teacher Signature:--

Witness Name & Signature: --------------------------------------

Date: --

Informed Consent Forms (Children)

Research Title: Exploring the use of online gamified learning activities in mathematics education at primary level in Saudi Arabia.

Researchers: Jawaher Al-Ghamdi/ Dr. Charlotte Holland

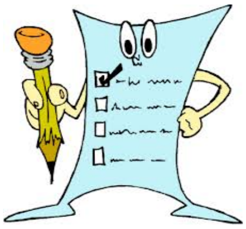
Please complete the following (Circle Yes or No under each picture)

I agree to play online game/s in-class.

Yes *No*

I agree to do class test/s.

Yes *No*



I agree to answer questions on a survey.

Yes *No*

I agree to be observed by a researcher in class.

Yes *No*

I agree to be interviewed by the researcher

Yes *No*

I agree to use eye- tracking device

Yes *No*

Section B.3: Plan Language Statement

Research Title: Exploring the use of online gamified learning activities in mathematics education at primary level in Saudi Arabia.

Researchers: Jawaher AlGhamdi/ Dr. Charlotte Holland

University: School of Education Studies, Dublin City University

This aim of this study is to explore the use of online gamified activities within mathematics education at primary level in schools in Saudi Arabia. The participants in this study are primary level pupils, aged 6 to 9, and their teachers. The research study will primarily focus on examining engagement of these pupils with online community mathematics software (such as mathletics) in school-based settings moderated by teachers. This research is being conducted as there is an absence of research at a global level on the behaviour of children aged 6-9 within gamified learning environment. This study is one of the earliest studies looking into the effects of the implementation of gamified learning technologies in Saudi Arabia, and thus has much to offer in unravelling the extent to which gamified learning environments enhance pupils' engagement and/ or achievement in mathematics education within Saudi Arabia, and beyond.

Pupils who decide to take part in this research will engage in online gamified learning activities. Pupils engagement within the gamified learning activities will be monitored by the researcher using direct observation and, in some cases, by also using eye-tracking and pulse-rate monitoring tools. The eye-tracking and/or pulse-rate monitoring tools will be used with up to six children to ascertain what attracts or stimulates their interest within online mathematics activities. These tools will provide with valuable information about how learners can be motivated when participating in educational games. Pupils may also be interviewed by the researcher, take mathematics tests and/ or asked to complete a survey about their use of gamified learning activities.

Teachers who decide to take-part in this research will be interviewed by the researcher about the ways in which they integrate technologies in their teaching and learning environment, with a specific focus on their experiences of the deployment of gamified learning activities.

The benefit of participation in this research is that participants will help inform the future design and development of gamified learning within primary education.

The observed sessions of pupils and teacher/s will not be recorded using video or audio; instead extensive hand-notes will be taken by the researcher. The interviews with teachers and pupils will be audio-recorded. The privacy of the participants will be protected by the anonymisation of all data – hence, none of the participants or work places will be identifiable. The data gathered in this study will only be used for the purposes of for research – thus, in this case, to explore gamified learning. Data will be securely stored in a password-protected computer file, with access limited to the researcher and supervisor. The data gathered in this study is subject to legal limitations of Data Protection (Amendment) Act (2003) of Ireland. The data will be kept securely in School of Education Studies, Dublin City University, Ireland, for two years from the date of award of doctorate, before being securely disposed of by system administrator in DCU. Please be advised that participation in this study is completely voluntary. Furthermore, participants can withdraw from the research study at any stage by notifying the researcher.

There are no specific risks in engaging in this study, as the primary focus is on examining engagement with commonly used online community mathematics software in everyday school-based settings moderated by teachers. A brief summary of the findings will be made available to participants by the researcher upon application.

Should you require any further information, or have any concerns, please do not hesitate to contact The Secretary, Dublin City University Research Ethics Committee, c/o Research and Innovation Support, Dublin City University, Dublin 9, IRELAND. Tel: 01-7008000

Section B.4: Saudi Ministry of Education Permission Letters

Approval from MoE to conduct the field study.

المملكة العربية السعودية
وزارة التعليم
(٢٨٠)
الإدارة العامة للتعليم بالمنطقة الشرقية
إدارة التخطيط والتطوير

بسم الله الرحمن الرحيم
وزارة التعليم
Ministry of Education

الرقم : ٦١٠٢٨٥١٦
التاريخ : ١٤٣٦/٥/١٩هـ
المرفقات : ٨

الرؤية: الريادة لبناء جيل مبدع	الرسالة: تقديم خدمات تربوية وتعليمية ذات جودة عالية وفق معايير عالية بمشاركة مجتمعية	القيم: المواطنة- الإتقان- العدل- العمل بروح الفريق- التنمية الذاتية- المسؤولية الإجتماعية

إلى : المكرم / مدير مكتب التعليم بالخبر حفظه الله

إلى : المكرم / مدير مكتب التعليم بالظهران حفظه الله

من: مديرة إدارة التخطيط والتطوير

بشأن: تسهيل مهمة الباحثة / جواهر الغامدي

السلام عليكم ورحمة الله وبركاته ، ، ،

بناءً على موافقتنا بشأن تسهيل مهمة الباحثة / جواهر الغامدي طالبة الدراسات العليا لمرحلة الدكتوراه بجامعة دبلن، والتي تجري بحثاً بعنوان (استكشاف استخدام أنشطة التعليم gamified على الانترنت في تعليم الرياضيات في المرحلة الابتدائية في المملكة العربية السعودية)، حيث يتطلب البحث تطبيق استبانة و مقابلة و ملاحظة على عينة من طالبات الصفوف الدنيا من الصف الأول إلى الصف الثالث الابتدائي و معلماتهن في بعض المدارس الحكومية والأجنبية .

عليه فلا مانع من تسهيل مهمتها ، علماً أن التطبيق سيكون من قبل الباحثة نفسها.

يسعدني شكركم على عنايتكم وتجاوبكم مع ظروف الباحثة.

والسلام عليكم ورحمة الله وبركاته ، ، ،

نوال بنت عبد الرحمن التيسان

١٩ / ٥

م/الجبير
٥/١٩

فاكس ٨٢٦٤٩٧٧ ☎ ٨٢٦٩٣٦١ ✉Office26@edueast.gov.sa

Kingdom of Saudi Arabia
Ministry of Education
(280)
General Directorate of Education in the Eastern Province
Department of Planning and Development

In the Name of Allah, Most Gracious, Most Merciful

Ministry of Education

Number: 361028516
Date: */ 9 Jumada Al-Ula 1436 A.H.*
Corresponding to: *9 March 2015* A.D.
Enclosures: 8

Vision: To take the lead m building a creative generation	Mission: To deliver high quality educational services according to international standards and through community engagement	Values: Citizenship; Perfection; Justice; Teamwork ; Self-Development ; Social Responsibility

To: *Hon. Director of Education in Al-Khobar* *May Allah Protect Him*
To: *Hon. Director of Education in Al-Dhahran* *May Allah Protect Him*
From: *Director of Planning and Development*
Re: *Facilitating the Task of Researcher/ Jawaher Al-Ghamdi*

May Allah's peace, mercy and blessings be upon you

Considering our approval to facilitate the task of *Researcher/ Jawaher Al-Ghamdi,* a postgraduate student pursuing a Ph.D. degree at Dublin University , who conducts a research entitled *"Exploring the Use of Gamified £-learning Activities in Mathematics Education in the Elementary Stage in K.S.A" ,* kindly accord her all necessary assistance and support. The research requires the student to conduct a questionnaire, an interview and an observation on a sample of lower grade level female pupils, from first to third primary grade, and their female teachers in some public and foreign schools. Kindly be informed that the researcher will conduct the above research activities herself.

I'd like to express my appreciation for your care and response to the researcher's circumstances.

May Allah's peace, mercy and blessings be upon you

For and on Behalf of
Nawal Bent 'Abdul Rahman Al-Taisan
(Signed)
19 Jumada Al-Ula 1436 A.H

(Illegible Signature)
19 Jumada Al-Ula 1436 A.H

DCU LS
language services
DUBLIN CITY UNIVERSITY

Fax: 8264977 W8269361
Office26@edueast.gov.sa

Approval to send the survey to teachers from the Department of Development and Information.

المملكة العربية السعودية
وزارة التعليم
(٢٨٠)
الإدارة العامة للتعليم بالمنطقة الشرقية
إدارة التخطيط والمعلومات
PI

بسم الله الرحمن الرحيم
وزارة التعليم
Ministry of Education

الرقم : ١٤٥٤٩
التاريخ : ١٤٣٩/٠٥/٠٧هـ
المرفقات : ـــ

الرؤية: الريادة لبناء جيل مبدع	**الرسالة:** تقديم خدمات تربوية وتعليمية ذات جودة عالية وفق معايير عالمية بمشاركة مجتمعية	**القيم:** المواطنة-الإتقان-العدل-العمل بروح الفريق-التنمية الذاتية-المسؤولية الاجتماعية

إلى: المكرمين / مديري ومديرات مكاتب التعليم **حفظهم الله**
من: مديرة إدارة التخطيط والمعلومات
بشأن: تسهيل مهمة الباحثة / جواهر الغامدي

السلام عليكم ورحمة الله وبركاته

بناءً على خطاب المركز الوطني لبحوث سياسات التعليم رقم ٦٦٣٦٣ بتاريخ ١٤٣٩/٤/٣٠ هـ بشأن تسهيل مهمة الباحثة جواهر بنت غرم الله الغامدي طالبة الدراسات العليا لمرحلة الدكتوراه بجامعة مدينة دبلن بإيرلندا ، والتي تجري بحثاً بعنوان (استكشاف استخدام أنشطة التعليم gamified على الانترنت في تعليم الرياضيات في المرحلة الابتدائية في المملكة العربية السعودية" ، حيث يتطلب البحث تعبئة استبانة الكترونية من قبل المعلمين و المعلمات بمدارس تطوير و المدارس الأجنبية على الرابط التالي :

https://www.surveymonkey.com/r/XNHXJXN
https://www.surveymonkey.com/r/GSL6RSC

عليه فلا مانع من تسهيل مهمتها ، وفق اللوائح والأنظمة خلال سنة من تاريخه.

يسعدني شكركم على عنايتكم وتجاوبكم مع ظروف الباحثة

والسلام عليكم ورحمة الله وبركاته

نعيمة بنت سالم السعدي
نعيمة
٥/٦

Office26@edueast.gov.sa ٨٢٦٤٣٦١ فاكس: ٨٢٦٤٩٧٧

Appendix C: Phase One Data Collection Tools

Section C.1: Interview questions

Teacher Interview Form.

Sample Teachers Interview Form

Teacher:	Date:	**Age:**
School:	Class level:	

- How long have you been teaching?
- Is mathematics a core subject in your primary degree? If not, what is your core subject?
- What is the grade level that most closely matches to your position?
- How long have you been working as a teacher at this school?
- What is your level of technology skills/ literacy? [Basic/ Advanced/ Expert]
- Have you taken continuing professional development courses in technology? If yes, please describe when, where and content of technology course?
- How do you integrate technology in your classroom?
- What types of technology do you regularly use in the classroom?
- Why do you use technology with your pupils?
- How frequently do you use the online mathematics games in-class?
- How do you integrate the online mathematics games within a standard class?
- Do you ask your pupils to use the online mathematics game/s at home? Why/ Why not?
- Has any pupil ever asked you for help in using the online mathematics game/s? Please explain.
- How do the in-class mathematics test results compare with the results (accumulated points) from the online mathematics game?
- What are the benefits and/ or limitations of using online gamified learning activities in mathematics education in your class?

Student Interview Form

Pupil:	Date:	Age:
School:	Class level:	

- *How do you spend your free time at home?*
- *What toy do you like to play with?*
- *What device (X-Box/ Play-station/ Tablet) do you like to play on at home?*

- Do you play Mathletics at school?
  - If yes, what aspects do you enjoy/ not enjoy it?
  - How many points did you collect?
  - Have you ever asked anyone to help you to collect points, if you could not collect them yourself?
  - Did you receive any certificate from online game/s? If yes, what type of certificate did you collect?
  - How much credit have you earned so far from playing online mathematics games in-school?
  - Do you play with your friend/s online today? Do you enjoy it? Explain

- How would you feel if you didn't collect points from online gaming in this week?
- Did you ever see your name on the leaderboard/s?
- How did you feel about seeing/ not seeing your name on the leaderboard/s?
- What did you like most/ least when playing the online game today?
- Do you play online mathematics game/s at home? If yes,
- Does anyone ever help you when you are playing at home?

* Please note that *Italic Text* indicates warm-up question to help relax the learner.

Section C.2: Whole-class Observation

Here is a sample of class observation for Grade 3

Date 18/11/2015	Grade: Grade 3
Day: Wednesday	Time: 07:30- 8:15
Topic: 2 and 5 as factors	Mathletics Activity: Group of 2, Group of 5
Session: 9	

The classroom is physically an appropriate size with interactive white- board in the front of the class and white board in the other side. There were 19 pupils seated at desks into four groups (4-5 pupils in each). The teacher has a desktop computer connected to Wi-Fi.

The teacher was moving around to check the homework. She then wrote the first question of the homework on the board and asked the students to answer. All students wanted to answer and the teacher asked one of the learners to come and answer. When all questions were answered on the board, the teacher asked the students to check on their answers and if any had a problem with the homework. The teacher wrote a pattern of 2 in the addition table and asked the learners to work in their group to write 2 as factors and find the products. The teacher was moving around. She then asked: who knew the answer? Some students were volunteering answers. The teacher typed the answers that were provided by the learners. The teacher then asked: what did you notice here? Some students were answering and each one provided a different answer. One learner said that all answers are even numbers, one learner said that we keep adding 2.

She then wrote another pattern for 5 in the addition table and asked the learners to work in their groups to write the factors of 5 and find the products. Some learners were working but other were talking, playing with their stuff and messing with other. The teacher warned them if they did not sit quietly and pay attention, they would not have a chance to play Mathletics.

The teacher then chose one learner from each group to come over the board and type the answers. The teachers then asked what did observe here - pointed to the pattern of 5? One of the learners said that we keep adding 5 and another learner said that all the answers end in 0 or 5.

The teacher then presented the guided activities on the smart board and explained the new topic. The teacher then asked the learners to open the TextBook and do the activities in their own groups. Only two or three students from each group were doing the activity and the other/s were playing and talking. Some of them were doing the activities individually. One of the learners was copying the answer from a copy of the times table that she had in her desk.

The teacher then presented the word problem on the smart board and asked one student to read the word problem question. Then she asked another learner to come over the board and answer. When the learners finished all the questions, the teacher then asked the learners to drop the book on her desk to make sure that all learners have answered all questions correctly.

The teacher then accessed the publisher ‘Pearson’ website and presented some activities on the smart board. She asked who wanted to answer the first question, a large number of students raised their hands and some came over to the board to answer. So, the teacher decided to play a game with them. She asked all learners to go back to their seats and threw a ball, and whoever caught the ball would get to answer the first question. She threw the ball and the students were jumping who will catch it first. They had to finish 10 questions, but the students were worried about the time and they would have no chance to play Mathletics. They asked the teacher if she can keep the rest of the activity for next time. The teacher then asked them to get the iPad from the bag and have access to Mathletics.

The students got the iPad from their bags and has access to Mathletics App. They were so excited. They moved around to show each other the points that they got and the activities that they did so far. They asked what is the name of the activity? After they have been informed about the activity, the activity for today is two different activities 'Group of 2, Group of 5'.

They also formed challenge groups, and decided on the activity that they would do first. Most of the students were standing up and held the iPad by hand and typed the answer by the other hand. The students were racing each other, their voices raised as they showed each other the correct answer. The students who completed the activities showed her friend the final feedback indicating all correct answers. One of the learners asked her friends who finished the first activity if they could make another group to play the second activity. A few students from different groups finished and they made other groups to play the other activity. They agreed that who will finished first, she will be the winner. They were screaming, shouting and racing. All the students had fun time they never left the iPad before they have completed the activity. When they finished they exchanged the iPad and compared each other points and then saw who was closest to '1000' points.

Some students completed both activities and they went to the teacher to show her their progress on the 'Gold Bar' in Mathletics. Some learners completed the activities but they made a few mistakes, so they re-tried the activity. One group decided to play 'Live Math'. They had access to the game and connected with other players from around the world but they remained playing at first level (as they were able to easily complete these questions, and thus earn more points.).

The time was up, and the teacher asked the learners to turn off the iPad and put it back into the bags. The teacher left the classroom as the math period had finished and another teacher arrived. Many students still had the iPad and continued doing the activity until the new teacher turned the WIFI off.

Section C.3: Sample Interactive Observation (used in Case Studies)

Date 08/12/2015	Grade: Grade 3
Day: Tuseday.	Case: 1
Time: 10:30- 11	Mathletics Activity: Group of Six

The learner completed the calibration for Tobii eye-tracker (this ensured that the equipment was aligned at the appropriate eye level). She accessed the Mathletics website and picked an activity to play. The learner then decided to play the 'Group of Six' activity. She looked at the screen and held the external mouse. She used the mouse and counted the number of arrays out loud. She looked at the key-board and typed the first answer. She then looked back at the computer screen, still holding the external mouse and used it for counting. She counted the circles one by one out loud.

The researcher asked, *do these shapes help you to get the answer*? The learner answered, Yeah. The researcher further asked, *How did help you*? The learner answered, I don't know to get the answer, so I count them. I also can count by fingers if there is no circles.

The researcher commented, *I do not think you can because it's multiplication*.

The learner answered, I could, but it would take lots of time.

She looked at the key-board, typed the answer and submitted the answer. She got incorrect for her answer. She did not express any emotion. She received the second question. The learner counted out loud the number of circles while she was holding the mouse. She got the correct answer. She was very happy when she got the feedback from the software saying it was correct. The learner got the third question which was similar to the second question, solved it and submitted the answer. When she was waiting for the forth question to appear on the screen, she said that 'I hope that the question is not repeated'. The learner answered the fifth question, she deleted half of the answer by mistake and submitted the answer. She got incorrect for her answer. The learner was so mad. The learner was holding the mouse and counting out loud. She completed the activity and got the final feedback.

The researcher asked, *how many mistakes did you get*?

The learner said, Three,

The researcher corrected this, stating, *Four*.

The learner, 'was so mad' No three, it should be three because one of them I did wrong. I wish if the game took account of this mistake.

The researcher asked, how did you feel when you got an incorrect answer?

The learner responded, I got slightly sad because I tried my best and was expected to have incorrect answers. Can I play again so I can get all correct answer?

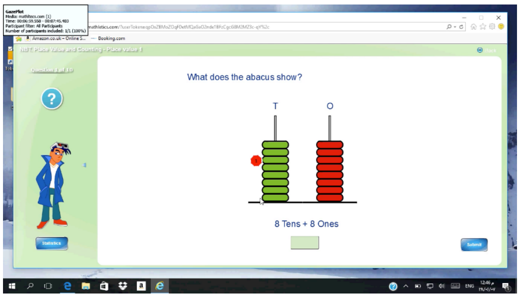
The researcher said, *ok now If the circles help you to get the answers, why did you get incorrect answers?*

The learner answered, *because of the colour. So, if the circles were in two colours or three colours* [as opposed to one colour in this Mathletics activity], *it will be better, but if it was a lot of colours it would take more time.*

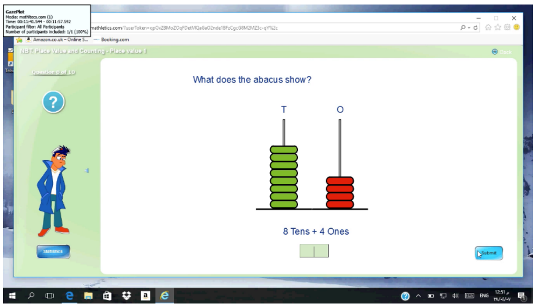
Section C.4: Sample of Eye-tracking Recordings

Here are two samples exported from eye- tracking software for Grade 2 Case 1.

The first recording shows that the learner never look at the textual question. She counted the circles on the left hand-side one by one. The second recording (question no.8), she looked at the numeric question only and typed the answer.



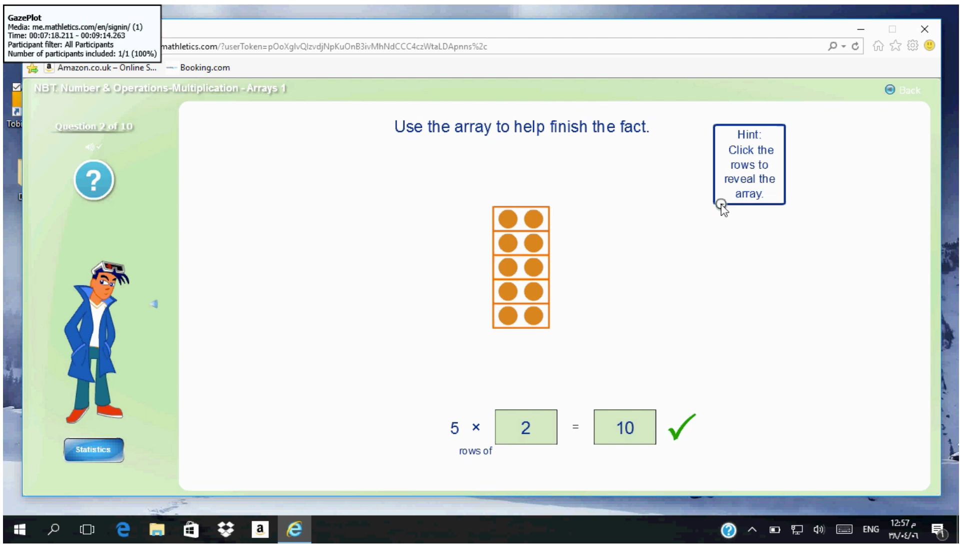
https://www.dropbox.com/s/0xp3nm3pw73qjhd/1-1-2%20%28Converted%29.mov?dl=0v



https://www.dropbox.com/s/emz7st4c5iecnfu/1-2%20%28Converted%29.mov?dl=0

Please find here a short recording exported from eye-tracking software for Grade3Case1.

The learner tried to count the circles by imagining there were circles in the blank array and using the mouse to count the invisible circles.



https://www.dropbox.com/s/vda0ar1iueaijyb/1-1-3%20%28Converted%29.mov?dl=0

Appendix D: Phase 1 – Data Analysis Process

Section D.1: Sample Code-book

Final Coding for Phase 1- Grade 1

This code book for data was collected from the first phase of this research for Grade 1. The data was collected from direct class observation, interviews with teacher and learners and Mathletics report. The data in this codebook is written by three different colors. The black words refer to the data was collected from the class observation. The blue words are the data was collected from the learners' interviews. Finally, the data in green is what the teacher said in her interview.

Codebook for General Pedagogical Approach.

First level of code		Sample Excerpts	Case	Second level of code
		Category 1: Pedagogy used in revision of previous topic in Traditional setting		
1.	Teacher rotates around the classroom to check and correct individual homework	the teacher asked them to open the homework….the teacher moved around to check for the home work.	G1S4	Teacher provides individual learner feedback on homework.
2.	Teacher engages pupils in whole-class question and answer on homework/ previous topic	She moved around and check and went to the smart- board and asked the learner who will come and answer the first question of the homework. She draws a rectangle and divided to two rectangles. At the left part, she draws four circles and at the right side she draws two circles. She asked the learners to answer. The teacher was starting to revise the last lesson (which covered the maths topic of Double). She picked two pupils from two different groups and asked them to come over to the board. She asked the first pupil to draw six circles (adding 3 and 3) and the second pupil to draw eight circles (adding 4 and 4). She picked anther two pupils to answer the questions.	G1S8 G1S15	Teachers engaged in whole class/ group discussion of homework.
3.	Teacher initiates peer assessment of homework	Not used in Grade 1		Peer assessment technique
		Category 2: Pedagogy used in introduction of new topic in Traditional setting		
4.	Teacher starts math class by playing a game.	The students were sitting on groups. Each group has a dice and a sheet. The teacher asked the pupils in their groups to throw the dice and write the number on the sheet and threw it	G1S4	Teacher introducing play activities in maths activity.

		again and write the number that is shown. Then they have to add these two numbers. When they got the answer, they can replace the numbers and find the answer then compare the final results.		
		we play videos [video games] related to the topic in the computer… before we start addition, we play some addition songs and addition games. So, it makes their mind more focused on the topic and they feel more active when they see things really on the screen visualizing it's better than paper and pencil work, it's better when it's focused. So, I feel kids are learning with fun	T1	
5.	Teacher explains the learning outcomes for the session.	The teacher then explained the meaning of order.	G1S4	Teacher explaining Goal setting for learners
		The teacher then explained the meaning of 'Near Double'	G1S15	
6.	Teacher displays new maths concept on whiteboard/ smartboard and explains how to solve the maths problem.	The teacher then presented the activities on the smart board and explained the way to get the answer.	G1S4	Teacher explanation of maths concept in didactic style – show and tell…
		then explained the first example of the Guided Activity.	G1S8	
		The teacher then presented the 'Near Double' questions projected from the Maths Book (Pearson website) on the interactive white-board and then explained the first question	G1S16	
		Technology makes learning more fun. it's visualizing the concept.	T1	
7.	Teacher uses resources on the Maths Book Publisher website/ to display the activity.	The teacher then uses the smart- board to present the digital book from the publisher website.	G1S4	Teacher deploying Online resources – in didactic sytle
		The teacher then presented the book from the publisher website on the smart-board then…...	G1S8	
		The teacher then presented the 'Near Double' questions projected from the Maths Book (Pearson website) on the interactive white-board, and issued a request for a volunteer to come answer one of the questions displayed on the smart board, who completed the first question.	G1S15	

8.	Teacher uses group-work to facilitate opportunities for group/ collaborative learning	The teacher then asked if they have already finish. The students still doing the activities. After a while, one of the groups finished and they screamed out and ask the teacher to come and check for their work. The teacher then presented the second example and asked the learners to work on this in their group.	G1S4 G1S8	Teacher facilitating Group-work
9.	Teacher uses question and answer to stimulate learner thinking on the topic.	The teacher asked the pupils: what do you observe? The students provided the answers. The teacher gave them another example and asked if there is another way to find the answer She then added one circle to each question and asked pupils from the other two groups to come over the board and find the sum.	G1S4 G1S 8 G1S15	Teacher using Question & Answer technique
10.	Teacher invites learners to answer questions on whiteboard/ smartboard.	The teacher asked one pupil to come over the smart board and answer. Other pupils raised their hands to have a chance to come over the smart board and answer the second question, while some still continued writing the first answer in the Book. We use of course, a smartboard in there in the class and we have the smart pen so when we work with our worksheets and paper-work, we project this in the screen. So, as it's projected on the screen, we give each student chances to come forward and use the smart pen and find out the answers…these answers were done by kids. Not by me as a teacher, So, learning in my class, I don't prefer teacher orientation [i.e. teacher-centred approach]… A teacher is not the one teaching in the class, I let the students come forward. You [learner] do the teaching today, so you get a chance to go to the board. So, I pick each one of them to work. So, I try to engage them with technology. It's not the way I'm using it [technology], they are using the technology.	G1S4 G1S15 T1	Teacher engaging Active Learning Approach
11.	Teacher actively seeks learner inputs on alternative ways to solve maths problem.	The teacher gave them another example and asked if there is another way to find the answer. Some students were providing the answers and the teacher was typing what they said.	G1S8	Teacher engaging participatory form of learning
12.	Teacher encourage learners actively participate in new math tasks.	The teacher announced that all have pay attention, she then asked one pupil in the group to stand up and read out loud their answer and the teacher typed the answer on the board. The teacher asked the pupils to open the 'Student Book' and asked one of the pupils to read the information about 'Near Double' out loud.	G1S4 G1S8	Teacher encouragement of learners' participation.

		Nature of Learner Engagement in the New Topic.		
13.	Learner sitting quietly, Eyes not focused, Messing with other children, Looking bored, losing attention,	…..other were very quiet. others were having an informal chat with each other. while some still continued writing the first answer in the Pupil Book….. Some pupils still choose to ignore this and kept chatting,	G1S8 G1S15	Learners expressing/ displaying a lack of Interest in the task.
		Category 3: Pedagogy of Maths Practice in Traditional Setting (paper-based maths practice activities)		
1.	Teacher directs the learners to use the Student maths activity book in groups.	She then asked the learners to open the book and answer the independent practices in the groups. The teacher then asked the learners to open the book and work in their groups on the independent activity. The teacher asked to do the questions on 'Near Double'. The activity book contains lots of practice exercises that pupils can do by themselves or in the group.	G1S4 G1S8 G1S15	Teacher re-organisation of learner interaction in groups.
2.	Teacher moves around the groups to check on individual/ group progress.	She was moving around and check on the learners' work. The teacher was moving around to check on their progress. The teacher was moving around to check their answers and help the pupil who did not understand.	G1S4 G1S8 G1S15	Teacher engaging in Guided Facilitation
3.	Teacher responds to questions posed by the individuals/ groups, Teacher re-explains the concept to the individual/ whole-class.	The teacher noticed that some of the learners had difficulties in solving the problems. She went over the board and asked the learner to pay attention. Some pupils requested more explanation of the concept of 'Near Double'. The teacher announced that she would re-explain by doing examples on the interactive white-board, and asked the pupils who will come and help answer the questions.	G1S8 G1S15	Teacher engaged in Scaffolding learning
4.	Teacher directs learner to help another group-member	The teacher then chose one of the learners from the first group to come and explained to her friends.	G1S8	Teacher encouraging co-operation
5.	Teacher directs learners in groups to exchange and correct each other's work	Not in Grade 1 level		Teacher encouraging peer-assessment

6.	Teacher reprimands learners for chatting informally or distracting others.	The teacher asked them to stay quiet and do the activity. Some pupils were paying attention. Other were still taking and their voices were raised. The teacher asked them to be quiet or they will not have a chance to play "Mathletics".	G1S4 G1S15	Teacher disciplining learners
7.	Teacher does not provide direct (real-time) feedback on learners' performance in paper- based activities,	The teacher asked the learners to finish the activities and drop the book on her desk to check. The teacher asked the learners to finish the activities and drop the book on her desk to check. As soon as pupils finished, they dropped the books on the teacher desk and made their way back to their own seats…. The teacher did not give immediate feedback on their performance.	G1S4 G1S8 G1S15	Teacher not engaging in direct feedback to learners on performance.
8.	Teacher uses resources on the Maths Book Publisher website/ or other websites to display the activity,	The teacher then presented the activities from the book website 'Pearson' on the smart board and explained the way to get the answer The teacher then presented the book for the publisher website on the smart-board then explained the first example of the Guided Activity. The teacher then presented the 'Near Double' questions projected from the Maths Book (Pearson website) on the interactive white-board.	G1S4 G1S8 G1S15	Teacher deploying Online resources
9.	Teacher ends the math time by playing a game.	Usually like three times a week, four times a week. It depends because usually we have our worksheets to be completed and [they need to work on] their writing skills. The day like when we finish early or sometimes, we have more time to work, I play math games and I let them, again come again and play with me the math games. So, it's like 3 times maximum in a week'. In classrooms I play with kids, like math games. We have a game, we have websites like Turtle Diary where it's devoted to math. We have A to Z reading skills [game], also math games are included. Some google sites in general, where it takes you directly to math games. For their age, for example we are learning about fractions and addition and subtraction, so [I search for related games I put them into Google. And they as a class, we play together on the smartboard' If you say benefits mean [of maths games], it focuses them better. The lessons and concepts we're teaching them with worksheets, they are grasping more knowledge when it comes to when we tell them "you are playing, but you it means that you are also learning addition or subtraction skills". So, it's like two in one. They're getting the idea [of mathematics	T1	Teacher encouragement playing at classroom.

		problem] from the paper but [they get] more ideas [on how to solve the maths problem] from the computer which is the benefits' We could play many games, but I prefer the games that relate to topics covered in class, and they are excited enough that they play with this. Not with any random games because maybe they might now know, or it would not have been related to what we are learning. So, it's better that they learn from what I am giving them and the resources that I mentioned. Addition has certain standards that they need to know how to count and find out the figures. So, related to these easy games, I post the games on the website. I write like "math games for grade one", "lower level", "advanced level", "middle level", so usually when I start playing games I start with the below level. When you write in google there are websites where you have [maths games] for low beginners. So, we play the beginner games then the second day or the third day when we have time, we play middle, like a little bit advanced level, and then finally the advanced where they can challenge themselves and you know, learn better, I mean learn better through games.		
10.	Teacher encourage learners to use online games at home.	Yes. I have a website, it's my classroom website and I have mentioned a lot of educational websites over there which they can even access at home. And I'm sure the kids are also playing it. No, because they are usually use games at home, I'm sure the parents are helping. And parents ask me that, like which game is more suitable like "we [the parent and learner] went to the Turtle Diary and we are playing math games" and I'm like "yeah, wow you could still continue" and they're like "yes it's easy for our kids and they are challenging themselves". I said, "because maybe they know from school. So, when you're playing the same game at home they feel more interested because they're happy to show their parents they know.	T1	Teacher encouragement playing at home.

Codebook for Nature of Learner Engagement in Maths Practice

Category 4: Nature of learner engagement in Maths Practice in Traditional Setting (paper-based maths practice activities)			
First level of code	**Sample Excerpts**	**Case**	**Second level of code**

1.	Learners completed all maths practice activities, and submit to teacher.	The students who finished the activity dropped the book on the teacher desk…..	G1S 8	Learner completes maths practice work
		The teacher asked the leaners to finish the activities and drop the book on her desk to check. Some of the learners had finished and ran to the teacher and drop the book on her desk	G1S8	
		As soon as pupils finished, they dropped the books on the teacher desk and made their way back to their own seats.	G1S15	
2.	Learner explains to another group member how to solve the problem	In one group, one of the learners was explaining her way to answer to her friends.	G1S8	Learners co-operating within groups.
3.	Learner choosing to work alone on solving maths activity.	She then asked the learners to open the book and answer the independent practices in the groups. Some of the learners were working alone by themselves. One learner was working by herself on the activity, she used fingers to account, she took time to complete the questions and submitted to the teacher	G1S4	Learner disengages with group discussion/ collaboration during maths practice activities.
4.	Learner have informal chatting, messing with other learners.	but some learner was playing and talking.	G1S4	Learners expressing/ displaying a lack of Interest in the activity
		However, not all pupils were able to complete the activities or appeared to be distracted within the group. Some of them were trying to find the answer but others were talking and playing.	G1S15	
5.	Learner expressing frustration with more challenging math practice question, learner asking teacher to re-explain the concept.	The teacher noticed that some of the learners had difficulties in solving the problems. She went over the board and asked the learner to pay attention.	G1S8	Learner is displaying level of anxiety/ frustration with more challenging maths activities
		The teacher was moving around to check their answers and help the pupil who did not understand. One of the pupils requested more explanation of the concept of 'Near Double'. The teacher asked the pupils who will come and help answer the questions.	G1S15	

Category 5: Learner engagement in Online Gamified Learning Practice Setting (Mathletics practice activities).

First level of code	Sample Excerpts	Case	Second level of code	Sub-Category.

1.	Learners looks proud of themselves, showing other their scores, finish first, completing the activity without help, completing the activity without mistake.	The students who finish the game and received the (10) points ran to the teacher and showed her their achievement…	G1S4	Learners are demonstrating pride in achievement	Motivation generated from confidence in learners' abilities.
		The pupil who finished first ran to the teacher and showed her their final score.	G1S15		
		I can play and collect points without any help even when I start a new game. I am proud to collect them by myself.	C1		
2.	Learners laughing, Shouting, expressing happiness, Repeating the activities. waiting with an excitement.	The teacher then gave them the permission to bring the iPads which were in their school bags outside the classroom. They ran to the door, but the teacher was controlling them, so they do not bother the other classes...The students were so excited by doing the activity by the platform...Some students re-tried the game more than one time…	G1S4	Learners expressing enjoyment from the use of Mathletics.	Motivation
		The students who already finished the class-work were so excited waiting for the teacher permission to use the iPad. The students understand what makes the teacher happy, so she can let them to play, however they arranged their stuff and sitting quietly. The teacher asked to bring the iPad from their bags outside of the classroom. The students ran to get them and coming back to the class…..The students were so excited and happy. They move physically in the classroom, took about the excitement of the activity and points that they got… Some pupils were paying attention. Other were still taking and their voices were raised. The teacher asked them to be quiet or they will not have a chance to play "Mathletics". They asked when they will get the iPad, the teacher said when you all finish the questions.	G1S8		
		Some learners finished the 'Doubles and Near Doubles' practice activities and re-try another set of practice maths question within this thematic area.	G1S15		
		I like to play Mathletics because it's fun and I learn new things.	C7		

		I like Mathletics it's so much fun, ….	C8		
3.	Learner has completed the activities – the bar only fills if all questions answered correctly.	Some students after they finished the activity, they visited the main page to show each the 'Gold Bar'. One learner ran to the teacher to show her the 'Gold Bar'	G1S4	Learners exhibiting a Desire to successfully complete the activities…	Motivation generated from confidence in learners' abilities
		Some students finished and had all correct answers they show their friend their final progress.	G1S8		
		The students who finished the activity show their friends the 'Gold Bar'	G1S15		
	Learners complete additional maths practice activities at home, learners talk about the completed activity at home.	Since they have access to the App, they showed each other the gold bar which indicated the activity successfully completed.	G1S8	Learners exhibiting the desire to engage in Mathletics beyond class-time	Motivation generated from confidence in learners' abilities.
		Some pupils have already played the Mathletics game at home and showed their friends the points that they have.	G1S15		

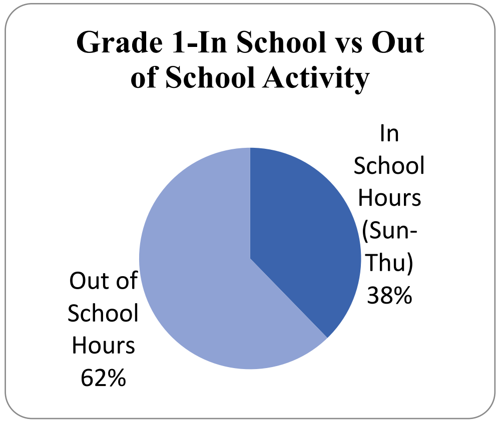


Figure 1: A bar chart from MR about the completed activities in and out of school.

The figure shows that 62% of the activities were completed at home.

MR

I play Mathletics at home and there is no one help me even when I start a new game.	C2
I play Mathletics at home by myself, there is no one help me.	C3
I play at home and sometimes I ask my father for help.	C4
I play at home, and there is no help me to play.	C5

Table 1

Completed activities in and out of school time.

In School vs Out of School Activity	
In School Hours (Sun-Thu)- 7:30 – 2:30	380
Out of School Hours	627
Total	1,007

The table shows that from a total of 1,007 completed activities, 627 activities were completed out of school time (the school starts from 7:30 to 2:30 Sunday to Thursday).

Student Name	Class Year-Grade	Topic Name	Activity	Result	Attempt	Date Completed	Time of Completion
C1	1		Make Big Numbers Count	60	1	Nov-01-2015	3:31:21 pr
C2	1		Compare Numbers to 100	60	1	Nov-01-2015	5:15:29 pr
C3	1		Sort It	40	1	Dec-02-2015	5:27:42 pr
C4	1		Collect the Shapes 1	80	1	Oct-30-2015	4:50:24 pr

Figure 2 sample of learners' engagement with some activities that they took with the teacher.

Student Name	Class Year-Grade	Topic Name	Activity	Result	Attempt	Date Completed	Time of Completion
C2	1		Add and Subtract Using Graphs	80	1	Nov-02-2015	7:31:46 pm
C4	1		Add Three 1-Digit Numbers	90	1	Nov-14-2015	2:44:42 pm
C10	1		Add Three 1-Digit Numbers	100	1	Nov-21-2015	5:48:11 pm

Figure 3 sample of learners' engagement with some activities that they did not take with the teacher.

4.	Learner noting need for teacher support.	Sometimes the game that I play by Mathletics at home is easy sometimes it's hard because we didn't learn it.	C7	Need for Teacher guidance in online maths context	Pedagogy
		I like 'Add to Ten' and I like 'Add and Subtraction Problems'. And I like other games. I like 'Fact Family'. I like other games too…I know what I think my myself, but sometimes I need a teacher just a little bit to show me how to do it.	C8		

Student Name	Class Year-Grade	Class Name	Group Name	Topic Name	Activity	Attempts	First Score	Recent Score	Recent Attempt
C3	1	1A	1A		Sort It	1	40	40	02/12/2015 - 17:27:42
C4	1	1A	1A		Picture Graphs: Who has the (	1	50	50	02/12/2015- 15:43:02
C8	1	1A	1A		Sorting Data	2	30	40	01/12/2015 - 18:23:40

Figure 4 from MR for three different learners (learner C3, C4 and C8) engagemnet with some activities at home that they did not take with the teacher and they scored very low.

5.	Learners connect with peers in-class and across the globe to engage in Online Maths challenging (Live Mathletics),	Some students after they finished the activity they enjoy "Live Mathematics" and made their own group to start the challenging.	G1S4	Learners display interest in connecting/ competing with other learners	Motivation generated from social interaction
		Some students who finished the activity, they made their own group and play "Live Mathematics". They connected to the class competition.	G1S8		
		One of the groups decided to play 'Live Mathematics'	G1S15		

Student Name	Group Name	1 Total Correct	Top Score	Accuracy %
C1	1A	2	1	67
C2	1A	79	15	99
C3	1A	-	-	-
C4	1A	219	25	98
C5	1A	210	20	96
C6	1A	138	35	97
C7	1A	25	17	96
C8	1A	576	38	97
C9	1A	348	37	94
C10	1A	316	20	94
C11	1A	0	0	-
C12	1A	0	0	-
C13	1A	48	10	83
C14	1A	37	14	95
C15	1A	139	16	93
C16	1A	263	20	92
C17	1A	0	0	-
C18	1A	0	0	-
C19	1A	308	35	95
C20	1A	47	16	90
C21	1A	535	34	95

Figure 5 from MR about learners' engagement with 'Live Mathematics'

The table shows that most of the learners in this grade able to connect online with other players. However, there were some cases who never play the online competition for example learner C3 and other example who tried the online competition, but they did not get any correct answer (e.g. learner C11, C12, C17 and C18).

6.	Learners are playing the Mathletics in friendly competition (In-class Mathletics), Discussion and sharing ideas, Explaining how they solve the problems to each other.	The students who found the activity started playing. They were sitting on their own groups…One of the groups made the second round as challenging. They agreed to start the game at the same time and who finish early will be the winner. The student who finished first stand up and screamed "I am the first".	G1S4	Learners exhibiting a desire for Collaboration and Competition.	Motivation generated from face to face collaboration.
		The pupils who find the activity sat on their groups with the iPad and ask their peers to join the group, so that they can compete with each other face-to-face.	G1S15		
		I like to play Mathletics at school because there is a friend.	C1		
		I like to play at school because I have friends.	C3		
		I like to play Mathletics at home and at school	C4		
		I like to play at school because of my friends.	C5		
7.	Learner chooses to work alone on solving maths activity.	She back to her own seat and do the activity.	G1S4	Learner preferring to work alone during maths practice activities.	Learning Disposition/ learning preference
		There were some learners who sat on their won seats and were doing the activity.	G1S8		
		I never ask any one for help even my friends.	C2		
8.	Learner is doing the tasks, Learner is focused on the screen.	The students were more focused on the iPads screen and answering so fast. Some of them were standing up hold the iPads by hand and use the other hand to type the answer.	G1S4	Learners displaying the capacity to retain their focus on the activities (Concentrate/ attention span)	Learning disposition
		They were more focused on the iPad screen. They were counting out loud and physically using their fingers, typing the answer as fast as possible.	G1S15		
9.	Learners create their own group/ to compete with each other face-to-face.	Not in this grade		Learners exhibiting the desire to self-direct their learning	Learning disposition

10.	Learners compare the challenge of question/s solved with each other 'a more worthy win' if the questions seem harder.	Not in this grade		Learners discernment of degree of challenge of questions on their performance	Learning disposition/motivation
11.	Learners repeat the activity to improve the final score and publicise the final score.	some students played the game more than once to get all correct answers.	G1S4	Learners displaying a self- challenging disposition	Learning disposition
		The students who finished and had a few mistakes, they re-tried the activity.	G1S8		

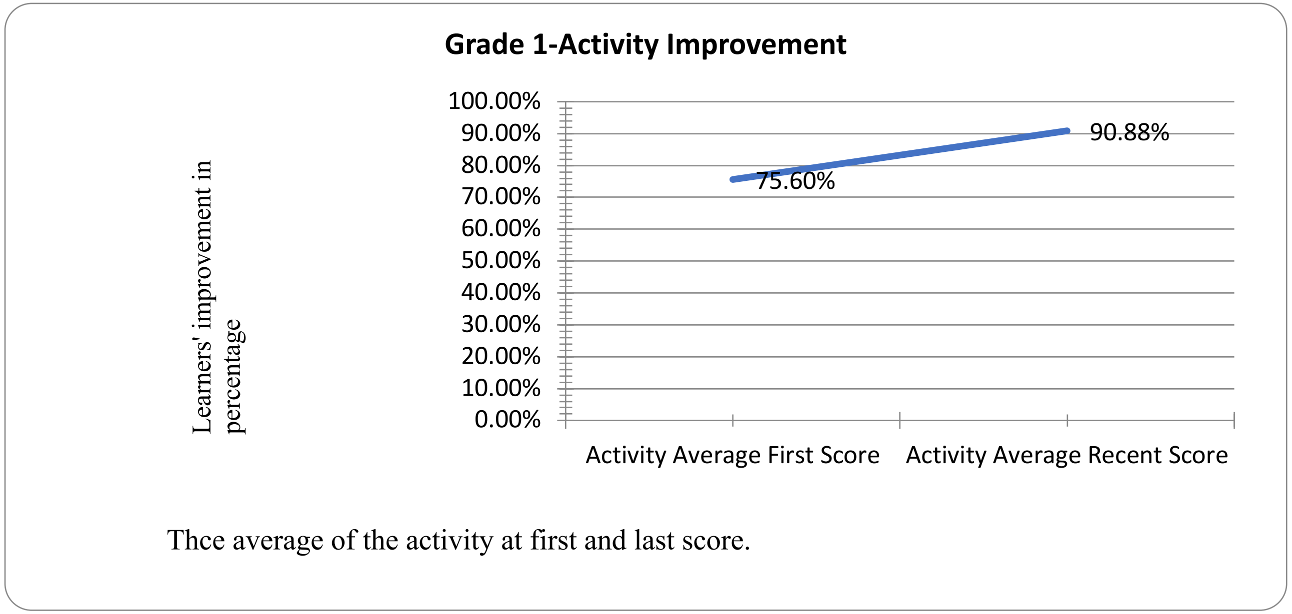


Figure 6. A line chart from MR shows that grade 1 learners improved their score average by about 15.30%.

Student Name	Group Name	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C2	1A	Related Facts 1	3	80	100	20%	100	17/11/2015 -11:40:35
C4	1A	Adding In Any Order	3	90	100	10%	100	04/11/2015 -09:50:49

Figure 7a: A sample from some leaners (e.g. learner C2, learner C4 in MR) engagement with some activities and had multiple attempted at math class to improve their final score.

Student Name	Group Name	Activity	Attempts	First Score	Recent Score	Improvement	High Score	Recent Attempt
C1	1A	Make Big Numbers Count	7	60	90	30%	90	19/12/2015 -16:48:12
C2	1A	Picture Graphs: Who has the	2	90	100	10%	100	15/11/2015 -16:09:04
C3	1A	Addictive Addition	2	60	90	30%	90	01/12/2015 -18:03:38
C5	1A	Compare Numbers to 100	3	40	90	50%	90	14/11/2015 - 16:47:39

Figure 7b: A sample from some leaners (e.g. learner C1, learner C2, learner C3 and learner C5 in MR) engagement with some activities and had multiple attempted at home to improve their final score.

12.	Learner disengaging with group to work alone on solving maths activity.	Not in this group		Learner disengages with group discussion/ collaboration to work alone during maths practice activities.	Disengaged in collaboration.
13.	Learner strive to collect points, Certificate, or any game elements. Learners continually check the final score (feedback).	The other groups were enjoying playing and show each other the points.	G1S4	Learners motivated by game elements, including rewards and feedback.	Motivation generated from game elements.
		they showed each other how many points they had collected since they start playing the games.	G1S8		
		They were so excited to see new points added to their account. Before they have been informed about the activity’s name, three pupils requested their bronze certificate earned through work the previous week. The researcher had the certificates ready and gave them to the teacher, so she could give it to the pupils. The teacher was playful in letting the pupils know about the certificates, indicating she had a ‘surprise’ for some pupils. The three awardees excitedly stood up and waited for the teacher’s surprise. The teacher asked: “guess who got a certificate from the game today?”. All were so excited to know who the winner is. The teacher called the girls’ names and asked each to come in front of the class and the pupils clapped for her. The pupils were so happy. They took the certificate and put it on their desks. Their friends were so excited to see the certificate and asked when they would be ready to also receive a certificate.	G1S15		

I have 20 points that I collected right now without any help but I do not have any certificate. If I cannot collect points 1000 points, I will feel sad.	C1
I have 100 points and three certificates. I can collect them without help. If I can collect more points, I feel sad.	C3
(the learner could not read the number of points, she had 330 points), I have two certificates. So, if I could not collect points I will feel worry because I will not have a certificate.	C4
I don't know how many points I have (she has 500 points) but I have one certificate. So, if I could not collect more points. I feel sad.	C5
Yesterday I had six here, and another six her and zero (660 points) and know I have nine here and nine here and zero (990 she collected 330 points). I have only one certificate. If I could not collect points, I will feel sad.	C6

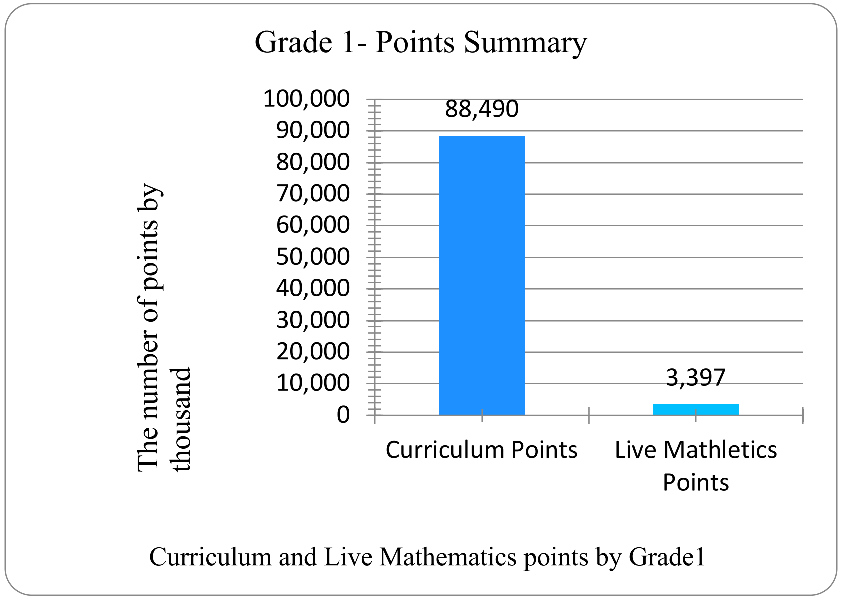
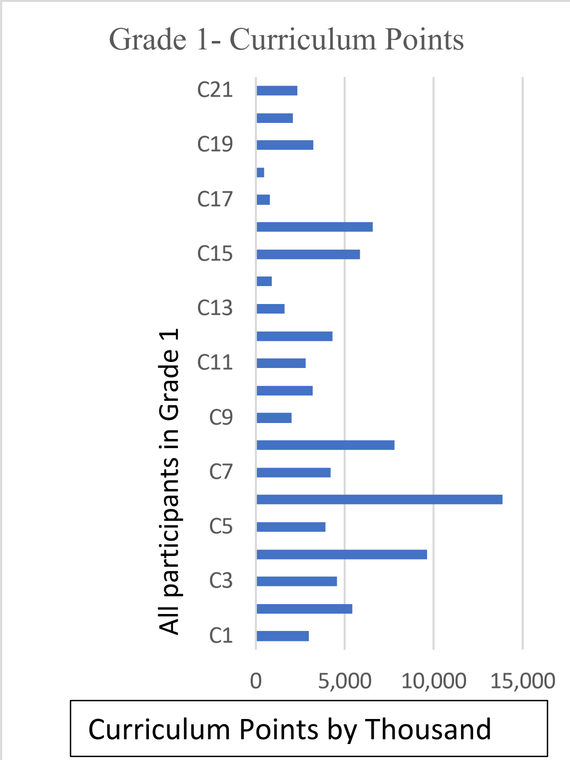
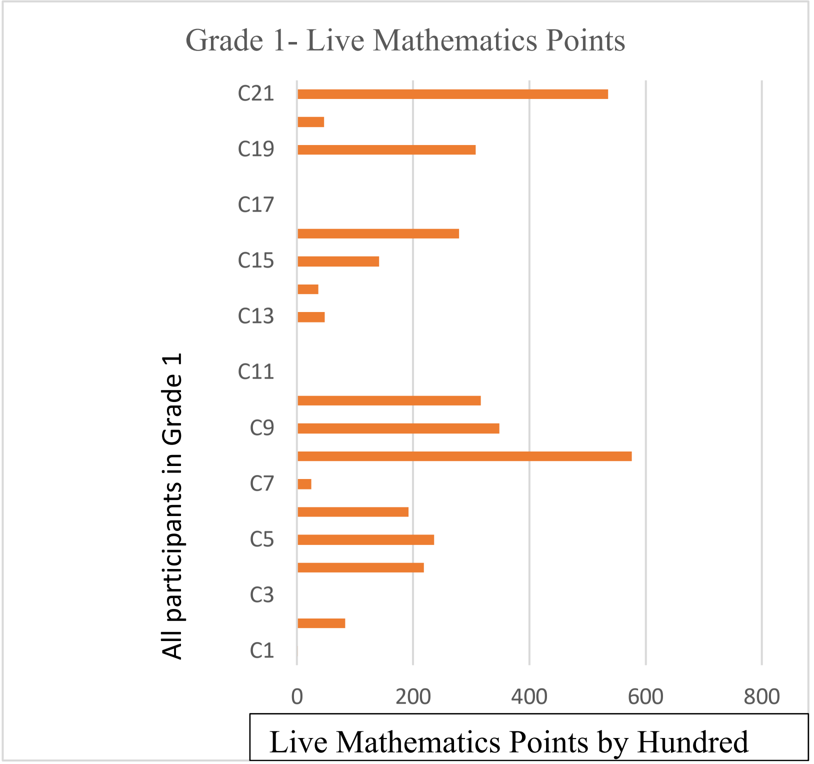


Figure 8: A bar chart from MR about the earned points from curriculum and Live Math by the learners in Grade 1.

The chart shows that the learners collected around 88,500 points from the curriculum and only 3,400 points from playing ‘Live Mathematics’.


Grade 1- Curriculum Points
All participants in Grade 1
C21
C19
C17
C15
C13
C11
C9
C7
C5
C3
C1
0
5,000
10,000
15,000
Curriculum Points by Thousand


Grade 1- Live Mathematics Points
All participants in Grade 1
C21
C19
C17
C15
C13
C11
C9
C7
C5
C3
C1
0
200
400
600
800
Live Mathematics Points by Hundred

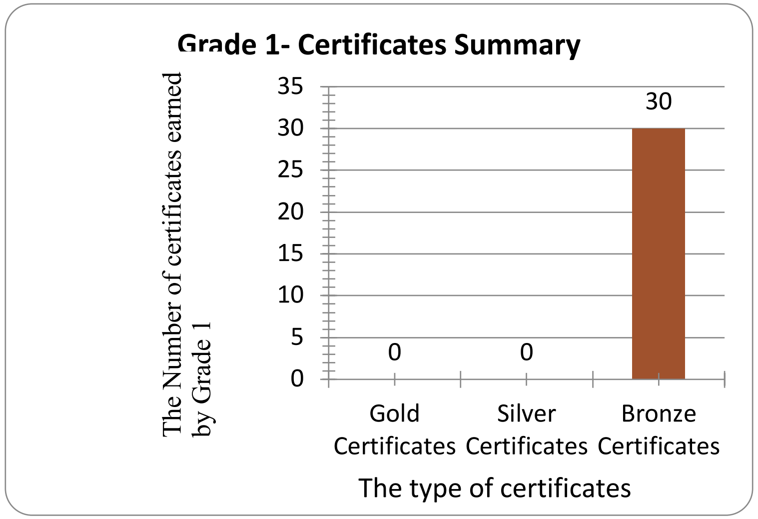
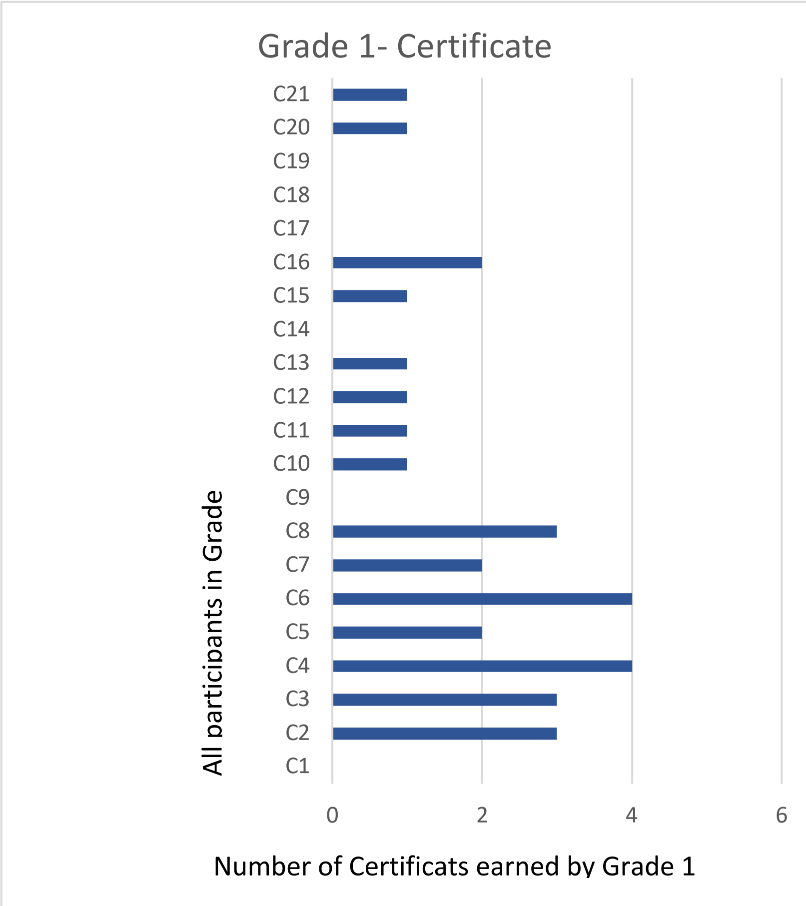


Figure 9: A bar chart from MR about the earned certificates by the learners in Grade 1

The Figure shows that a total of 30 Bronze certificates were earned by the learners in this grade.



14.	Learner has difficulty understanding the notion of '1000' points (G1), Expressing Disappointed from Missing Some Points.	When they finish the activity, they asked the teacher if it is the time to have the certificate? Who has the most points? The pupil who finished first ran to the teacher and showed her their final score and asked if they are ready to have the certificate?	G1S4 G1S8	Learners lacking the mental capacity to understand large numbers (such as 1000) at this grade level [Recommendation for change to game design to address this – perhaps change to 100 points for example]	Game design issues.

	It is the first day of the week, so the pupils have no points collected on Mathletics. Pupils express frustration about points not counting from the previous week's work, and continually ask when they will have a chance to get the certificate. A group of three pupils went to the teacher and asked who has more points? And who will get the certificate first? When the learner was asked about the points the she collected so far, she could not read the number of points, so she showed the researcher to read the numbers. She could not read the number of points She could not read the number of points	G1S15 C2 C4 C6		
15. Learner request assistance from teacher	One of the learners went to the teacher and asked her to help to read the question.	G1S4	Teacher- assisted learning	
16. Learners not reading the textual question	One of the learners went to the teacher and asked her to help to read the question. The teacher encouraged her to try. The leaner then ignored the textual question and started to do the activity. She back to her own seat and do the activity.	G1S4	Learner preference for visual information/ Possible issue in framing of question.	Game design issues.
17. Learners choose to remain playing at First level in 'live math' to score more points. (G2/G3)	Not in grade 1		Learners' disposition to focus on the 'win' rather than the 'learning value'	Game design issues.
Category 4: Pedagogy of Practice in in Mathletics Practice activities				
Teacher moves around the groups to check on individual/ group progress, but mainly leaves learners to self-direct learning.	The teacher was correcting the students' book and then she moved around to check on their work in the platform. The teacher was moving around to check in their work The teacher moved around to see how they were performing and to offer help to anyone who might have a difficulty, but the pupils didn't avail of her assistance and indicated they were fine, happy and enjoying the activities. The teacher opinion was that she likes the game and she said there is no one get bored when they are doing the activity by the	G1S4 G1S8 G1S15 T1	Teacher facilitates a high degree of self-directed/ independent learning	

platform. She posted the certificates on her website to motivate other girls and their families to play the game. she said that the games help them to be more active in math class.

General Information about the teacher.

Teacher 1 [T1] has six years experience teaching at primary and elementary level, and she was in her first year of teaching at this school during the period of study. Her primary subject degree is in the English language. The teacher indicated that she had never undertaken professional development in ICT but considered herself to have an advanced level of knowledge of technology integration in education.

Section D.2: Length and frequency of engagement within Mathletics sessions - 6 learner case studies

Grade	1 (aged 6-7)		2 (aged 7-8)		3 (aged 8-9)	
Learner	Learner A	Learner B	Learner A	Learner B	Learner A	Learner B
Number of Mathletics Sessions (time-range)	4 (7-17mins)	3 (8- 13min)	3 (8- 20min)	4 (8- 20min)	4(6- 20min)	3(6- 20min)
Total No of Questions Sampled	*14* questions	*8* questions	*9* questions	*10* questions	11 questions	7 questions
Session 1: Theme Topic (Duration)	*Related facts* *(5mins)*	*Adding in Any Order* *(6:50mins)*	*Odd or Even* ***and*** *Place Value1* *(5mins and 5:30mins)*	*Fact Families: Add and Subtract* *(9mins)*	Group of Three (6:30mins).	Group of Three (3:30mins).
No. of Questions Answered	*10 (within one activity)*	*10 (within one activity)*	*10 (within each activity)*	*10 (within one activity)*	*7 (within one activity)*	*10 (within one activity)*
Number of Questions Sampled for Research	*2* *[Q1/Q2]*	*2* *[Q1/Q2]*	*2 from activity 1* *[Q1/Q5]* *2 from activity 2* *[Q1/Q2]*	*2* *[Q1/Q6]*	2 *[Q1/Q3]*	*2* *[Q1/Q6]*
Session 2: Theme/ Topic (Duration)	*Missing Numbers* *(5mins)*	*Related facts* *(7:53mins)*	*Number Line Order* *(11mins)*	*Counting by 2s, 5, and 10s* *(6mins)*	Group of Six **and** Array2 *(12mins* ***and*** *6mins)*	Array 1 *(10mins)*
No. of Questions Answered	*10 (within one activity)*	*10 (within one activity)*	*10 (within one activity)*	*10 (within one activity)*	*10 (within each activity)*	*10 (within one activity)*
Number of Questions Sampled for Research	*4* *[Q1/Q2/Q4/Q6]*	*2* *[Q1/Q9]*	*2* *[Q1/Q8]*	*2* *[Q1/Q3]*	*2 from activity 1* *[Q1/Q4]* *2 from activity 2* *[Q1/Q5]*	*2* *[Q1/Q3]*
Session 3: Theme/ Topic (Duration)	*Doubles and halves to 20* ***and*** *Who has the Goods?* *(5mins)* ***and*** *(3mins)*	*Doubles and Nearest to Double* ***and*** *Sort it* *(5:40mins)* ***and*** *(3:14mins)*	*Counting by 2s, 5, and 10s* *(8mins)*	*Place Value 1* *(2mins)*	Array 1 *(10mins)*	Multiplication to 5×5. *(11mins)*
No. of Questions Answered	*10 (within activity 1)* *10 (within activity 2)*	*10 (within activity 1)* *10 (within activity 2)*	*10 (within one activity)*	*10 (within activity 1)*	*10 (within one activity)*	*10 (within one activity)*
Number of Questions Sampled for Research	*4 Qs from activity 1* *[Q1/Q2/Q3/Q6]* *2 Qs from Activity 2* *[Q1/Q3]*	*2 Qs from activity 1* *[Q1/Q6]* *2 Q from activity 2* *[Q1, Q2]*	*3* *[Q1/Q5/Q6]*	*2* *[Q1/Q9]*	*3* *[Q1/Q2/Q3]*	*3* *[Q1/Q2/Q6]*
Session 4: Theme/ Topic (Duration)	*Collect Simple Shapes* *(4mins)*			*Repartition Two-digit Numbers* *(10mins)*	Multiplication arrays *(12mins)*	
No. of Questions Answered in the session	*10 (within one activity)*			*10 (within one activity)*	*10 (within one activity)*	
Number of Questions Sampled for Research	*2* *[Q1/Q5]*			*4* *[Q1/Q2/Q3 /Q6]*	*2* *[Q1/Q4]*	

Section D.3: Sample Analysis from Eye-tracking Data from Case Studies

A number of templates had to be constructed to capture what the visual data was contributing in terms of this research study. The example below of Grade 1, Case 1, Learner A shows one such screen, and its accompanying templates. The "Related Facts 1" activity is under Operations and Algebraic Thinking, consists of 10 different questions, of which a sample of 4 questions would have been studies by the research in depth, guided by three templates as follows. The first review would have explored the aesthetic and pedagogic layout of the interface, as shown on Figure 1, and recorded it in Template A. The second template would have reviewed the movement displayed in Figure 2 and recorded this movement within Template B. The final template was the Coding Matrix (Template C) and this matrix brought together findings from the review of the eye-tracking data-sets with data gleaned in interactive observations when researcher present with individual learners using Mathletics.

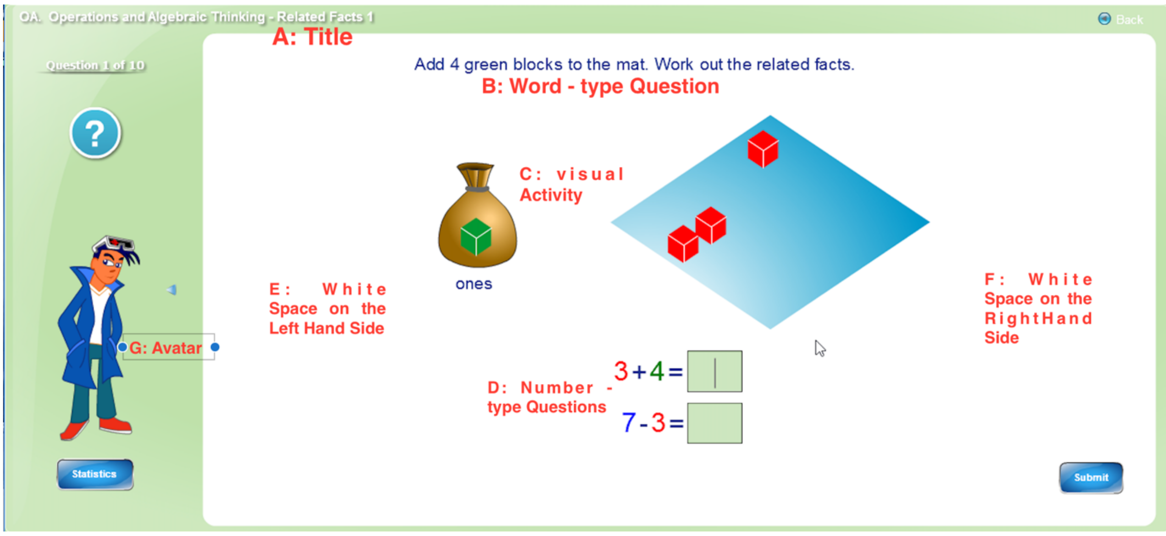


Figure 1: Screenshot of the initial screen of related facts 1 activity.

Template A: Pedagogic Design of Adding in Related Facts 1 activity Interface

Pedagogic Design of Interface	Please tick:		If yes, please describe in detail.
	YES	NO	
Title: Is there a Section Title visible on-screen?	√		The title is written in the top left-hand corner of the screen: 'Related Facts 1' (Fig. 2, A).
Question Type: Is the question offered in 'Word' form with Visual Scaffold?	√		The question is written in word form (Fig. 2, B), as well as being given as a visual activity (Fig. 2, C) and being written in a number form (Fig. 2, D).
Question Type: Is the question offered in 'Word' form <u>without Visual Scaffold</u>?		√	
Question Type: Is the question offered in 'Number' form with Visual Scaffold?	√		Yes, the question is framed into three types of questions: textual question, visual activity and numeric question.
Question Type: Is the question offered in 'Number' form <u>without Visual Scaffold</u>?		√	
Question Type: Is the question offered in Visual form only (<u>with no Word form or Number form</u> on-screen)?		√	

Is the level of English used is too difficult for target age-group?	√		The English used may not be easy to understand for students who have difficulty reading at this level.
Is there just one question visible on-screen?		√	
Are there two questions are visible on-screen?	√		There are two number-type questions for the student to work on, both of which use the same visual activity.
Aesthetic Design Feature of Interface	Please tick:		If yes, please describe in detail.
	YES	NO	
Has White space been provided on screen?	√		There are two white spaces (on the left and the right sides of the activity).
Is there a Guide-Avatar (or other prompts) visible on side of screen?	√		There is an avatar on the left-hand side. Underneath, there is a 'Statistics' icon, which presents some information about the avatar. Above the avatar, there is a 'hint' icon (in the form of a question mark).
Is Colour used to differentiate between objects on-screen?	√		The cubes are presented in two different colours, and each colour refers to a particular number (e.g. the red cube refers to the number 3).
Is there any unusual positioning of objects on-screen that are liable to cause confusion?		√	
Are there opportunities for learners to interact on-screen (for example: to click & drag objects)?	√		The student can click on the green cubes in the bag in order to drop the required number on the mat. The answers should then be typed into the answer boxes.

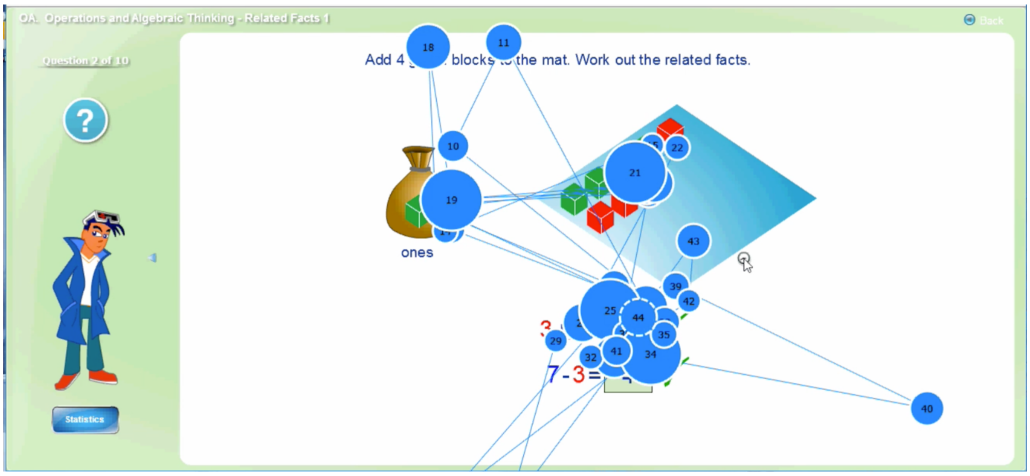


Figure 2: screenshot of the learner's eyes back to the second answer box (Plots 1- 41).

Figure 3: The screenshot of the heat map for the first example shows that the student was more focused on the numerical question and the visual activity.

Template B. The student interaction on-screen with the second activity

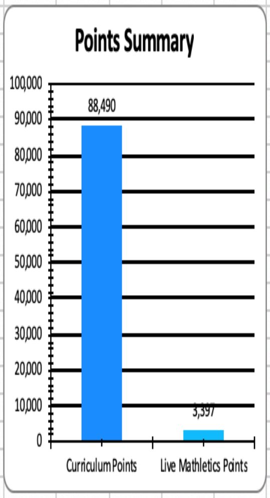
User Interaction On-screen		Please be very specific in your response to each of these questions. **Write full sentences** (not phrases).
Point of entry: Where does the learner's eye first land on the screen?		The student was looking at the mat with shorter fixation duration (Fig. 4).
Pathway of eye: Where does the learner's eye travel to next on-screen, and next, and so on, from the beginning to the end of the activity? You need to be specific about the places where the learner stopped or spent time before moving on by referring to landing sites on-screen (i.e. landing on words within word questions, number questions, or visual objects, etc.) Please note where the speed of the Internet slowed or a connection problem occurred, as this may account for some of the time learners spent 'drifting in white space' (recorded by eye-tracking) in Mathletics.		She then scanned the mat, the bag and the first numbers row and she looked at the question key word with longer fixation duration much later. (Fig. 5). The student then looked at the bag with longer fixation duration and dropped 4 cubes on the mat. She had longer fixation duration on the first answer box (Fig. 6) and then looked down of the screen (Fig. 7). Then she looked back to first number in the first row with short fixation duration (Fig. 8). The student had longer fixation duration on the first answer box and looked off the screen (Fig. 9). The gaze plots (fig. 10) indicated that the student did not fixate at the mat again to get the second answer. She was more concentrate in the second row numbers with longer fixation duration. Her eyes moved back to the second row.
Delay: Did the learner's eye drift for a period of time in 'white-space' on any part of the screen?		The student did not fixate on the white spaces at any time
Off-screen activity: If the learner's eye moves off-screen, please write down when this happened, how often it happened, how long they were off-screen, and where they re-entered the screen.		The student looked out the screen that after reviewing the answer box and back to the answer boxes .
On-screen answer: Did the learner insert the right or wrong answer to the question/s? Describe where the learner's eye moved after inserting a wrong answer.		The student got the correct answers.
No activity: Were there parts of the screen that the eye never travelled to, or objects or question types that the learner did not look at? Describe this in detail.		The gaze pattern show that the student did not look at the white spaces, the avatar, statistic icon, help icon. and the word question "except the key-word".
Interactivity: Did the learner interact with a click and drag activity or another type of interactive feature? Explain.		To answer the question, the student has to drop numbers of the cubes on the mat and then type the answer in the answer boxes.
Guide/avatar: Did the learner click on the avatar for assistance at any time? Explain.		The whole recording did not show any clicking on that avatar.
Personal question preference: Explain, did the learner show a preference for one type of question form over another type, such as word questions rather than number questions?		She spent 27 seconds in this activity. The heat map (Fig. 11) indicated that the student was more concentrated on the visual activity and the numbers rather than the word question.
Internet quality: Were there times when the learner was delayed waiting for the screen to become visible (slowness of Internet). Explain where the eye 'rested' on-screen during this time.		No disruption so not applicable
Confusion: Did you observe any activity that might indicate that the learner was confused on-screen?		No confusion so not applicable.
Other interesting observations about on-screen eye-movement or activity:		

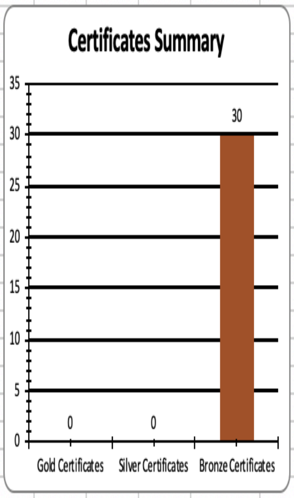
Template C: Coding Processing Template

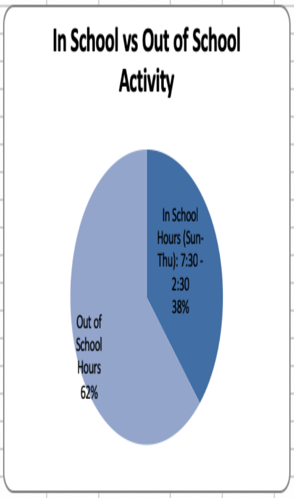
User Interaction On-screen	First Cycle of Coding	Theme/ Category
Point of entry: The eye tracking data clearly shows that the eye first landed on the graphical objects. There was no additional information drawn from interviews or observations to explain why this occurred.	Entry-landing point on graphical objects	Entry-landing points.
Pathway of eye: The student then looked at the bag with longer fixation duration and dropped a number of cubes on the mat. She had longer fixation duration on the first answer box. She answered the first question by holding the red number in her head (as expressed out loud by pupil) and used the cubes. She then looked down off the screen to use the key-board. The gaze plots indicated that the student did not fixate at the mat again to get the second answer. She was more concentrated in the second row numbers with longer fixation duration. Her eyes moved back to the second row. She held the red number in her head and counting on from there by fingers only while her eyes were on the screen. She then fixated at the second answer box and moved down the screen to look at the key-board to type and submit the answer.	Problem solving strategy -Fixation on the graphical objects. Problem solving strategy – using mental approach and visual support. Problem solving strategy – mental approach and physical use of fingers to count.	Problem- solving strategies
Delay: No drift in this case.		
Off-screen activity: She moved off-screen, and as explained above, to use keyboard.	Off- screen activity (using key-board).	
On-screen answer: The student has ability to answer all the question correctly. She was happy when she saw the feedback from game and so excited to know the next question. Her observed reaction was that she loudly declared: "I can get it and complete by myself". The pupil also said that after she submitted the final answer and was waiting for the next question to appear on the screen, she wished that the next question would be more challenging, as this wanted to ascertain her true abilities (internally	Performance of learner was very good in this set of questions. Identifies feedback as a motivation factor in game-play Expressing Enjoyment in game-play	Academic Performance Very Good Motivational Factors (pedagogic) in game-play. Positive emotions during game-play

competitive). This acted as a motivator for her to continue to complete mathematics problems. [It appears that when the game design is straightforward and intuitive, then learner seeks a higher degree of challenge within mathematics problems.]	Identifies challenging as a motivation factor in game-play	Motivational Factors (pedagogic) in game-play..
No activity: The whole recording shows that the student did not fixate on the word question except the key word. In addition, it appears that the student did not look at the white spaces on the left and right hand sides. In this activity, the student did not look at the avatar	**Redundancy in the design of interface in the provision of multiple representations of same question** **No use of help facility – Avatar/ Hint**	**Over-design**
Interactivity: Too many different ways to answer this question, the learner can work with the numeric question only and used mental approach or fingers to find the final answer. She also can use visual activity and drop the number of cubs on the mat and drop them back to the bag (with or without using mental math approach and fingers). But the pupil usually, looked at the key- word in the question and then moved to the visual activity. She dropped the numbers of cubes on the mat and answered the first question. She then mentally or used fingers to get the second answer instead of drooping cubs. The student explained that she has the ability to work with easy numbers to add and subtract mentally but with hard number would always need to use the graphic shapes and fingers in counting numbers.	Problem solving strategy – mental approach.	Problem solving strategy
Guide/avatar: The pupil never used/ accessed the avatar, the statistic icon, nor clicked on them to see what they had to offer in terms of help or guidance. When the pupil was asked about this, she said that she didn't like the avatar character -isn't appear to be interest.	Non-use by the learner of the avatar, statistics icon.	Redundancy in the provision of avatar and related statistics as motivational features in aesthetic design.
Personal question preference: She was able to work with easy numeric equation without using the graphical props (cubes). The student explained that she dropped the cubes onto the mat, as she thought the game activity would not accept her answer without positioning them.	Strategic form of thinking/ strategic action	Strategic thinking
Internet quality: No disruption so not applicable		
Confusion: No confusion so not applicable.	Indicative of an Intuitive interface design of this set of Mathletics exercises	Positive aesthetic design
Other interesting observations about on-screen eye-movement or activity:		

Section D.4: Sample of Mathletics Report



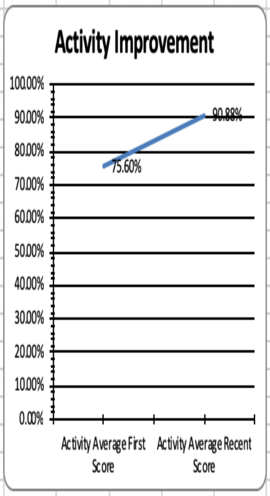




Participation & Points Summary	
Curriculum Points	88,490
Live Mathletics Points	3,397

Certificates Summary	
Gold Certificates	0
Silver Certificates	0
Bronze Certificates	30

In School vs Out of School Activity	
In School Hours (Sun-Thu): 7:30 -2:30	380
Out of School Hours	627



Average Time Online Per Student	
Average Per Student	3h 27m
Total Time Online	72h 32m

Average Completed Activities Per Student	
Average Per Student	46
Total Completed Activities	1,007

Activity Improvement	
Activity Average First Score	75.60%
Activity Average Recent Score	90.88%
Activity Average Improvement	15.28%

Appendix E: Phase 2: Data Collection Tools

Section E1: Interviews.

Control Group Teacher Interview Form.

Sample Teachers Interview Form

Teacher:	Date:	Age:
School:	Class level:	

- How long have you been teaching?
- Is mathematics a core subject in your primary degree? If not, what is your core subject?
- What is the grade level that most closely matches to your position?
- How long have you been working as a teacher at this school?
- What is your level of technology skills/ literacy? [Basic/ Advanced/ Expert]
- Have you taken continuing professional development courses in technology? If yes, please describe when, where and content of technology course?
- How do you integrate technology in your classroom?
- What types of technology do you regularly use in the classroom?
- Why do you use technology with your pupils?
- How frequently do you use the online mathematics games in-class?
- How do you integrate the online mathematics games within a standard class?
- Do you ask your pupils to use the online mathematics game/s at home? Why/ Why not?
- What are the benefits and/ or limitations of using online gamified learning activities in mathematics education in your class?

Mathletics Group Teacher Interview.

Sample Teachers Interview Form		
Teacher:	Date:	**Age:**
School:	Class level:	

- How long have you been teaching?
- Is mathematics a core subject in your primary degree? If not, what is your core subject?
- What is the grade level that most closely matches to your position?
- How long have you been working as a teacher at this school?
- What is your level of technology skills/ literacy? [Basic/ Advanced/ Expert]
- Have you taken continuing professional development courses in technology? If yes, please describe when, where and content of technology course?
- How do you integrate technology in your classroom?
- What types of technology do you regularly use in the classroom?
- Why do you use technology with your pupils?
- How frequently do you use the online mathematics games in-class?
- How do you integrate the online mathematics games within a standard class?
- Do you ask your pupils to use the online mathematics game/s at home? Why/ Why not?
- Has any pupil ever asked you for help in using the online mathematics game/s? Please explain.
- What are the benefits and/ or limitations of using online gamified learning activities in mathematics education in your class?
- How did you see the integration of online gamified learning (Mathletics) in classroom setting?
- From your point of view how can we integrate online gamified learning in classroom setting? Explain.
- From your point of view, can this technology replace the teacher? Explain.

Control Group - Learner Interview.

Sample Control Group Interview Form		
Pupil:	Date:	Age:
School:	Class level:	

- How much do you enjoy maths?
- What particularly do you like? What do you dislike?
- What would you like your teacher to do when you are learning maths? Explain.
-

Mathletics Group - Learner Interview.

Sample Mathletics Group Interview Form

Pupil:	Date:	Age:
School:	Class level:	

- *How do you spend your free time at home?*
- *What toy do you like to play with?*
- *What device (X-Box/ Play-station/ Tablet) do you like to play on at home?*

- Do you play Mathletics at school?
    - If yes, what aspects do you enjoy/ not enjoy it?
    - How many points did you collect?
    - Have you ever asked anyone to help you to collect points, if you could not collect them yourself?
    - Did you receive any certificate from online game/s? If yes, what type of certificate did you collect?
    - How much credit have you earned so far from playing online mathematics games in-school?
    - Do you play with your friend/s online today? Do you enjoy it? Explain

- How would you feel if you didn't collect points from online gaming in this week?
- Did you ever see your name on the leaderboard/s?
- How did you feel about seeing/ not seeing your name on the leaderboard/s?
- What did you like most/ least when playing the online game today?
- Do you play online mathematics game/s at home? If yes,
- Does anyone ever help you when you are playing at home?

In Phase 2, these questions were added:
- Do you think you need a teacher to be present when learning maths? Explain
- What have you found most difficult?
- What would you like your teacher to do when you are learning maths? Explain.
- Do you think you could learn maths without a teacher (from a game like Mathletics for example)? Explain.

Parent Interview Form.

Sample Parent Interview Form

Parent:	Date:
Class level:	**Gender:**

- Does your daughter play Mathletics at home? Explain.
- Did she enjoy it? If so, explain.
- What motivates her to continue playing the game?
- Did your daughter talk with her siblings about Mathletics?
- Did she do her homework before engaging in Mathletics?
- How do you feel about your daughter using Mathletics?

Section E2: Observation

Here is a sample of class observation for Grade 2 Control Group.

Date 04/04/2016	Grade: Grade 2 Control Group
Day: Monday	Time: 07:30- 8:15
Topic: Non- Standard Unit	Session: 1

The teacher starts the lesson by distributing small cubes to the students, so it helps them to understand. And she let them measure the length of their stuff by using the cubes and writing down the results. She gave them 5 minutes to do this. The girls moved around to find some things to measure. The first few minutes the girls were seriously using the cubes for measuring. After a while some of them start playing by the cubes, loudly talking and moving around. The teacher warned them to be quiet and go back to their places. The students went back to their sets and teacher moved around to see the results which they recorded and how many things they could measure in 5 minutes. She chose one of the learners to read the preparation from the book out loud. She used the white board and drew some shapes and used the cube to measure the length. She asked if they used the same way to measure. They interrupted her by giving some of the results which they got and showed her how they measured. Some students re-measured their thing, While, other played with the cubes. The teacher decides to stop explaining to get their attention. She asked one of the learners to come over the board and use the cubes to measure one of the shapes - she started to do the activities. and asked them to open the student textbook – she further asked one of the learners to read the first question out loud. Then she gave them a chance to work in their groups to finds the answers for all the questions. She then chose one learner from each group to come over the board and write the answers. She then asked them to type the answer in their books and whoever finished first were allowed to start doing workbook activity. The students were so noisy - they talked out loud. Some were helping each other to find the answer, other were talking generally about other things.

The teacher began to walk around to make sure that everyone worked on the activities and helped those who had difficulties. The first three questions appeared to be easy for all the students as there was no one asking for help. Some of the learners worked in their group. They used the paper clips that the teacher provided to get the answers. But some other were playing with them instead of doing the activities.

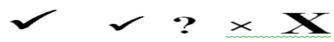
The teacher noticed that the fourth question was a little hard. She asked one learner from each group to help her friends. Some of the learners worked on the activity and others closed the book before even completing the activity. The teacher then asked the learners to drop the book on her desk to check later.

Section E.3: Mathematics Disposition Survey

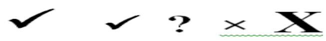
Mathematics Disposition Survey

PUPIL NAME:

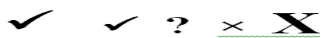
1 / Math in general:

a)	How good are you in math?	
b)	How much do you like math?	
c)	How happy or unhappy are you when you have difficulties with math?	
d)	How worried are you, when you have difficulties with math?	
e)	How confident do you feel about passing the next math test in-class?	

2 / Written maths problems (maths problems worked out on paper):

a)	How good are you at completing math problems on paper?	
b)	How happy are you doing math problems on paper?	
c)	How happy or unhappy are you when you have difficulties completing math problems on paper?	
d)	How worried are you when you have difficulties completing math problems on paper?	
e)	How satisfied do you feel when you successfully complete maths problems on paper?	

3 / Mental math (completing math tasks in your head)

a)	How good are you at completing math tasks in your head?	
b)	How much do you like completing tasks in your head?	
c)	How happy or unhappy are you when you have difficulties with completing math tasks in your head?	
d)	How worried are you when you have difficulties completing math tasks in your head?	
e)	How satisfied do you feel when you successfully complete math tasks in your head?	

4 / Easy math tasks

a)	How good are you in easy math tasks?	✔ ✓ ? × X
b)	How much do you like easy math problems?	0 ★ ★★ ★★★ ?
c)	How happy or unhappy are you when you have difficulties with easy math task?	😄 🙂 😐 🙁 😞
d)	How worried are you when you have difficulties with easy math tasks?	😞 🙁 😐 🙂 😄
e)	How satisfied do you feel when you complete easy math tasks?	😄 🙂 😐 🙁 😞

5 / Difficult math tasks

a)	How good are you in difficult math tasks?	✔ ✓ ? × X
b)	How much do you like difficult math tasks?	0 ★ ★★ ★★★ ?
c)	How happy or unhappy are you when you have difficulties in difficult math tasks?	😄 🙂 😐 🙁 😞
d)	How worried are you when you have difficulties in difficult math tasks?	😞 🙁 😐 🙂 😄
e)	How satisfied do you feel when you complete difficult math tasks?	😄 🙂 😐 🙁 😞

6 / Math homework

a)	How good are you in math homework?	✔ ✓ ? × X
b)	How much do you like math homework?	0 ★ ★★ ★★★ ?
c)	How happy or unhappy are you when you have difficulties in math homework?	😄 🙂 😐 🙁 😞
d)	How worried are you when you have difficulties with math homework?	😞 🙁 😐 🙂 😄
e)	How satisfied do you feel when you complete math homework without help?	😄 🙂 😐 🙁 😞

7 / Listening and understanding in math class

a)	How good can you listen and understand what the teacher explains in math class?	✔ ✓ ? × X
b)	How much do you like to pay attention in math class?	0 ★ ★★ ★★★ ?
c)	How happy or unhappy are you when you don't understand something in math class?	😞 🙁 😐 🙂 😄
d)	How worried are you when you don't understand something in math class?	😞 🙁 😐 🙂 😄
e)	How satisfied do you feel when you complete math work in class without help?	😄 🙂 😐 🙁 😞

Section E.4: Mathematics Performance Test.
A: Grade 2 Mathematics test activities from the Student Book.

أنشطة الرياضيات
الصف الثاني ابتدائي

اسم الطالبة: ---

1- ما هو مجموع النقود.؟

المجموع .... ريال .... ، .... ، .... ، .... ، ....

2- اكتب الوقت الظاهر تحت كل صورة:

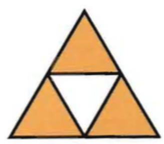
(أ)

(ب)

(ج)

3- اكتب الكسر الدال على الجزء الملون:

(أ)



....

(ب)

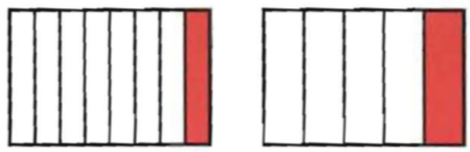
....

(ج)

....

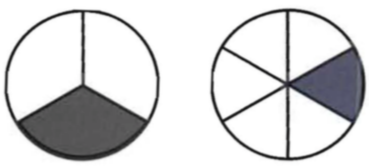
4- اكتب (اقل من <), (أكبر من >) , أو(تساوي =)

(أ)



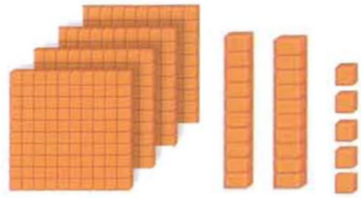
$\frac{1}{5}$ ☐ $\frac{1}{8}$

(ب)



$\frac{1}{6}$ ☐ $\frac{1}{3}$

5- اكتب المجموع في الخانة المخصصة:



مئات	عشرات	آحاد

6- اجمع الأرقام التالية:

1- 5 + 50 +500 = ...

2- 7 + 90 +200 = ...

7- احوط القيمة المنزلية للرقم الذي تحته خط

1) 911

900 90 9

2) 816

6 60 600

8- اكتب العدد بالرقم :

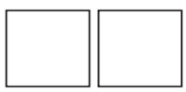
تسع مائة واثنان وسبعون

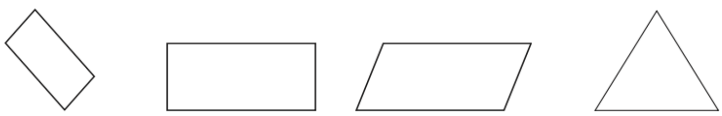
....

9- اكتب اسم الشكل واحوط الشيء الذي له الشكل نفسه:

....

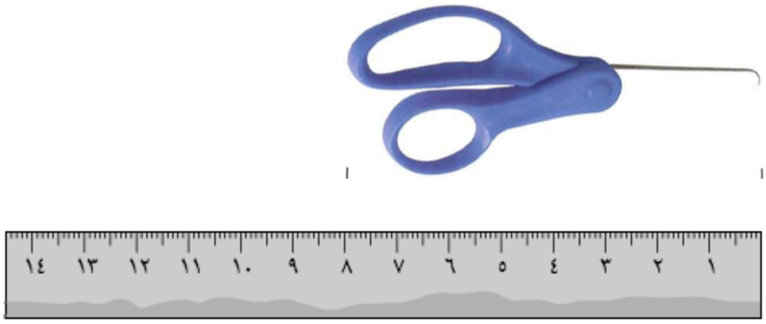
10- ما هو الشكل الذي يمكن عمله من هذان المربعان:





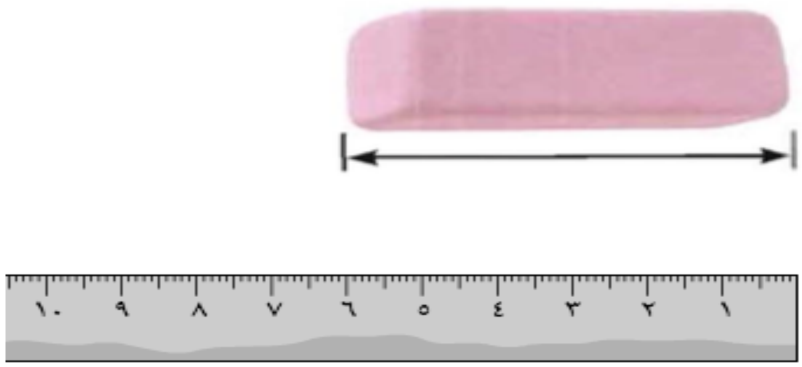
(د) (ج) (ب) (أ)

11-استخدم المسطرة الموجودة تحت الشكل لقياسه, ما هو طول المقص؟



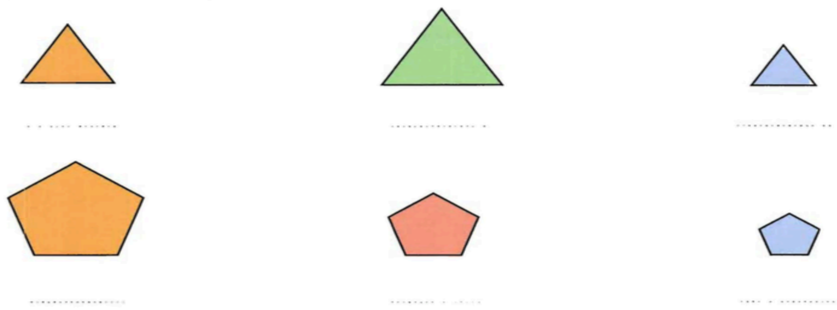
4   6   8   10

12- كم طول الممحاة بالسنتيميتر. **11-**



6   7   14   17

13-ارتب الاشكال حسب مساحتها من الأكبر الى الأصغر (اكتب 3,2,1)



14-اكمل التالي:

300 +300 = ...

600 + 400= ....

(c)
332
549 +

(d)
773
559 -

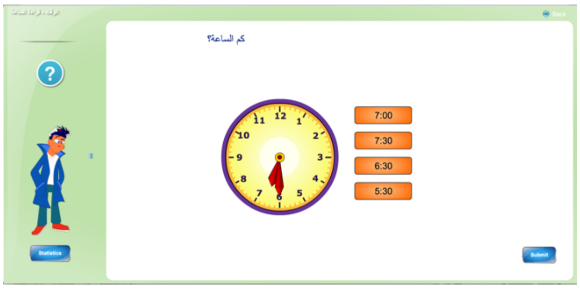
(e)
476
231 +

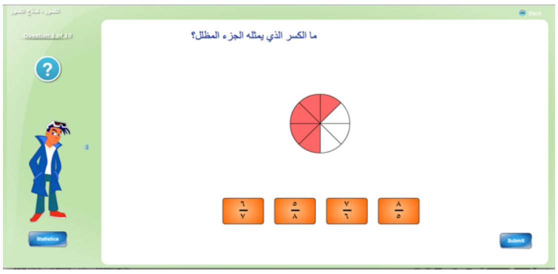
(f)
446
171 -

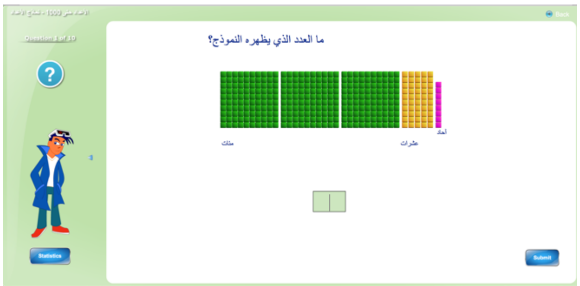
15-اقرب العدد ثم اجمع:

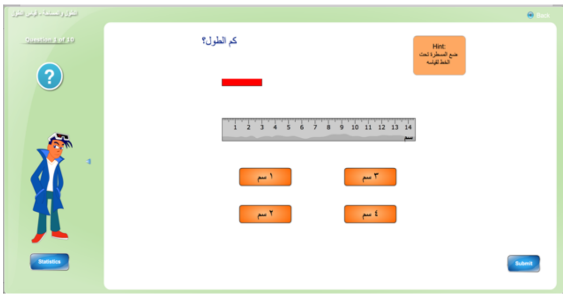
العدد	الى اقرب عشرة	الى اقرب مئة
5 7 3 1 4 6 +	………… ………… +	………… ………… +
6 2 8 2 2 4 -	………… ………… -	………… ………… -

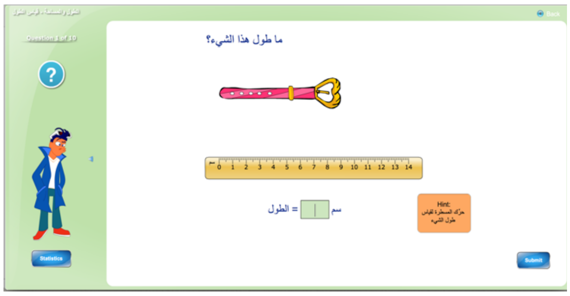
Mathematics activities from Mathletics Platform for Grade 2 learners.

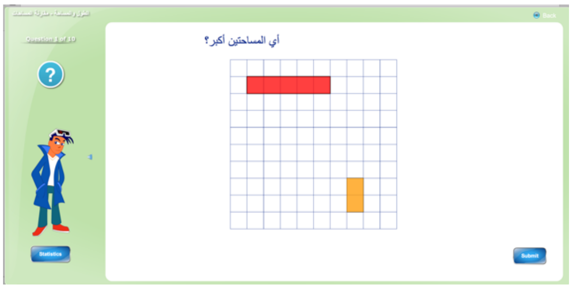


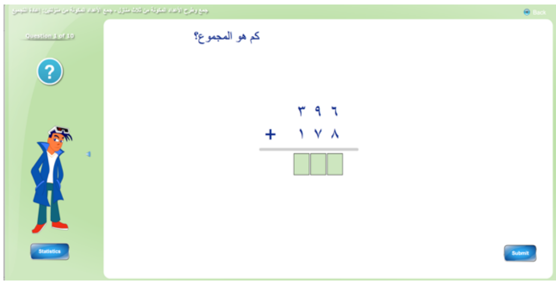


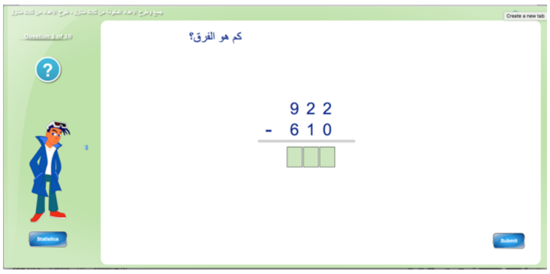


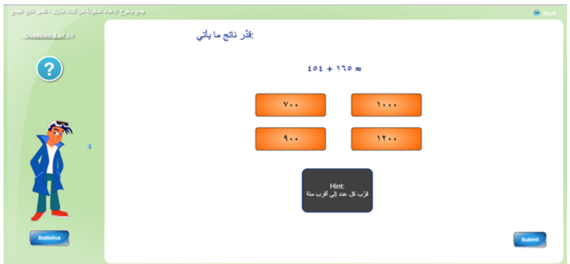

Question 1 of 10
كم الطول؟
Hint:
ضع المسطرة تحت الخط لقياسه
1 2 3 4 5 6 7 8 9 10 11 12 13 14
سم
١ سم
٣ سم
٢ سم
٤ سم
Statistics
Submit


Question 1 of 10
ما طول هذا الشيء؟
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
الطول = سم
Hint:
حرّك المسطرة لقياس طول الشيء
Statistics
Submit


أي المساحتين أكبر؟
Statistics
Submit


كم هو المجموع؟
٣ ٩ ٦
+ ١ ٧ ٨
Statistics
Submit


كم هو الفرق؟
9 2 2
- 6 1 0
Statistics
Submit


Question 1 of 10
قدّر ناتج ما يأتي:
٤٥٤ + ١٦٥ ≈
٧٠٠
١٠٠٠
٩٠٠
١٢٠٠
Hint:
قرّب كل عدد إلى أقرب مئة
Statistics
Submit

Grade 3 Mathematics test activities from the Student Book.

أنشطة الرياضيات

اسم الطالبة: --

١ـ اوجد الناتج:

١٦ ÷ ٢ =　　　　٢٤ ÷ ٨ =

٢ـ

حَضَرَ ٤٨ طَالِبًا لِمُشَاهدةِ بَرْنامجٍ عِلْمِيٍّ، إِذَا جَلَسَ كُلُّ ٨ طُلَّابٍ فِي صَفٍّ، فَمَا عَدَدُ الصُّفُوفِ الَّتِي شَغَلُوهَا؟

أَكْتُبُ جُملةً عَدَدِيَّةً تُبيِّنُ الحَلَّ.

٣ـ

لَدَى هِنْدٍ ٣٥ قَلَمَ تَلْوِينٍ، وتُرِيدُ حِفْظَهَا فِي عُلَبٍ تَتَّسِعُ كُلٌّ مِنْها لِـ٥ أَقْلَامٍ، فَكَمْ عُلْبَةً تَحْتَاجُ لِحِفْظِ الأَقْلَامِ جَمِيعِهَا؟

أ) ١　　　جـ) ٧

ب) ٥　　　د) ٨

٤ـ

أَخْتَارُ الْوَحْدَةَ الأَنْسَبَ (الْمِلِّمِتْرَ، السَّنْتِمِترَ، المتْرَ، الكِيلُومِتْرَ)؛ لِقِيَاسِ كُلٍّ مِنَ الأَطْوَالِ الآتِيَةِ: (الدرس ٨-١)

١ المَسَافَةِ الْمَقْطُوعَةِ بِالسَّيَّارَةِ.

٢ طُولِ بَاصِ المَدْرَسَةِ.

٥ـاجد محيط الشكل التالي:

٦ـ

أَجِدُ مِسَاحَةَ سَجَّادَةٍ طُولُهَا ٦ أَمْتَارٍ وعَرْضُهَا ٥ أَمْتَارٍ؟ (الدرس ٨-٤)

٧-

أَخْتَارُ الإِجَابَةَ الصَّحِيحَةَ :

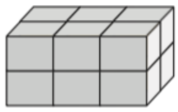
❶ أَخْتَارُ الْوَحْدَةَ الأَنْسَبَ لِقِيَاسِ سَعَةِ الكُوبِ المُجاوِرِ.

أ) ١٠ مل   جـ) ٢ ل

ب) ١٠٠ مل   د) ٥ ل

٨-

❸ مَا حَجْمُ الْمُجَسَّمِ أَدْنَاهُ؟



أ) وَحْدَةٌ مُكَعَّبَةٌ وَاحِدَةٌ

ب) وَحْدَتَانِ مُكَعَّبَتَانِ

جـ) ٨ وَحَدَاتٍ مُكَعَّبَةٍ

د) ١٢ وَحْدَةً مُكَعَّبَةً

٩-

تُوَضِّحُ السَّاعَتَانِ أَدْنَاهُ مَتَى بَدَأَ مُحَمَّدٌ تَرْتِيبَ غُرْفَتِهِ، وَمَتَى انْتَهَى مِنْ ذَلِكَ.

بَدَأَ   انْتَهَى

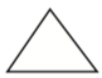
كَمِ اسْتَغْرَقَ مِنَ الْوَقْتِ فِي تَرْتِيبِ غُرْفَتِهِ؟

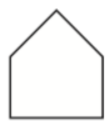
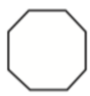
أ) سَاعَةً واحِدَةً   جـ) سَاعَتَيْنِ

ب) سَاعَةً وَنِصْفًا   د) سَاعَتَيْنِ ونِصْفًا

١٠-

أَيُّ الأَشْكَالِ التَّالِيَةِ يُسَمَّى شَكْلًا خُمَاسِيًّا؟

أ)    جـ) 

ب)    د) 

-١١

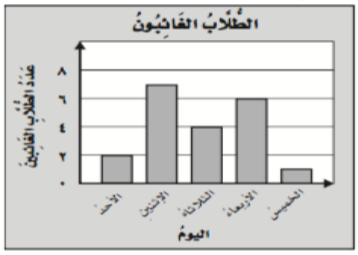
أَيٌّ مِمَّا يَأْتِي يَصِفُ شَكْلَ عُلْبَةِ مَعْجُونِ الطَّمَاطِمِ المُجَاوِرَةِ؟

أ) الدَّائِرَةُ　　　جـ) الأُسْطُوَانَةُ

ب) المَخْرُوطُ　　　د) الكُرَةُ

-١٢

التَّمْثِيلُ بِالأَعْمِدَةِ أَدْنَاهُ يُبَيِّنُ أَعْدَادَ الطُّلَّابِ الَّذِينَ تَغَيَّبُوا خِلَالَ ٥ أَيَّامٍ، فَمَا عَدَدُ الطُّلَّابِ الغَائِبِينَ جَمِيعًا؟



أ) ١　　　جـ) ١٣

ب) ٧　　　د) ٢٠

-١٣

أَدَارَتْ هُدَى مُؤَشِّرَ القُرْصِ أَدْنَاهُ مَرَّةً وَاحِدَةً. مَا اللَّوْنُ الَّذِي يَكُونُ تَوَقُّفُ المُؤَشِّرِ عِنْدَهُ أَقَلَّ احتِمَالًا؟

أ) الأَخْضَرُ

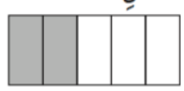
ب) الأَحْمَرُ

جـ) الأَزْرَقُ

د) الأَصْفَرُ

-١٤

مَا الكَسْرُ الَّذِي يُمَثِّلُ الجُزْءَ المُظَلَّلَ فِي الشَّكْلِ أَدْنَاهُ؟



أ) $\frac{١}{٥}$　　　جـ) $\frac{٢}{٥}$

ب) $\frac{١}{٤}$　　　د) $\frac{١}{٢}$

١٥-

ما الكَسْرُ الَّذِي يُكَافِئُ الكَسْرَ $\frac{٦}{٩}$ ؟

أ) $\frac{٢}{٣}$ جـ) $\frac{٢}{٥}$

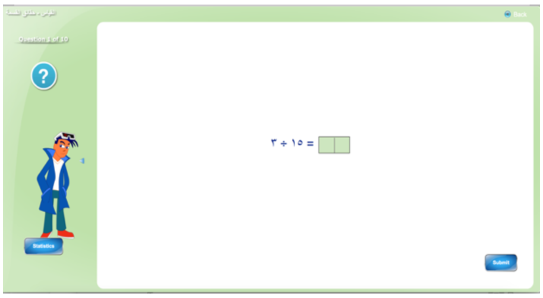
ب) $\frac{٣}{٤}$ د) $\frac{١}{٣}$

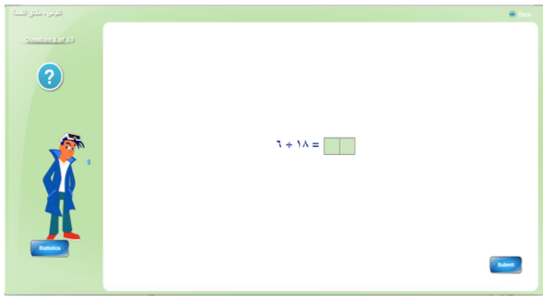
١٦-

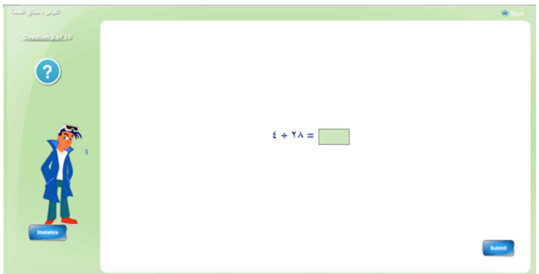
أُرَتِّبُ الْكُسُورَ الْآتِيَةَ مِنَ الأَكْبَرِ إِلَى الْأَصْغَرِ:

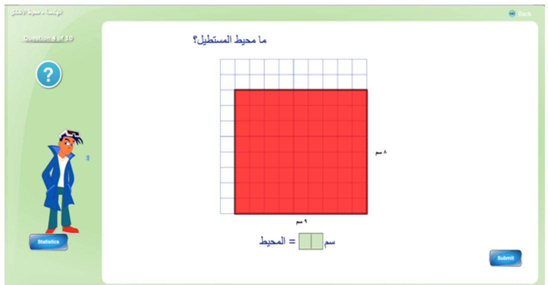
$\frac{٤}{٨}$ ، $\frac{٥}{٨}$ ، $\frac{٣}{٤}$

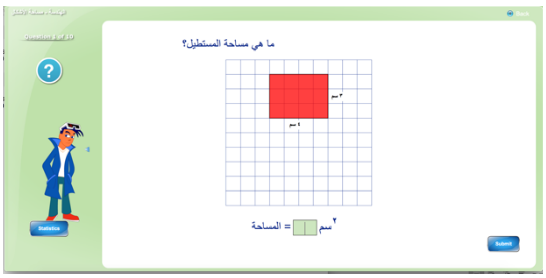
Mathematics activities from Mathletics Platform for Grade 3 learners.

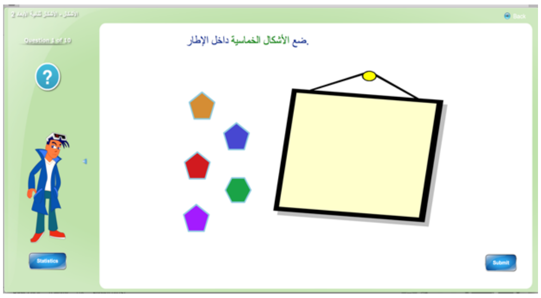








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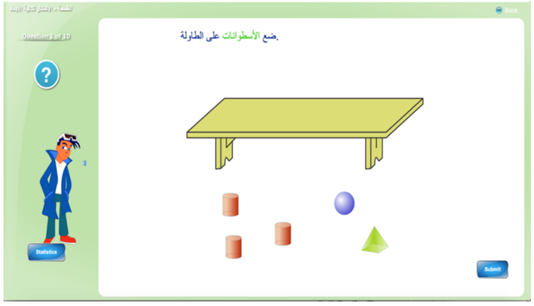
ضع الأسطوانات على الطاولة.
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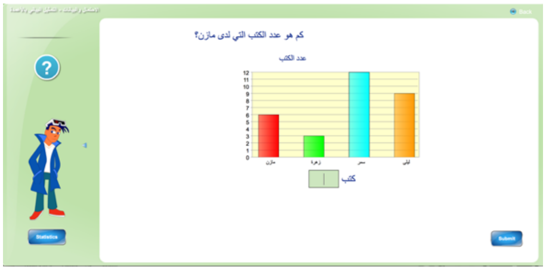
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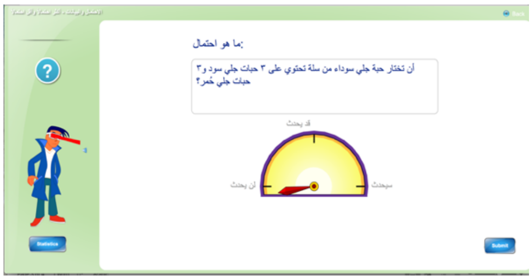
ما هو احتمال:
أن تختار حبة جلي سوداء من سلة تحتوي على ٣ حبات جلي سود و٣ حبات جلي حُمر؟
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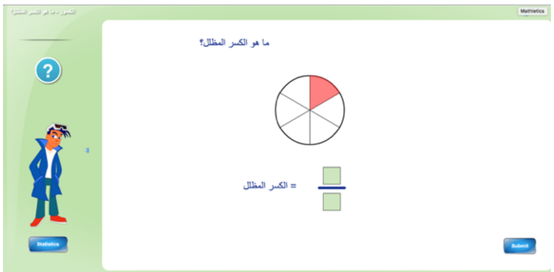
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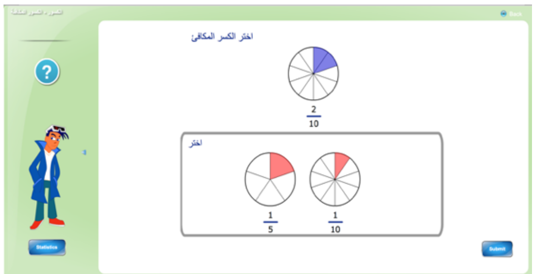
اختر الكسر المكافئ
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رتِّب الكسور الآتية تصاعدياً:
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Appendix F: Phase 2 - Data Analysis Process.

Final Coding for Phase 2

Grade 2- Control Group

This code book for data was collected from the second phase of this research for Grade 2 Control Group. The data was collected from direct class observation, interviews with teacher and focus groups with learners. The data in this codebook is written by three different colors. The black words refer to the data was collected from the class observation. The blue words are the data was collected from the focus group interviews with learners. Finally, the data in green is what the teacher said in her interview.

Note: G2: refers to Grade 2 and S refers to session. CT2 is Control Group Teacher. G2CC1is Grade 2 Control Group Case 1

Codebook for General Pedagogical Approach.

First level of code	Sample Excerpts	Case	Second level of code
Category 1: Pedagogy used in revision of previous topic in Traditional setting			
Teacher rotates around the classroom to check and correct individual homework	The teacher asked the learners to open the homework and moved around to check individual learners. [12 observed sessions]	G2S5	Teacher providing individual learner feedback
Teacher engages pupils in whole-class question and answer on homework/ previous topic	She then went over the white- board and asked who will answer the first question of the homework. A large number of the learners raised their hands. The teacher then chose one of the learners to answer. She did this with each of the other questions. [5 out of 12 observed sessions]	G2S4	Teacher engages in whole class discussion of homework/ previous topic
Teacher initiates peer assessment of homework	The teacher chose two learners from each group to check on their friends' homework. [3 out of 12 observed sessions]	G2S5	Teacher uses peer assessment technique
Category 2: Pedagogy used in introduction of new topic in Traditional setting			
Teacher uses question and answer to stimulate learner thinking on the topic.	The teacher asked the learners, when you go to the doctor what is the first thing the doctor does? (the math topic was about **Gram and Kilogram**. So, the answer is to check the weight). [all 12 observed sessions]	G2S7	Teacher using Question & Answer technique

	Teacher explains the learning outcomes for the session.	The teacher explained the goal of the lesson '**Nonstandard Capacity Unit'**. [4 out of 12 observed sessions]	G2S4	Teacher explaining Goal setting for learners
	Teacher displays new maths concept on whiteboard/ and explains how to solve the maths problem.	The teacher started explaining the math concept. She uses the white board and draws some shapes and use the cube to measure the length of these shapes. [all 12 observed sessions]	G2S1	Teacher demonstrated how to complete the activity – show and tell
	Teacher deploys physical resources (such as: ruler, wooden cubes) to help learners understand the topic	The teacher started the lesson by distributing small cubes. she let the learners to measure the length for their stuff by using the cubes and write down the results. She gave them about 5 min to do. She moves around to see the results which they recorded. The teacher took a real spoon and a cup and asked how can you measure a bottle of water by a cup or a spoon? The teacher asked the learners to use the ruler and measure their own stuff and record the results…. [3 out of 12 observed]	G2S1 G2S4 G2S2	Teacher deploys Physical resources
	Teacher uses resources in the Maths Digital Book to display the activity.	she asked them to open the student book … The teacher then projected the real word problem from the Student Book on the white board. The teacher presented the Student Book activity on the whiteboard. [all sessions] Technology is the essence of the life. It makes the lesson more enjoyable. It saves time and teacher effort. I usually use PowerPoint and Projector that is it. and I can see these help learners to understand the lesson more easily because they can see, hear and write. The problem of not integrating technology in the classroom is because these is no computer and Internet.	G2S1 G2S4 G2S5 CT2	Teacher deploys digital resources.
	Teacher uses group-work to facilitate opportunities for group/ collaborative learning and discussion.	She asked the learners to open the Student Book and work in the groups on the questions. And asked the learners to work in their groups …… The teacher then asked the learners to do the higher order thinking question on the groups Then she gave them a chance to work in their groups to finds the answers for all the question in the Student Book. [all 12 observed sessions]	G2S4 G2S1 G2S5 G2S7	Teacher facilitating Group-work

Teacher invites learners to answer questions on whiteboard/ smartboard.	The teacher asked one of the learners to come over the board and use the cubes to measure one of the shapes the teacher draw on the board and write the results. The teacher then chose one learner from each group to come over the board and write the answers. The teacher chose one of them to come over the board and answers [all 12 observed sessions]	G2S1 G2S4 G2S5	Teacher engaging Active Learning Approach
Teacher actively seeks learner inputs on alternative ways to solve maths problem.	[Not observed in this grade.]		Teacher engaging participatory form of learning
Teacher encourages learners to actively participate in new math tasks.	The learners interrupted her by giving some of the results, which they got and show her how they measure their thing using the cubes. Some learners re-measured the things… [all 12 observed sessions]	G2S1	Teacher encouragement of learners' participation.
Teacher reprimands learners for chatting informally or distracting others.	The teacher decides to stop explaining to get their attention. The teacher loudly requested the class to stop taking. [all 12 observed sessions]	G2S1 G2S5	Teacher disciplining learners
Teacher encourage reading in mathematics class	She chose one of the learners to read the preparation from the book out loud… The teacher then asked them to open the Student Book and asked one of the learners to read the first question out loud.	G2S1 G2S7	Teacher enhancing literacy
Teacher connects learner with real world	The teacher then asked a question 'Is the big thing always heavier than the little one? She let the learners work in the groups to find the answer and sked them to give an example of their answers. [Teacher posed question about what doctor checks first during a patient visit.] The learners provided answers - the doctor check on the temperature, one of the learners said the doctor check on the weight. The teacher then asked how much is your weight? The learners loudly said their weight by kilogram and one of them was comparing her weight by her brother weight.	G2S G2S7	Teacher making real life connection.

Category 3: Pedagogy of Maths Practice in Traditional Setting (paper-based maths practice activities)

	Teacher directs the learners to use the Student maths activity book in groups/ individually.	The teacher then asked the learners to open the Workbook and do the first three questions. The students were asked by their teacher open the workbook and answer the first, second and the fifth questions of 'Milliliter and Litter' activities in their group. The teacher then asked them to type the answer in their books and who finished can start to do the activity in the workbook. The teacher then asked them to open the workbook and asked to do the first three questions in the groups. [all 12 observed sessions]	G2S4 G2S5 G2S1 G2S7	Teacher re-organisation of learner interaction in groups/ individuals
	Teacher moves around the groups to check on individual/ group progress.	The teacher began to walk around to make sure that everyone worked on the activities and help who has difficulties. The teacher moved around to make sure all working on the activity. The teacher was moving around to check on their work. [all 12 observed sessions]	G2S1 G2S4 G2S7	Teacher engaging in Guided Facilitation
	Teacher responds to questions posed by the individuals/ groups, Teacher re-explains the concept to the individual/ whole-class.	The teacher noticed that some of the learners had difficulties…. The teacher noticed that the fourth question of 'Non-Standard Units' is a little hard. However, some students faced a difficulty to answer the fifth question of 'Milliliter and Liter' activities. The teacher wrote the questions on the white board and re-explained the way to get the answer. [all 12 observed sessions]	G2S4 G2S1 G2S5	Teacher engaged in Scaffolding learning
	Teacher directs learner to help another group-member	The teacher then asked one learner who understand the topic to help her friends. The teacher then asked one of the learners to help her friend to read the word question. [3 out of 12 observed sessions]	G2S1 G2S7	Teacher encouraging co-operation
	Teacher directs learners in groups to exchange and correct each other's work	The teacher then asked one of the learners from each group to check on her friends' work. [9 out of 12 observed sessions]	G2S7	Teacher encouraging peer-assessment
14.	Teacher reprimands learners for chatting informally or distracting others.	The teacher asked the learners to be quiet and do the activities. [all 12 observed sessions]	G2S1	Teacher disciplining learners

15.	Teacher does not provide direct (real-time) feedback on individual performance in paper- based activities,	The teacher then asked the learners to drop the book on her desk to check later. The teacher checked on some learners' workbook and told others to drop the book on her desk because its time up. The teacher asked them to bring the workbook next day to check. [all 12 observed sessions]	G2S1 G2S4 G2S5	Teacher not engaging in direct feedback to individual learners on performance.
16.	Teacher uses resources on the Maths Book Publisher to display the activity,	The teacher then projected the digital workbook activities on the whiteboard and re- explained the hard question. [4 out of 12 observed sessions]	G2S5	Teacher deploying digital resources [CDs]
17.	Teacher ends the math time by playing a game.	[Not observed in this grade]		Teacher encouragement playing in classroom.
18.	Teacher encourage learners to use online games at home.	[Not observed in this grade]		Teacher encouragement playing at home.

Codebook for Nature of Learner Engagement in

Category 4: Nature of Learner Engagement in the New Topic.

Learner sitting quietly, un-focused, Messing with other children, Looking bored, losing attention,	The teacher started to explain the lesson '**Millilitre and Litre**'meanwhile some of the learners were talking... The first few minutes the learners were seriously using the cubes for measuring. After a while some of them start playing with the cubes, loudly talking and moving around...The students were making so much noise as they were talking very loudly. Mathematics is a hard subject that requires hard work from the teacher to hold the learners' attention and keep them on task. I like mathematics but sometimes I do not, and I lose concentration when the teacher takes too long to explain. I lose concentration because the teacher sometimes talks too fast.	G2S5 G2S1 CT2 G2CC1 G2CC2	Learners expressing/ displaying a lack of Interest in the task.

	Sometimes, I got so bored in mathematics class sometimes and I feel like the class is too long.	G2CC3	
	When the lesson is difficult, I feel it becomes long and I loss concentration… But if the teacher brings some things, for example cubes, or models, the lesson becomes interesting.	G2CC4	
	[some learners were observed expressing/ displaying a lack of interest in all 12 observed sessions]]		
Learner actively participated in the new topic.	The teacher asked how can you measure a bottle of water by a cup or a spoon? Most of the learners screamed the answer. ……other learners had already attempted the question at home so they engaged to show friends how they can answer.	G2S4	Learner express interest in the new topic.
	A large number of the learners wanted to answer the questions that the teacher presented on the board about '**Millilitre and Litre'**	G2S5	
	The learners were providing the answers, the doctor check on the temperature, ... one of the learners said the doctor check on the weight… some of the learners loudly called out their own weight by kilograms. [all of 12 observed sessions – but not all learners participated to same extent in all sessions]	G2S7	
Learner work in groups on the new topic.	Some of the learners were discussed the idea about the question and think about real life example...	G2S7	Learner work in the group in the new topic.
Learner expressing frustration with more challenging math question, learner asking teacher to re-explain the concept.	the teacher then asked the learners to do the higher order thinking question on the groups. But a lot of learners had difficulties and asked the teacher for help.	G2S5	Learner is displaying level of anxiety/ frustration with more challenging maths activities
	She then asked learners to answer the third question (higher order thinking question) - this question required mental arithmetic, many students have difficult to do this, so the teacher decided to re-explain it on the board.	G2S10	

	Some of the questions are very hard so some of the learners expressed anxiety from these questions if they do not understand in the classroom. They asked to re-explain, especially higher order thinking activities. [8 out of 12 observed sessions – note: not all sessions had a higher order component integrated within the session]	CT2	

Category 5: Nature of learner engagement in Maths Practice in Traditional Setting (paper-based maths practice activities)

First level of code	Sample Excerpts	Case	Second level of code
Learners completed all maths practice activities, and submitted these to teacher.	Some of the learners worked on the maths practice activities in their group. They used paper clips that the teacher provided to measure the shapes that were presented in the activity book and completed them. One learner opened the workbook and completed the activities while the teacher was explaining the new topic. [learners completed allocated maths practice activities across all observed sessions]	G2S1 G2S4	Learner completes maths practice work
Learner explains to another group member how to solve the problem	One of learners was help her friends to find the answer for Non-Standard Units activities. [?? out of 12 observed sessions]	G2S1	Learners co-operating within groups.
Learner moves away from group-work choosing to work alone on solving maths activity.	Some learners moved out of groups to complete the maths practice activities by themselves. [6 out of 12 observed sessions]	G2S4	Learner disengages with group discussion/ collaboration during maths practice activities.
Learner were informally chatting, and messing with other learners,	Others closed the book before maths practice activity even completed and had informal chat. other were talking… One girl took out the coloured pencils and started to colour the black and white pictures in the Workbook. In one group, one of the learners already did the activities at home. Some of her friends copied the answers and close the workbook to had informal chat with their friends. I like when the teacher asks an easy question. But when she gives us a hard question, I got so bored and I lose concentration…	G2S1 G2S4 G2S7 G2CC1	Learners expressing/ displaying a lack of Interest in the activity

		[all 12 observed sessions]		
	Learner expressing frustration with more challenging math practice question, learner asking teacher to re-explain the concept.	One of the learners had difficulties to answer. Some learners faced a difficulty to answer - one learner raised her hand and asked the teacher to re-explain the question. [8 out of 12 observed sessions]	G2S4 G2S5	Learner is displaying level of anxiety/ frustration with more challenging maths activities
	Learner try out advanced maths practice activities at home (before explained in school).	When the teacher asked to work in the workbook activity, some of the learners already did the activity at home. So, their friends copied the answers. I like to do the activities at home before we take with the teacher because it helps me to understand fast and the teacher gives me a gift. I like to do the workbook activities when the teacher still explaining the new topic. Because when the teacher asks us to do the workbook activities, I showed her my answers, and when all answers are correct, the teacher gives me a gift like pencil or rubber. The teacher usually brings very nice gifts. [all 12 observed sessions – most of the learners attempt to complete questions at home in advance of topic being explained]	G2S4 G2CC2 G2CC4	Learner exhibits initiative in attempting more advanced math practice activity at home.

General Information about the teacher.

Garde 2 Control Group teacher (CT2) has four years experience teaching at primary level (Lower Level), this year is the second year in this school.
Teacher primary subject degree is Islamic Studies. The teacher said that she undertook three months ICT professional development, that was organised by Ministry of Education. The teacher considers herself to have basic level of knowledge of integration technology in education.

Final Coding for Phase 2:
Grade 2 Integrated Group

This code book for data was collected from the second phase of this research for Grade 2 Mathletics Group. The data was collected from direct class observation, interviews with teacher, learners and mothers. The data in this codebook is written by three different colors. The black words refer to the data was collected from the class observation. The blue words are the data was collected from the learners' interviews. The orange words are what the mothers said. Finally, the data in green is what the teacher said in her interview. The observation involved class observation of 29 (with a particular focus on the 10 learners who would be using Mathletics at end of session). So, 10 leaners who play Mathletics were named Mathletics Group (MG) and the other who did not use the platform named Workbook Group (WG). The teacher continued with workbook activities with the other 19 learners.

Note: for example: G2S1: refers to Grade 2 Session 1. MT2 is Mathletics Group Teacher. G2MC1is Grade 2 Mathletics Group Case 1, M1 is the first Mother.

Codebook for General Pedagogical Approach.

First level of code	Sample Excerpts	Case	Second level of code
	Category 1: Pedagogy used in revision of previous topic in Traditional setting [29 learners]		
Teacher rotates around the classroom to check and correct individual homework	The teacher asked the learners to open the homework and moved around to check individual learners. [all 12 observed sessions] On some occasions, the teacher reported checking on the learners' workbooks before the mathematics class, which she distributes to individual learners at the outset of the class. [4 of 12 observed sessions].	G2S4	Teacher providing individual feedback.
Teacher engages pupils in whole-class question and	because it is a new chapter, so, the teacher decided to do the preparation activities which covered all previous topics about Measurement before she	G2S8	Teacher engages learners in Whole class discussion.

answer on homework/ previous topic	started the new topic '**Nonstandard Length Units'**. When all questions were answered on the board, she asked them to write down the answer. [4 of 12 observed sessions]		
Teacher initiates peer assessment of homework	The teacher asked the group leader to check on her friends' homework. [4 of 12 observed sessions]	G2S5	Peer assessment technique
	Category 2: Pedagogy used in introduction of new topic in Traditional setting [29 learners]		
Teacher uses question and answer to stimulate learner thinking on the topic.	The teacher asked who can use the ruler to measure these shapes. [all 12 observed sessions]	G2S5	Teacher using Question & Answer technique
Teacher explains the learning outcomes for the session.	The teacher prepares her students for the new topic and explained the new topic goal which is '**Using Centimetre Ruler**'. [5 of 12 observed sessions]	G2S5	Teacher explaining Goal setting for learners
Teacher displays new maths concept on whiteboard/ smartboard and explains how to solve the maths problem.	She projected the Student book on the white board… She then used the ruler to show them the way to measure the objects. [all 12 observed sessions]	G2S5	Teacher explanation of maths concept using didactic style
Teacher deploys physical resources (such as: wooden cubes) to help learners understand the topic	The teacher had cubes that is 1 cm and explained the new topic which was abut Measuring Length using 1 cm cube in length. [5 of 12 observed sessions]	G2S4	Teacher using Physical resources

Teacher uses resources in the Maths digital Book to display the activity.	She then projected the guided activities from the digital book on the whiteboard. Technology is useful in some lessons, it saves time and teacher effort. I use Projector, PowerPoint and Microsoft Word… [all 12 observed sessions]	G2S4 MT2	Teacher deploying digital resources
Teacher uses group-work to facilitate opportunities for group/ collaborative learning and discussion.	She gave each group different size of cubes (1cm, 5cm..) and asked to measure their own stuff using these cubes and write the answers. After a while, she asked one learner from each group to read their answers. She then gave them a few questions from the book to answer in the groups. [all 12 observed sessions]	G2S4 G2S5	Teacher facilitating Group-work
Teacher invites learners to answer questions on whiteboard/ smartboard.	The teacher then chose one of them to come up to the board and use the ruler to measure the length of one of the shapes. When they all finished, she presented the activity on the white board and asked who will come up to the board and answer the first question. [all 12 observed sessions]	G2S4 G2S5	Teacher engaging Active Learning Approach
Teacher actively seeks learner inputs on alternative ways to solve maths problem.	Not observed in this grade.		Teacher engaging inclusive form of learning

Teacher encourages learners actively participate in new math tasks.	She asked who will answer the first question on the board, all learners raised hands.	G2S4	Teacher encouragement of learners' participation.
	…and asked who can come over the board and use the ruler to measure these shapes. [all 12 observed sessions]	G2S5	
Teacher encourage reading.	The teacher asked one of the learners to read the information about the new topic out loud.	G2S4	Teacher enhancing literacy.
	She then asked one of the learners to read the higher order thinking question out loud.	G2S5	
	Aside: The teacher did highlight a challenge in encouraging participation of learners, on that some of the learners like to read the word question out loud but others needed help in reading (and thus would not actively participate if asked to read).	MT2	
Teacher connects learner with real world	She gave them examples on real life situations "can we use cm to measure a football field? and some of them answered the questions incorrectly, she asked one them to stand up and help them to understand the question and give them hints to answer.	G2S4	Teacher making math concept relevant.
	The teacher then asked a question from real life 'can you give an example of objects that are 1 cm from the world around you?'	G2S5	

	[all 12 observed sessions]		
Teacher reprimands learners for chatting informally or distracting others.	some of the learners were playing by the math set, so the teacher asked them to leave the stuff and focus on the board… [all 12 observed sessions]	G2S5	Teacher disciplining learners
Category 3: Pedagogy of Maths Practice in Traditional Setting (paper-based maths practice activities) – 29 learners			
Teacher directs the learners to use the maths Workbook in groups/ individually.	The teacher asked them to do the workbook questions in groups The teacher then asked them to do the first three questions from the workbook in the groups. [all 12 observed sessions]	G2S4 G2S5	Teacher re-organisation of learner interaction in groups/ individuals
Teacher moves around the groups to check on individual/ group progress.	The teacher moved around to check on their work and help who did not understand. the teacher moved around to check on their work…. [all 12 observed sessions]	G2S4 G2S5	Teacher engaging in Guided Facilitation
Teacher responds to questions posed by the individuals/ groups, Teacher re-explains the concept to the individual/ whole-class.	One of the learners asked the teacher a question about one of **Nonstandard Length Units** activities. The teacher then explained to her individually. [all 12 observed sessions].	G2S4	Teacher engaged in Scaffolding learning
Teacher directs learner to help another group-member	One group, they had difficulties in '**Add Numbers: Regroup a Ten**' activities. So, they asked the teacher for help, the teacher was busy with one of the learner, so the teacher asked one leaner from other group to help her friends.	G2S11	Teacher encouraging co-operation

		The teacher asked one of the learners to read the question for her friends. [all 12 observed sessions]	G2S8	
	Teacher directs learners in groups to exchange and correct each other’s work	The teacher asked the groups to exchange the sheets and check on other’s work. [5 of 12 observed sessions]	G2S11	Teacher encouraging peer-assessment
	Teacher reprimands learners for chatting informally or distracting others.	The teacher has already given them a warning about using their iPads “if you don’t focus with the lesson you will not have the chance to spend time on your devices”, [all 12 observed sessions]	G2S4	Teacher disciplining learners
	Teacher does not provide direct (real-time) feedback on individual performance in paper- based activities,	The teacher asked who finish the workbook activities to drop the book on her desk. she then asked the learners to leave the workbooks open for her to check (at a later stage), and gives them permission to take the iPads. [all 12 observed sessions]	G2S4 G2S5	Teacher not engaging in direct feedback to learners on performance.
	Teacher uses resources on the Maths Book Publisher website to display the activity,	Not observed in this grade		Teacher deploying Online resources
	Teacher ends the math time by playing a game.	Not observed in this grade		Teacher encouragement playing at classroom.

Teacher encourage learners to use online games at home.	Not observed in this grade		Teacher encouragement playing at home.

Codebook for Nature of Learner Engagement

Category 4: Nature of Learner Engagement in the New Topic. [29 learners]			
Learner sitting quietly, un-focused, Messing with other children, Looking bored, losing attention,	Some of the learners were playing by their own stuff … [all 12 observed sessions]	G2S5	Learners expressing/ displaying a lack of Interest in the task.
Learner actively participated in the new topic.	She [the teacher] asked who will answer the first question, a large number of the learners raised hands. Moats of the learners raised hand and the teacher chose one learner…. Some of the learners raised hand and want to come over to the board. the learners were screaming the answers and the teacher typed their answers on the board. The teacher then asked a question involving higher order thinking. The learners were working on the question and each one wanted to finish fast. [all 12 observed sessions]	G2S 4 G2S5	Learner express interest in the new topic.
Learner work in the group in the new topic.	The learners worked in the group and use these cubs to measure their own stuff. The learners were doing the activity in the group and help each other to use the ruler. They have argued about how they can perform the measurement, whether to start from zero or one. [all 12 observed sessions]	G2S 4 G2S5	Learners co-operating within groups.

Learner expressing frustration with more challenging math question, learner asking teacher to re-explain the concept.	The teacher gave them examples on real life situations - some of them did not get the answer, the teacher then invited one of them to go up the board and helped them to understand the question and give them hints on how to answer. One of the learners asked the teacher for help [expressing frustration at not being able to use the ruler]. [6 of 12 observed sessions]	G2S4 G2S5	Learner is displaying level of anxiety/ frustration with more challenging maths activities.

Category 5: Nature of learner engagement in Maths Practice in Traditional Setting (paper-based maths practice activities) – 29 learners

First level of code	Sample Excerpts	Case	Second level of code
Learners completed all maths practice activities, and submitted these to teacher.	Some of the learners completed the activities and asked the teacher to have the iPads. The learners tried to complete the maths practice activity in workbook as fast as they could and asked the teacher if it is the time to play Mathletics. [all 12 observed sessions].	G2S4 G2S5	Learner completes maths practice work
Learner explains to another group member how to solve the problem	The learners were observed explaining to one another the answer (in groups). They were helping each other to find the answers. [all 12 observed sessions]	G2S4 G2S5	Learners co-operating within groups.

	Learner choosing to work alone on solving maths activity.	In the first group, two of the learners were individually working by themselves to solve the maths practice activities. [7 of 12 observed sessions].	G2S5	Learner disengages with group discussion/ collaboration during maths practice activities.
	Learner have informal chatting, messing with other learners.	After 15 minutes of answering and explaining one of the learners expressed boredom and asked is the topic going to be much longer. Some of the learners moved to have informal chatting with friends in the other group. [all 12 observed sessions]	G2S4 G2S5	Learners expressing/ displaying a lack of Interest in the activity
	Learner expressing frustration with more challenging math practice question, learner asking teacher to re-explain the concept.	In one group, the learners got frustrated in trying to measure the length of one of the shapes in the workbook. So, one of them asked the teacher, how can we use these cubes to measure something that is very long?	G2S8	Learner is displaying level of anxiety/ frustration with more challenging maths activities
	Learner try out advanced maths practice activities at home (before explained in school).	Some of the learners had already did the workbook activity at home. They showed the teacher their answers.	G2S4	Learner exhibits initiative in attempting more advanced math practice activity at home.
	Learner disengaged in workbook activity and tried to interact with Mathletics software.	It a first time to play Mathletics, when we started, some of the learners in WG cried..	G2S1 G2S5	Learner display frustration at not being able to engage with Mathletics software.

	Some of learners from WG left the workbook on the desk and tried to engage with their friend from MG to use the platform, the teacher then checked on their workbook and asked to complete the workbook activities first.		

Category 6: Learner engagement in Online Gamified Learning Setting (Mathletics Practice activities). [Group of 10 learners]

First level of code	Sample Excerpts	Case	Second level of code
Learners look proud of themselves, showing others their scores, finish first, completing the activity without help, completing the activity without mistakes.	They started screaming and shouting in excitement and happiness, they decided to prove how smart and intelligent they are by repeating the Mathletics activities without any mistakes. The learner who has the longest colour, asked the teacher and friends to see her achievement. Now I can play by myself – there is no need for anyone help me. But if I need help, I will ask my mother because I play most at home. I am proud of myself that I can play without help. [all 12 observed sessions]	G2S4 G2MC1 G2MC2	Learners are demonstrating pride in achievement
Learners laughing, Shouting, expressing happiness, waiting with an excitement.	The learners were so excited to know the new activity and want to start the challenging.	G2S4 G2MC1	Learners expressing enjoyment from the use of Mathletics.

	I like mathematics class, but when you bring Mathletics game, I became more concentrated when the teacher explains. I want the teacher to finish fast so I can practice by the game and understand more. The game also helps me to understand so when I have difficulty in understanding mathematics, I can play more and more.	
	I like mathematics class, but I became more focus with the teacher when she explains. Mathletics helps me to understand more and I became faster and smart in solving the problems because I solve them in my head and type the answers.	G2MC2
	I like mathematics class, but I like it more when we start playing Mathletics. The game makes me more focused and good at mathematics because I answer in my head and then type the answers. The most things that I like to play is addition and subtraction. These two topics were hard but now became easy because I play over and over again.	G2MC3
	Mathematics is one of the subjects that the learners like because it related to their life such as money, time, addition and subtraction. But the presence of the game has increased enthusiasm for Mathematics. They have enthusiasm, so they brought their devices. So, I suggest integrating this technology at school time because it really increases their enthusiasm in mathematics class. But it is good after I have explained the lesson as an additional course, so they can practice by using the game.	MT2

		So, it should be integrated at school time with clear plan. It is necessary to have equipments in school such as devices, Internet and the game itself. My daughter likes mathematics but this game (Mathletics) makes her better at math. She can solve the problems in head and then type the answer. Since this game introduced to the school, my daughter was so excited about mathematics class. She asked to charge the device before went to bed so it will be ready for the next day. [all 12 observed sessions]	 M1	
	Learner has completed the activities – the bar only fills if all questions answered correctly.	The learner who has Gold Bar in Mathletics, asked the teacher and friends to come and see her achievement. When they completed the activity, they visited the main interface and show each other the 'Gold Bar' [all 12 observed sessions]	G2S4 G2S5	Learners exhibiting a Desire to successfully complete the activities…
	Learners complete additional maths practice activities at home, learners talk about the completed activity at home.	The learners had their devices in their hands and ready to play the Mathletics activity 'How Long is That?'. The learners started to show each other how much they filled in the bar last night. I played at home, I played the previous lessons such as Measurement, Geometry. I play Mathletics at school and at home.	G2S5 G2MC1	Learners exhibiting the desire to engage in Mathletics beyond class-time

			G2MC2	
		When my daughter came back home, she played about half an hour. she talked about the game with her siblings. She can play the game by herself, she never asks for help.	M1	
		Generally, my daughter is independent she never asks me for help unless she did not get the answer. But after the integration of this game (Mathletics) she never asks for help. She usually finished her homework and then played the game. She visited some of the activities that they took at the beginning of the semester and practiced something new. She talked with her brother about the excitement that she had when she played with her friends in the classroom and the activities that they played together and who won the competition. She encouraged her brother, who is a year older than her, to have an account and play the game. [all 12 observed sessions]	M2	
	Learners connect with peers in-class and across the globe to engage in Online Maths challenging (Live Mathletics), learner connects with peers and across the globe at home in online math challenging.	Some of the learners played 'Live Mathematics' they found each other in the game and they then physically moved in the class and ask each other "who want to play with me". Since the game started counting down, the girls repeated the number 3,2,1 and "GO". some students were standing up and held the iPad by hand and type by the other hand. And some have the iPad on the desk and type the answer. One group decided to play Live Mathematics at the second level…	G2S4 G2S5	Learners display interest in connecting/ competing with other learners

		[all 12 observed sessions]		
	Learners are playing the Mathletics in friendly competition (In-class Mathletics), Discussion and sharing ideas, Explaining how they solve the problems to each other.	Some learners competed with each other to see who would fill the bar (complete activities) first. They started to play and tried not to make mistakes to fill the bar. Some of them did not know where the activity was located within Mathletics and they needed more help to find it, and they asked their friends for guidance.	G2S4	Learners exhibiting a desire for Collaboration and Competition
		……and were racing who will finish first. They were talking to each other about the game while they were playing and answering out loud. A number of learners finished at the same time and each one shouted "I am first". So, some learners seemed more confident to be with a partner, so their friends gave a hand to them when they struggled with some questions in the games (e.g. using the ruler). The leaners from Non-GL group were helping their friends (GL) in Mathematic activity 'How Long is this'… Some learners in the cohort of 19 learners not playing Mathletics were observed attempting to connect and assist those playing Mathletics. At the beginning, I didn't know how to do the activity. When I have joined my friends, I have learnt how to play.	G2S5	

		The most enjoyable thing is to play with my classmates. ….But I like to play at school with my classmates. Because when I need help, I can ask them. I play at school and at home, but I like to play at school because of my friends.	G2MC1 G2MC2 G2MC3	
	Learners create their own group to compete with each other face-to-face.	They made their own groups and played Mathletics activity 'Measuring Length'. They have divided themselves in groups and started the challenge… [all 12 observed sessions]	G2S4 G2S5	Learners exhibiting the desire to self-form groups and self-direct their learning
	Learners compare the challenge of question/s solved with each other 'a more worthy win' if the questions seem harder.	They showed each other the question that they received and compared that with their friends who have the harder question. [all 12 observed sessions]	G2S4	Learners discernment of degree of challenge of questions on their performance
	Learners repeat the activity to improve the final score and publicise the final score.	the learners who have incorrect answers, asked if they can play the game again and try to have all correct answers in the second attempt. The game can provide the feedback so, she can play multiple times until gets the correct answers. For example, she had difficulty in one of the topics, I think 'Addition' but when she played the game it became	G2S4 M2	Learners displaying a self- challenging disposition

		easy because she repeated the activities over and over again and she can see her progress. [8 of 12 observed sessions]		
	Learner chooses to work alone on solving maths activity.	One of the learners generally sat by herself in her seat and did the activity by herself. [This was the exception and just one learner was observed doing this across all 12 observed sessions]	G2S4	Learner preferring to work alone during maths practice activities.
	Learner disengaging with group to work alone on solving maths activity.	Not observed in this grade.		Learner disengages with group discussion/ collaboration to work alone during maths practice activities.
	Learner strive to collect points, Certificate, or any game elements. Learners continually check the final score (feedback).	The learners compared points and were talking about the points that they had before they started the game.	G2S4	Learners motivated by game elements, including rewards and feedback.
		Session 5 was the first time to hand out a certificate. Only one girl had a certificate, all were surprised and asked how did she get it? The learners were surrounded her expressing excitement, asking her what you have done to get it.	G2S5	
		I like to play Mathletics to collect the points and to win the competition. I have 78 points that I have collected right now. I have only one certificate, so I have to play a lot to collect more points and have another certificate.	G2MC1	

	I have 400 points and one certificate. I have to play more to get more points.	G2MC2	
	I like to collect points. I have 100 points and last week I had 1200 points. I have one certificate. So, if I cannot receive a certificate, I have to play more. But if the week passed and I did not have a certificate, I will be so sad.	G2MC3	
	My daughter plays the game (Mathletics) at home because there is a challenging between her and her friends about the points that lead to the certificate. When she got a certificate at the first time, she was so excited. So, she played a lot to get more certificates. I am so excited about the integration of the iPads at school. This gives the kids confidence that they can take care of their own stuff. The kids are so happy to bring their own device and play with their friends at school. Also, I think bringing their own device at school will develop a good relationship between home and school. Our kids will be so excited to talk about the activities that they will do with their friends and the competition that they will make at school. [all 12 observed sessions]	M2	
Learner request assistance from the teacher	Some needed a little more help so they asked the teacher about how they can use the ruler in the game. (the learners were taught to use the ruler from right to left to measure the length (Arabic mode), whereas Mathletics activities were presented to use the ruler from left to right (Western/ English mode). [3 of 12 observed sessions]	G2S5	Teacher- assisted learning

	Learner has difficulty understanding the notion of '1000' points, Expressing Disappointed from Missing Some Points.	Not observed in this grade		Learners lacking the mental capacity to understand large numbers (such as 1000) at this grade level [Recommendation for change to game design to address this – perhaps change to 100 points for example]
	Learners choose to remain committed to playing at First level in 'live math' to score more points.	One group decided to play 'Live Mathematics' but they joyed the first level.	G2S4	Learners' disposition to focus on the 'win' rather than the 'learning value'
	Learners not reading the textual question	Not relevant at this grade level.		Learner preference for visual information/ Possible issue in framing of question.
	Learners disengaged in Mathletics activity.	The leaners were asked to do 'Adding Three Digit Number-Regrouping'. The learners did the first few questions by a pencil and paper but then they closed the activity and tried to do other activities. The learners were asked to do 'Estimated Addition' activity, the design of the activity was hard and there is an assign (≈) that the leaners did not understand. We then decided to close this activity and do other activity.	G2S11 G2S12	Learner express lack of interest/disengaged of in the activity. (game design issue).
	Learners notice the important of the teacher.	I have difficulties with the test and some of the activities. But the teacher helps us for example she re-explains when we need, she lets us to practice on the board, she lets us to help each other and sometimes she	G2MC1	Learners' perceptions of the role of the teacher in learning mathematics

	brings games. When we have difficulties in some of the questions such as higher order thinking question, the teacher writes the question on the board and explains it until we got it. So, the game the you gave us (Mathletics) is useful but the teacher is important because she teach us and take care of us.	
	I had difficulties with some hard questions like higher order thinking questions, but the teacher help us. She re-explained for us individually, she lets to practice on the board, she lets us to practice the hard activities at home. So, I can say the teacher is important for us. So, the game that you gave us (Mathletics) is useful but it never replaces the teacher. We have to have a teacher to teach us reading, writing and mathematics and then practice in the game. But this game (Mathletics) helps me to revise the previous topic and I feel like I became smart because I answer in my head and then type the answer in the game.	G2MC5
	In mathematics, there are some hard questions. but the teacher helps us. She lets us work in groups to help each other and she gives us real life examples. So, I agree with my friends that the game (Mathletics) is useful but could never replace the teacher. The game helps to practice more and revise the previous topic.	G2MC6

Category 4: Pedagogy of Practice in in Online/Mathletics Practice activities [10 learners]

	Teacher moves around the groups to check on individual/ group progress, but mainly leaves learners to self-direct learning.	The teacher moved round and check on their answers.	G2S4	Teacher facilitates a high degree of self-directed/ independent learning
		I suggested to integrate such technology as an additional course two to three time per- week because mathematics class is not enough. I take 20-30 mins to explain the new topic and the learners have to practice what they have learnt in the workbook. And also, learners need time to have access to the game. This technology never replaces the teacher, 'the teacher is like a key of the box'. Especially for this age. [all 12 observed sessions]	MT2	

General Information about the teacher.

Teacher 2 Mathletics Group teacher [MT2] has seventeen years experience teaching at secondary level and she was in her first year of teaching at primary level this school during the period of study. Her primary subject degree is in Home Economy. The teacher indicated that she had undertaken professional development in ICT but considered herself to have basic level of knowledge of technology integration in education.

Section F. 3: Analysis of Mathematics Mathematics Disposition Survey.

Sample of Analysis of Mathematics Disposition Survey for category of interest for Grade 2 Control Group in mathematics homework. And category of interest for Mathletics Group in Difficult Mathematics. We choose these two sample because there were differences between these two groups.

Grade 2 Control Group: category 'Math homework':

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Confidence; How good are you in math homework? at pre- test	.244	19	.000
Confidence; How good are you in math homework? at post- test	.362	19	.000
Interest: How much do you like doing your homework? at pre-test	.571	19	.000
Interest: How much do you like doing your homework? at post- test	.244	19	.000
Satisfaction: How satisfied do you feel when you complete math homework without help? at pre- test	.545	19	.000
Satisfaction: How satisfied do you feel when you complete math homework without help? at post-test	.433	19	.000
Anxiety at pre- test	.779	19	.001
Anxiety at post- test	.874	19	.017

a. Lilliefors Significance Correction

The output presented in the above table is the **Sig** level for Shapiro-Wilk was .000 for all the scales. This is not bigger than the alpha level of .05, so the distributions are not normal. In this case, Wilcoxon Signed Rank Test is used.

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Confidence; How good are you in math homework? at post- test - Confidence; How good are you in math homework? at pre- test	Negative Ranks	2[a]	2.00	4.00
	Positive Ranks	1[b]	2.00	2.00
	Ties	16[c]		
	Total	19		
Interest: How much do you like doing your homework? at post- test -	**Negative Ranks**	**0[d]**	**.00**	**.00**
	Positive Ranks	**6[e]**	**3.50**	**21.00**
	Ties	**13[f]**		

Interest: How much do you like doing your homework? at pre-test	**Total**	**19**		
Satisfaction: How satisfied do you feel when you complete math homework without help? at post-test - Satisfaction: How satisfied do you feel when you complete math homework without help? at pre- test	Negative Ranks	2[g]	4.00	8.00
	Positive Ranks	4[h]	3.25	13.00
	Ties	13[i]		
	Total	19		
Anxiety at post- test - Anxiety at pre test	Negative Ranks	8[j]	7.56	60.50
	Positive Ranks	4[k]	4.38	17.50
	Ties	7[l]		
	Total	19		

a. Confidence; How good are you in math homework? at post- test < Confidence; How good are you in math homework? at pre- test
b. Confidence; How good are you in math homework? at post- test > Confidence; How good are you in math homework? at pre- test
c. Confidence; How good are you in math homework? at post- test = Confidence; How good are you in math homework? at pre- test
d. Interest: How much do you like doing your homework? at post- test < Interest: How much do you like doing your homework? at pre-test
e. Interest: How much do you like doing your homework? at post- test > Interest: How much do you like doing your homework? at pre-test
f. Interest: How much do you like doing your homework? at post- test = Interest: How much do you like doing your homework? at pre-test
g. Satisfaction: How satisfied do you feel when you complete math homework without help? at post-test < Satisfaction: How satisfied do you feel when you complete math homework without help? at pre- test
h. Satisfaction: How satisfied do you feel when you complete math homework without help? at post-test > Satisfaction: How satisfied do you feel when you complete math homework without help? at pre- test
i. Satisfaction: How satisfied do you feel when you complete math homework without help? at post-test = Satisfaction: How satisfied do you feel when you complete math homework without help? at pre- test
j. Anxiety at post- test < Anxiety at pre test
k. Anxiety at post- test > Anxiety at pre test
l. Anxiety at post- test = Anxiety at pre test

Test Statistics[a]

	Confidence; How good are you in math homework? at post- test - Confidence; How good are you in math homework? at pre- test	***Interest: How much do you like doing your homework? at post- test - Interest: How much do you like doing your homework? at pre-test***	Satisfaction: How satisfied do you feel when you complete math homework without help? at post-test - Satisfaction: How satisfied do you feel when you complete math homework without help? at pre- test	Anxiety at post- test - Anxiety at pre test
Z	-.577[b]	***-2.333[c]***	-.541[c]	-1.698[b]
Asymp. Sig. (2-tailed)	.564	***.020***	.589	.089

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

Wilcoxon Signed Ranks Test conducted as the scales were not normally to test the significant differences between the scales under two situations. The table showed Confidence ($z = -.577$, $p = .564$), Anxiety ($z = -1.698$, $p = .089$) and Satisfaction ($z =-.541$, $p= 0 .589$) suggestion there were no significant differences between pre and post tests on students' disposition toward math homework.

Whereas, there was statistics significant difference between pre and post tests on students' interest(z value is -2.333) this significant at $p = 0.02$. This result based on a negative rank where the post-test's score is less than pre-test's score. So, this result suggests that learners' interest math homework decreased over time.

B- Grade 2 Mathletics Group: category 'Difficult Math':

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Confidence; How good are you in difficult math tasks? at pre- test	.696	10	.001
Confidence; How good are you in difficult math tasks? at post- test	.366	10	.000
Interest : How much do you like difficult math problems? at pre-test	.509	10	.000
Interest: How much do you like difficult math problems? at post- test	.773	10	.007

Satisfaction: How satisfied do you feel when you complete difficult math tasks? at pre- test	.727	10	.002
Satisfaction: How satisfied do you feel when you complete difficult math tasks? at post-test	.532	10	.000
Anxiety at pre- test	.953	10	.700
Anxiety at post- test	.927	10	.422
*. This is a lower bound of the true significance.			
a. Lilliefors Significance Correction			

The distribution of normality assessed by Shapiro-Walk test. The scales are used to evaluate the affect of online gamified learning on students' attitude toward difficult math tasks.
The above table showed that almost scales value is less than .05 indicated that these scales are deviate from a normal distribution. In this case, Wilcoxon Signed Ranks Test was used.

Anxiety value, on the other hand, show greater than .05 (pre-test value = 0.953 and post-test value = .927). indicated that they were normal distribution. In this case paired t- test will be used.

Ranks

		N	Mean Rank	Sum of Ranks
Confidence; How good are you in difficult math tasks? at post- test - Confidence; How good are you in difficult math tasks? at pre- test	Negative Ranks	0[a]	.00	.00
	Positive Ranks	3[b]	2.00	6.00
	Ties	7[c]		
	Total	10		
Interest: How much do you like difficult math problems? at post- test – Interest: How much do you like difficult math problems? at pre-test	***Negative Ranks***	***6[d]***	***3.50***	***21.00***
	Positive Ranks	***0[e]***	***.00***	***.00***
	Ties	***4[f]***		
	Total	***10***		
Satisfaction: How satisfied do you feel when you complete difficult math tasks? at post-test – Satisfaction: How satisfied do you feel when you complete difficult math tasks? at pre- test	Negative Ranks	1[g]	1.50	1.50
	Positive Ranks	3[h]	2.83	8.50
	Ties	6[i]		
	Total	10		

a. Confidence; How good are you in difficult math tasks? at post- test < Confidence; How good are you in difficult math tasks? at pre- test
b. Confidence; How good are you in difficult math tasks? at post- test > Confidence; How good are you in difficult math tasks? at pre- test
c. Confidence; How good are you in difficult math tasks? at post- test = Confidence; How good are you in difficult math tasks? at pre- test
d. Interest: How much do you like difficult math problems? at post- test < Interest: How much do you like difficult math problems? at pre-test
e. Interest: How much do you like difficult math problems? at post- test > Interest: How much do you like difficult math problems? at pre-test
f. Interest: How much do you like difficult math problems? at post- test = Interest: How much do you like difficult math problems? at pre-test
g. Satisfaction: How satisfied do you feel when you complete difficult math tasks? at post-test < Satisfaction: How satisfied do you feel when you complete difficult math tasks? at pre- test
h. Satisfaction: How satisfied do you feel when you complete difficult math tasks? at post-test > Satisfaction: How satisfied do you feel when you complete difficult math tasks? at pre- test

i. Satisfaction: How satisfied do you feel when you complete difficult math tasks? at post-test = Satisfaction: How satisfied do you feel when you complete difficult math tasks? at pre- test

Test Statistics[a]

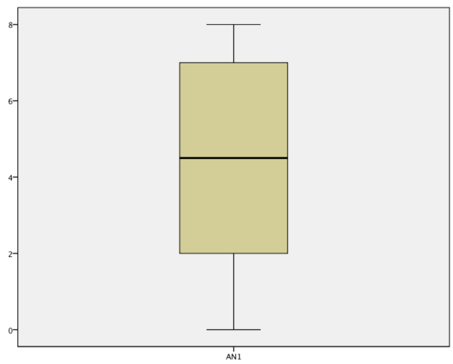
	Confidence; How good are you in difficult math tasks? at post- test - Confidence; How good are you in difficult math tasks? at pre- test	***Interest: How much do you like difficult math problems? at post- test – Interest: How much do you like difficult math problems? at pre- test***	Satisfaction: How satisfied do you feel when you complete difficult math tasks? at post-test - Satisfaction: How satisfied do you feel when you complete difficult math tasks? at pre- test
Z	-1.633[b]	***-2.271***[c]	-1.289[b]
Asymp. Sig. (2-tailed)	.102	***.023***	.197
a. Wilcoxon Signed Ranks Test			
b. Based on negative ranks.			
c. Based on positive ranks.			

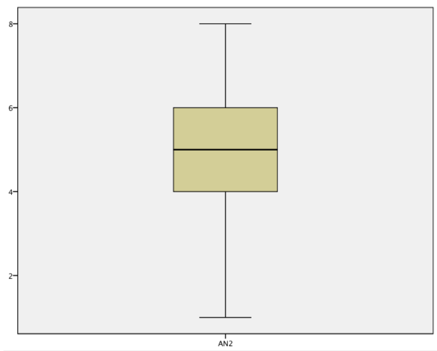
The Wilcoxon signed-rank test is the nonparametric test is used to understand whether there was a difference in difficult math tasks before and after implementing online gamified leaning program.

The table showed that the p value for Confidence test (z= -1.633, p =0.102), also, Satisfaction (z = -1,289, p =0.197) greater than .05 suggestions there were no differences between pre and post-test.

In terms of, Interest, the statistic is based on the positive rank, when the scores from post-test are bigger than the scores in pre-test, z =-2.271, and this value is significant at p = .023. This concludes that there is a significant increase on students' attitude toward difficult math tasks after implementing the program.

The distribution for Anxiety value were normal distribution, however, a paired t –test is used to test whether there was difference before and after implementing online gamified learning program on students toward difficult math tasks. Before using paired t- test, outliers have been checked. Outliers are appearing as little circle "o" or asterisk "*"with ID number. The circle indicates that there is an outlier and asterisk indicate extreme outliers. The Boxplots indicate that there were no outliers.
These two figures show that there is no outlier





Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			

Pair 1	Anxiety at pre-test - Anxiety at post- test	-.60000	3.37310	1.06667	-3.01297	1.81297	-.563	9	.588

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Anxiety at pre test	4.5000	10	2.59272	.81989
	Anxiety at post- test	5.1000	10	2.07900	.65744

The table showed that there was a no significant difference between Anxiety at pre-test (M = 4.5, SD= 2.59) and post-test (M= 5.1, SD= 2.07, t (10) = -.563, p= .588.

Appendix G: Phase 3 Data Collection

Teacher Technology Survey.

Teacher Survey on the use of Information and Communication Technology (ICT) into Primary Education Classroom

Your school has been selected to participate in this research study examining how Information and Communications Technologies (ICTs) are being used by Saudi primary teachers in teaching and learning processes.

The aim of the survey is to explore Saudi primary teachers' experience using ICT for teaching, their access to ICT infrastructure, support that is available to the teachers, ICT based activities and material used, difficulties in using ICT and finally teachers' skills and attitudes to the use of ICT in education.

Please be advised that the data gathered in this study will only be used for the purposes of research. The privacy of the participants will be protected by the anonymisation of all data – hence, none of the participants or work places will be identifiable. Data will be securely stored with access limited to the researcher and the supervisor, and will be securely disposed of within two years of completion of the research study. The green highlighting indicates a new question, and the yellow highlights where a question was modified.

The survey has 27 questions that can be easily answered by choosing the appropriate box/ boxes. It should take no longer than 17 minutes to answer the questions. Please note that by clicking on OK below, you are agreeing to participate in this research study.

Thank you for participating in this survey.

A. Information about the target class you teach

1. Do you currently teach:

Tick one box only:

- Girls only
- Boys only

2. How many students typically do you teach in a class?

Tick one box only:

- 10 or less
- 11-20
- More than 20

3. Which subject do you currently teach to the target class?

Tick one box only

- All subjects
- Language (Arabic or English)
- Mathematics
- Science
  - Islamic Studies
  - Art Studies
  - Other

4. What grade level do you currently teach:

Tick as appropriate

- Kindergarten
- Grade 1
- Grade 2
- Grade 3
- Grade 4
- Grade 5
- Grade 6
- Other

5. For how many hours a week do you teach the target class?

Tick one box only

- Fewer than 12 hours per week
- 12-18 hours per week
- 19 or more hours per week

B. Experience with ICT for teaching

6. Have you used computers and/or the Internet for the following activities in the last 12 months?

Tick one box for each row

Yes No

- Preparing lessons
- Class teaching in front of/with the students

*[If the answer to both items, or at least the second one is 'NO', respondents are directed to question XX about learning activities]

7. For how many years have you been using computers and/or the Internet at any school?
Tick one box only
- Less than 1 year
- Between 1 to 3 years
- Between 4 to 6 years
- More than 6 years

C. ICT access for teaching

8. Under which conditions do you have access to the following in lessons with the target class?

Tick one box for each row

	No Access	Access on Demand	Permanent access
Desktop computer without internet access			
Desktop computer with internet access			
Non-internet-connected laptop, tablet PC, netbook or mini			
notebook computer			
Internet-connected laptop, tablet PC, netbook or mini			
notebook computer			
E-reader (a device to read books and newspapers on screen			
Mobile phone provided by the school			
Interactive whiteboard			
Digital camera or camcorder			
Computer laboratory			

9. Has the school provided you with a laptop (or tablet PC, netbook, notebook) for your own use this school year?
- Yes
- No

10. Has the school provided students of the target class with a laptop (or tablet PC, netbook, notebook) for their own use this school year (1 to 1 type of initiatives)?
- Yes
- No

11. Are the target class students allowed to use the personally owned devices listed below at school for learning?
Tick one box for each row
Yes No
- Laptops, tablet, netbook, notebook
- Mobile or smartphone

D. Support to teachers for ICT use

12. Is participation in ICT training compulsory for a teacher in your subject?
- Yes
- No

13. In the past two school years, have you undertaken professional development in the following areas?
Tick one box for each row

	Yes	No
Introductory courses on internet use and general applications (basic word-processing, spreadsheets, presentations, databases, etc		
Advanced courses on applications (advanced word-processing, complex relational databases, Virtual Learning Environment etc		
Advanced courses on internet use (creating websites/home page, video conferencing, etc.		
Equipment-specific training (interactive whiteboard, laptop, etc.		
Courses on the pedagogical use of ICT in teaching and learning		
Subject-specific training on learning applications (tutorials, simulations, etc.		
Course on multimedia (using digital video, audio equipment, etc.		
Participate in online communities (e.g. mailing lists, twitter, blogs) for professional discussions with other teachers		
ICT training provided by school staff		
Personal learning about ICT in your own time		
Other professional development opportunities related to ICT		

14. Please indicate who has provided the teacher training:
Tick one box for each row

- Private Training company Yes No
- Public body – Government Yes No

15. In total, how much time have you been involved during the past two school years in the above professional development opportunities?

Tick one box only

- No time at all
- Less than 1 day
- 1-3 days
- 4-6 days
- More than 6 days

E. ICT based activities and material used for teaching

16. How often do you do the following activities with the target class?

Tick one box for each row

	Never or almost never	Several times a month	At least once a week	Every day or almost every day
Browse / search the internet to collect information to prepare lessons				
Browse or search the internet to collect learning material or resources to be used by students during lessons				
Use applications to prepare presentations for lessons				
Create your own digital learning materials for students				
Prepare exercises and tasks for students				
Post home work for students on the school website				
Use ICT to provide feedback and/or assess students' learning				
Evaluate digital learning resources in the subject you teach				
Communicate online with parents				
Download/upload/browse material from the school's website or virtual learning environment / learning platform				
Look for online professional development opportunities				

17. Which of the following types of materials/interactive content have you used when teaching the target class with the aid of a computer and/or the Internet?

Tick one box for each row

	Yes	No
Material that you've searched the Internet for		
Existing online material from established educational sources		
Material that is available on the school's computer network or database		
Electronic offline material (e.g. CD-ROM)		
Material provided by Ministry of Education		
Online game/s (for example: Minecraft. Mathletics, Haven math)		

F. Obstacles to using ICT in teaching and learning

18. Is your use of ICT in teaching and learning adversely affected by the following?
Tick one box for each row

	A lot	Partially	A little	Not at all
Insufficient number of computer				
Insufficient number of internet-connected computer				
Insufficient Internet bandwidth or speed				
Insufficient number of interactive whiteboard				
Insufficient number of laptops/notebook				
Insufficient skills to monitor learners' safe usage of Internet				
School computers out of date and/or needing repair				
Lack of adequate skills of teacher				
Insufficient technical support for teacher				
Insufficient pedagogical support for teacher				
Lack of adequate content/material for teacher				
Lack of content in national language				
Too difficult to integrate ICT use into the curriculum				
Lack of pedagogical models on how to use ICT for learning				
School time organisation (fixed lesson time, etc.)				
School space organisation (classroom size and furniture, etc.)				
Pressure to prepare students for exams and tests				
Most parents not in favour of the use of ICT at school				
Most teachers not in favour of the use of ICT at school				
Lack of interest of teachers				
No or unclear benefit to use ICT for teachers				
Using ICT in teaching and learning not being a goal in our school				
Concerns about students safely online				

***Re-direct from Question 13:**

G. Learning activities with the target class

19. To what extent do the following aspects of teaching and learning (with or without ICT) feature when teaching the target class?
Tick one box for each row

	A lot	Sometimes	A little	None
I present, demonstrate and explain to the whole class				
I support and explain things to individual students				
Students work alone at their own pace				
Students work in groups				
Students work on exercises or tasks individually at the same time				
Students give presentations to the whole class				
Students take tests and assessment				
Students are engaged in enquiry-based activities				
Students discuss ideas with other students and the teachers				
Students reflect on their learning				
Students participate in assessing their work.				

H. Teacher skills

20. To what extent are you confident in the following?
Tick one box for each row.

	A lot	Somewhat	A little	None
Produce a text using a word processing programme				
Use emails to communicate with other				
Capture and edit digital photos, movies or other graphics				
Edit text online containing internet links and images				
Create a database				
Edit a questionnaire online				
Email a file to someone, another student or teacher				
Organise computer files in folders and subfolder				
Use a spreadsheet				
Use a spreadsheet to plot a graph				
Create a presentation with simple animation function				
Create a presentation with video or audio clip				
Participate in a discussion forum on the Internet				
Create and maintain blogs or web sites				
Participate in social networks				
Download and install software on a computer				
Use online games/activities within the classroom				
Download or upload curriculum resources from/to websites or				
learning platforms for students to use				
Teach students how to behave safely online				
Teach students how to behave ethically online				
Prepare materials to use with an interactive whiteboard				

I. Teacher opinions and attitudes

21. Do you consider ICT use during lessons has a positive impact on the following?
Tick one box only for each line.

	Not at all	A little	Somewhat	A lot
Students concentrate more on their learning				
Students try harder in what they are learning				
Students feel more autonomous in their learning (they can repeat exercises if needed, explore in more detail topics that they are interested in, etc.				
Students understand more easily what they learn				
Students remember more easily what they've learn				
ICT facilitates collaborative work between students				
ICT improves the class climate (students more engaged, less disturbing)				

22. To what extent do you disagree or agree with each of the following statements about the use of ICT at school?

Tick one box for each row:

	Strongly Agree	Agree	Disagree	Strongly Disagree
a) ICT should be used for students to:				
○ Do exercises and practice				
○ Retrieve information				
○ Work in collaborative ways				
○ Learn in autonomous ways				
b) ICT use in teaching and learning positively impacts on students':				
○ Motivation				
○ Achievement				
○ Higher order thinking skills (critical thinking, Analysis, problem solving)				
○ Competence in transversal skills (learning to learn, social competences, etc.)				
c) ICT use in teaching and learning is essential to prepare students to live and work in the 21st century.				
d) For ICT to be fully exploited for teaching and learning radical changes in schools are needed				

J: Personal background information

23. Are you:
Tick one box only
- Female?
- Male?

24. What is your age?
Tick one box only
- 30 or less
- 31-35
- 36-45
- 46-55
- More than 55

25. Including this school year, how long have you been teaching (at any school)?
Tick one box only:
- Less than 1 year
- 1-3 years
- 4-10 years
- 11-20 years
- 21-30 years
- 31-40 years
- More than 40 years

26. How often do you use a computer for activities other than work (e.g. shopping, organising photos, socialising, entertainment, booking a hotel, contacting family and friends)?
Tick one box only

- Never
- A few times year
- Almost monthly
- Weekly
- Daily

27. Do you use a computer and the Internet to update your subject knowledge or undertake personal or professional development in any subject (i.e. whether or not related to the subject you teach)?

- Yes
- No

Thank you for completing this Survey.

Appendix H: Phase 3 Data Analysis Process.

Test of normality for some factors.

Tests of Normality				
	What is your gender?	Shapiro-Wilk		
		Statistic	df	Sig.
Students concentrate more on their learning	female	.827	12	.019
	male	.686	12	.001
Students try harder in what they are learning	female	.830	12	.021
	male	.668	12	.000
Students feel more autonomous in their learning (they can repeat exercises if needed, explore in more detail topics that they are interested in, etc.	female	.811	12	.012
	male	.731	12	.002
Students understand more easily what they learn	female	.811	12	.012
	male	.680	12	.001
Students remember more easily what they've learn	female	.828	12	.020
	male	.731	12	.002
ICT facilitates collaborative work between students	female	.746	12	.002
	male	.624	12	.000
ICT improves the class climate (students more engaged, less disturbing)	female	.859	12	.048
	male	.554	12	.000
Do exercises and practice	female	.802	12	.010
	male	.650	12	.000
Retrieve information	female	.824	12	.018
	male	.784	12	.006
Work in a collaborative ways	female	.784	12	.006
	male	.674	12	.000
Learn in an autonomous ways	female	.552	12	.000
	male	.781	10	.008
Motivation	female	.650	12	.000
	male	.327	12	.000
Achievement	female	.608	12	.000
	male	.465	12	.000
Higher order thinking skills (critical thinking, Analysis, problem solving)	female	.650	12	.000
	male	.552	12	.000
Competence in transversal skills (learning to learn, social competences, etc.)	female	.784	12	.006
	male	.679	12	.001
To what extent do you agree or disagree with: ICT use in teaching and learning is essential to prepare students to live and work in the 21st century	female	.608	12	.000
	male	.327	12	.000
To what extent do you agree or disagree for ICT to be fully exploited for teaching and learning radical changes in schools are needed.	female	.818	12	.015
	male	.552	12	.000

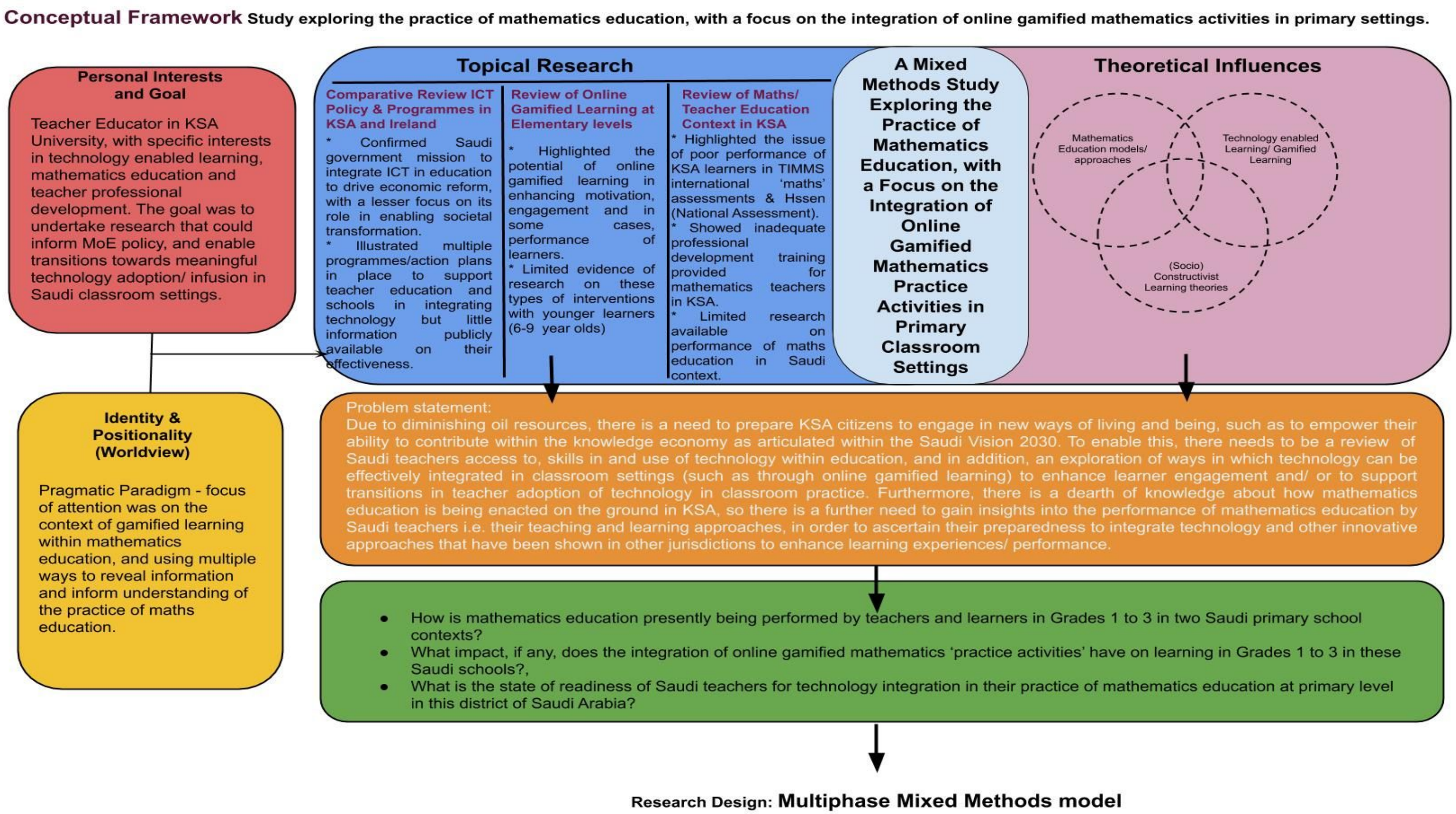
a. Lilliefors Significance Correction

The distribution of normality assessed by Shapiro-Walk test. The scales are used to test the differences between male and female opinions and attitudes. The above table showed that all scales value is less than .05 indicated that these scales are deviate from a normal distribution. In this case, Mann-Whitney U Test was used.

Sample of Mann-Whitney U Test between Tatweer teachers' opinion and attitudes on the impact of ICT on teaching and learning and Tatweer teachers' gender.

	i)Students concentrate more on their learning	ii)Students try harder in what they are learning	iii)Students feel more autonomous in their learning	iv)Students understand more easily what they learn	v)Students remember more easily what they've learnt	vi)ICT facilitates collaborative work between students	vii) ICT improves the class climate
Mann-Whitney U	55.500	53.000	54.000	54.000	51.000	62.000	45.000
Z	-1.025	-1.204	-1.113	-1.126	-1.299	-.634	-1.710
Asymp. Sig. (2-tailed)	.305	.228	.266	.260	.194	.526	.087
a. Grouping Variable: What is your gender?							

Appendix I: Conceptual Framework



Appendix J: Publication

Game-Play: Effects of Online Gamified and Game-Based Learning on Dispositions, Abilities and Behaviours of Primary Learners

https://link.springer.com/chapter/10.1007/978-3-319-74310-3_7