Developing the key skills of communication and working with others alongside scientific planning skills in the science classroom

by

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Declaration

I hereby certify that this material, which I now submit for assessment of the program of study leading to the award of MSc. is entirely my own work, that I have exercised reasonable care to ensure that the work is original and, to the best of my knowledge, does not 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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"Stand in awe of all Mná"

Abstract

This thesis examines the extent to which the key skills of working with others and communication can be integrated, developed and monitored within the science classroom while also developing student's scientific planning skills. The ability to communicate, to work as part of a team or independently are prerequisites for life and for the workplace in the 21st century as well as developing investigative skills that allow students to work like scientists. This research presents a new approach to the development and monitoring of the key skills of communication, working with others and scientific planning skills with Junior Cycle Science students through the use of a skills passport which monitors the development of the key skills and provides timely feedback. The researcher believes that students need to be proficient in the skills of COM and WWO in order to engage with and be successful at inquiry science which is the pedagogical method that underpins the junior cycle science specification and that these skills can enhance the development of scientific planning skills that are developed through inquiry science. This research study which lasted three years employed a case study design and was undertaken in an Irish secondary school and involved a sample of one hundred and nine participants split between six class groups over three phases. One group completed two years of the project and four groups completed one year of the project. One second year group didn't take part in the project but their EEI and interviews on their EEI projects were analysed. The outcomes of this study indicate that the key skills of communication and working with others can be developed and supported alongside scientific planning skills in the junior cycle science classroom and students who undertook two years of project showed clear development in the skills over this time and the benefits of engaging in the project were evident in the interviews at the end of year 1 and 2. Due to time constraints it was not possible to follow students for the 3 years of the junior cycle science programme, however future work could focus on the monitoring the development of skills and students interaction with the skills over three years and any implications on the students second CBA in third year.

Contents

List of Abbreviations

COM – Communication

IBL - Inquiry Based Learning

IBSE -Inquiry based science education

NCCA – National Council for Curriculum and Assessment

nJCSS- New Junior Cycle Science specification

NOS – Nature of Science

NRC – National Research Council

OECD - Organisation for Economic Co-operation and Development

PISA – Programme for International Student Assessment

rJCSS- Revised Junior Certificate Science Syllabus

WWO - Working with others

Chapter 1 Introduction

1. Introduction

International trends in education show a stronger focus on pedagogy, assessment and curriculum design that centres on developing the knowledge, skills, attitudes and values that students will need to thrive and shape their world (OECD, 2018). The OECD learning compass 2030 framework for education for the future, states that in order to protect the educational system it must be globally informed and focus on preparing students to meet the needs of rapid changes in society (OECD, 2020) and focus on developing and closing the skills gap in 21st century competencies. Students need to develop *"curiosity, imagination, resilience and self-regulation; they will need to respect and appreciate the ideas, perspectives and values of others; and they will need to cope with failure and rejection, and to move forward in the face of adversity*" (OECD, 2018). The mobilisation of knowledge, skills and attitudes is also highlighted in OECD learning compass 2030 as a key element of education (OECD, 2020). Disciplinary knowledge, epistemic knowledge and procedural knowledge should be transferable across a range of domains and the curriculum should be developed from "predetermined and static" to "adaptable and dynamic" (OECD, 2018).

1.1 Science Education in Ireland

Science, Technology, Engineering and Mathematics (STEM) Education has been recognised as important for the success of the Irish economy. The Department of Education report *STEM Education 2020 report "Reporting on Practice in Early Learning and Care, Primary and Post-Primary Contexts"* states that science education plays a crucial role in the development of life skills and scientific skills that play a key role in the future success of Irish industry and research and development (DES, 2020). This report also highlights that now more than ever it is apparent that STEM education is vital to the health and wellbeing of Irish citizens.

In recent years, concerns over the poor performance and decrease in interest in STEM subjects has been expressed by EU policy makers and in EU education committee reports (Rocard et al, 2007).

The OECD Programme for International Student Assessment (PISA) is an international survey of 15-year-old students that takes place every three years. PISA produces internationally comparable education ‘indicators’ (measures related to education systems) and is used by many countries to provide guidance on developing educational policy.

In 2006, science literacy was the focus of the assessment and the results showed that Ireland’s performance on the overall science scale is above the OECD country average by a small margin. As the results achieved were similar to results obtained in the 2000 and 2003 PISA test this suggested that the revised Junior Certificate Science Syllabus (rJCSS) which was introduced in 2003 had not yet led to any discernible improvement in students’ science achievement. In the 2006 PISA assessment, three science competencies were assessed and Ireland’s students scored above average on just one (‘identifying scientific issues’ (DES, 2007)). The findings suggest Ireland has relatively few students with minimal scientific literacy, but that there is room for improvement among higher performing students (DES, 2007). PISA 2018 showed that Irish students achieved a mean score of 496.1 in science literacy, which is significantly above the OECD average (488.7) and the mean score of their peers in the EU (484.0) (OECD, 2019). Between 2006 and 2018, the proportion of students who scored at Level 5 or 6 on the PISA scale (top-performing students) decreased by 3.6 percentage points, and the 90th percentile of the performance distribution moved down on the PISA scale by about 5 score points per 3-year period.

63% of countries (50/79 countries) that participated in PISA 2018 had scored lower than the OECD average for performance in science. Of these 50 countries, 15 attained below a level 2 indicating that students in these countries cannot correctly recognise the correct explanation for a familiar scientific phenomena or use knowledge to identify in simple cases, whether a conclusion is valid based on the data produced (OECD, 2019). This is a slight increase from the result of the PISA 2015 report; here 50% of the countries scored lower than the international OECD average (OECD, 2016). However, it is important to note that in PISA 2018 the proportion of items used to test students ability to apply scientific investigative skills in virtual experiments increased to reflect the growing emphasis on measuring students ability to apply scientific skills rather than their knowledge of facts (OECD, 2019). This increase in the number of students scoring below the OECD average may indicate that schools are placing a greater emphasis on knowledge of facts rather than on investigative planning skills in the science classroom.

In Ireland the STEM Education Policy Statement 2017-2026 (DES, 2017) sets out the objectives and actions required by those involved in education to help achieve and improve the STEM education experience and outcomes for all our learners. The policy which will be implemented over three phases from 2017 to 2026 sets out the ambitious vision for STEM education:

"In line with our ambition to have the best education and training service in Europe by 2026, Ireland will be internationally recognised as providing the highest quality STEM education experience for learners that nurtures curiosity, inquiry, problem-solving, creativity, ethical behaviour, confidence, and persistence, along with the excitement of collaborative innovation" (DES, 2017, p3).

The vision of the STEM Education policy is to focus on better educational outcomes for all learners, raise standards of teaching, learning, assessment and school improvement (DES, 2017). The policy highlights one of the challenges that exist is to:

"*Ensure that Irish students' learning in STEM disciplines significantly improves including the development of skills such as problem-solving, inquiry-based learning and team working to address demands from the world of work*" (DES, 2017, p3).

The STEM Education Policy has identified inquiry as an important pedagogy in science education, it states that "*STEM education that should provide learners with opportunities for real world and inquiry-based tasks*" (DES, 2020 p9) and teachers will "adopt *an inquiry-oriented approach to their teaching and learning*" (DES, 2020 p15). Inquiry based science education (IBSE) is also suggested as a possible solution to the problem highlighted by PISA 2018 and provide Ireland with the required graduates with STEM and life skills such as team work as well as the skilled workforce to fulfil existing and growing needs.

1.2 Junior Cycle Science in Ireland

In Ireland, the framework and curricula for lower second level education, referred to as Junior Cycle, for students aged 12-15 years, has undergone significant revision over the last decade with new syllabus introduced in schools since September 2014. The new framework for Junior Cycle gives schools greater flexibility to design programmes that are suited to the needs of their junior cycle students and to the particular context of the school (DES 2015). The new Junior Cycle subject curricula place greater emphasis on the development of 21st century skills and the preparation of students to work in an ever-changing working and learning environment. The new curricula recognise that students need a wide range of skills to face the complex challenges of today's society, such as, the ability to communicate, to work as part of a team or independently and to be able to be a reflective practitioner are a prerequisite for life and for the workplace in the 21st century.

As a school subject, science has evolved over the last 100 years, "…*its original purpose has tended to remain the predominant determinant of the content and means of teaching and learning"*. (UNESC0, 2008, p15). Over the years many changes have taken place to the Irish Junior Cycle science curriculum and each time the changes focused less on the scientific content and more on the complex relationships between science, technology, society and the environment (Orpwood, 2001). Changes to science curricula and assessment often seek to promote a particular approach and over the past three decades the use of an inquiry-based learning (IBL) pedagogy has been widely promoted.

Over the past thirty years, the Irish Junior science curriculum has had three major revisions in Ireland. In 1989, the Junior Certificate Science Syllabus was presented as a list of content, which was intended to be taught and learned with an emphasis on student's experiences of science as a practical activity (DES, 1989). The 1989 syllabus placed very little emphasis on practical work, to resolve this issue a new syllabus was introduced into schools in 2003. The 2003 revised Junior Certificate Science Syllabus (rJCSS) focused on "a *movement towards doing rather than simply observing and learning off science" (*NCCA, 2006, p3). An investigative approach was at the heart of this new syllabus. Eivers, Shiel, & Cheevers (2006) noted that: "*The revised Junior Certificate Science Syllabus (rJCSS) [places]…greater emphasis on student investigation and practical work, designed to help students develop an understanding of science concepts, as well as acquire the necessary science process skills*" (p. 3). However the Chief Examiners report for 2010 revealed that students were not engaging with the new examined practical element of the course (Coursework B) and that the *presentation of similar coursework by a number of candidates is a cause for some concern* (SEC, 2010, p28). It was also highlighted that: "*In some schools, students were not learning about Science in an investigative way, as required by the syllabus"* (DES, 2003, p37). Many teachers felt there was an overemphasis on rote learning, and little time to examine practical concepts (Cheevers, Eivers & Sheils, 2006). The Irish Chief Examiners Report for Science in 2010 also highlighted that only 0.6% of students were opting for an investigation of their own choice (SEC, 2010). This indicated that students were not engaging with the inquiry and investigation element of the 2003 syllabus and that the rationale for conducting students' investigations focused on reaching particular conclusions rather than focusing on the development of specific scientific skills and practices.

The new Junior Cycle Science specification (nJCSS) was implemented in 2016 and differed from its predecessor in a number of ways, including the addition of Classroom Based Assessment (CBA's), development of 21st century skills, grounded in the inquiry approach to science, and the addition of the earth and space strand and the Nature of Science element. With the introduction of the new science syllabus the NCCA (2013) have stated that:

> *"The focus in science education has moved away from the acquisition of a wide range of science context to the development of a limited number of core scientific ideas which provide a context for students to continually build on and revise their scientific knowledge and skills as they progress in their learning" (NCCA, 2013* p 18).

The nJCSS curriculum places a greater emphasis on the use of an inquiry based approach to science education and states explicitly in the rationale and aims that the new curriculum should be grounded in inquiry: *"Learning science through inquiry enables students to ask more questions, and to develop and evaluate explanations of events and phenomena they encounter"* (NCCA, 2016, p.4). An inquiry approach can enable students to ask more questions, work collaboratively and creatively, increases motivation and provides ample opportunities for group work and the development of scientific planning skills (Llewellyn, 2005).

In line with international trends and influenced by the Lisbon strategy and the 2005 OECD DeSeCo (Defining and Selecting Key Competencies) Initiative, the Irish National Council for Curriculum and Assessment (NCCA) developed a framework of key skills. This framework forms a major part of the Junior Cycle programme of teaching and learning. According to the OECD DeSeCo, Key Skills are determined by the psychosocial prerequisites for a successful life and well functioning society and by the nature of our goals, both as an individual and as a society (OECD, 2005). The NCCA identified eight skills that they believed to be an important feature and be central to teaching and learning at Junior Cycle these include being literate, managing myself, staying well, managing information and thinking, being creative, being numerate, communication and working with others (NCCA, 2012). The NCCA considers that the development of key skills plays a major part in students reaching their potential during their time in secondary school and in their future.

1.3 Focus of this research

This research focuses on the link between two of the key skills adapted from the NCCA definitions, Communication and Working with Others and the development of planning skills in the Junior Cycle Science classroom. How to develop and monitor the development of these key skills in terms of day to day learning and assessment is clearly not universally agreed by policy makers and this poses an issue for teachers. This lack of clarity poses further questions as to how best to develop these skills so as to support Inquiry in the classroom while developing scientific planning skills and scientific content, as required by the Junior Cycle Science curriculum.

This research presents a new approach to the development and monitoring of the key skills of communication, working with others and scientific planning skills with Junior Cycle Science students over a three year period. The school in which this research took place did not have assessment policies in place to monitor/assess these skills and it is the researchers belief that if the development of these skills is not supported by appropriate assessment then the teaching of such skills will not be treated as a priority. This research aims to investigate whether the key skills of working with others and communication can be integrated, developed and monitored within the science classroom while also developing student's scientific planning skills. This thesis will address the research question:

> ***To what extent are student's key skills of communication and working with others developed alongside scientific planning skills in a junior cycle science classroom?***

1.4 Pedagogical approach of the researcher

During this research study, the researcher was working as a science department head and as a guidance counsellor in an Irish Second level school. Her role as a guidance counsellor involved interaction with employers who voiced concerns that the school curricula do not fully prepare students to live and work in an ever-changing society and brought to the forefront the importance of students to develop both the skills of COM and WWO while at second level. Her experience as a science teacher highlighted that these skills are also important if inquiry is to be successfully implemented in the science classroom. This led to an interest in determining if developing the skills of COM and WWO in the science classroom would enhance the development of inquiry planning skills and how the development could be monitored.

As a teacher of over 13 years her pedagogical approach had evolved from teaching as telling to teaching for understanding. Over the past 13 years she has adapted, adjusted and made professional judgements in response to how her students learn. Her pedagogical approach is underpinned by a constructivist approach to learning with a focus on social constructivism theory. The research approach taken by the researcher was a mixed method single embedded case study that sought to gain an understanding of the extent in which key skills of communication and working with others are developed alongside scientific planning skills in the junior cycle science classroom. The quantitative and qualitative data collected allowed for a more complete understanding of the case

First, it is important to outline the classroom environment as this is conducive in implementing any pedagogical approach. There is a positive relationship between the researcher and her students. The researcher takes her time to get to know all her student's strengths and background information. Her dual role as a Guidance Counsellor provides her with the skill necessary to do this successfully. By focusing on the student's strengths and building this into their learning students become more engaged with the subject and interest is increased allowing for the development of a student-centred classroom. The atmosphere in the science classroom is relaxed, encouraging and positive, attributes that she believes are important to foster classroom discussions and group work. Students' classwork and project boards are displayed around the lab, fostering a sense of belonging and feeling valued.

Constructivism learning theory suggests that learners construct knowledge and form meaning based upon experience, therefore students learn by doing (Burner, 1990). As an important element for the researcher is to instil the skills students need to work like scientists, the constructivist approach is a suitable approach. This approach manifests in the researcher classroom through the design and use of curricula that allows for extended investigations which motivate and engage the students. By doing this the researcher can align the students' thinking processes and activities with those of real scientists. Students mimic real scientists by developing their own research questions, designing ways to investigate their questions and collaborating with others. A key element to this pedagogy approach is reviving the student's innate and intrinsic instinct of "play". When an activity/investigation is introduced students are given time to explore and design. No step by step procedure is given, just a blank sheet with headings to guide them (Question, Hypothesis, procedure, equipment, variables, results and conclusion). Students then plan, design and carry out an investigation. We will now focus on what happens in the researcher's classroom, looking at first year, scaffolding is used to help students to meet the criteria for each heading, or they may be given the research question but by the end of second year these investigations are open ended. When students are carrying out the investigations the researcher's role is to facilitate the group discussion, partake in dialogue with the students to help them construct their own knowledge, question students on their approach to the investigation and give oral feedback on their investigations. Depending on the time dedicated to the investigation students will be given the opportunity to carry it out and redraft their procedure for homework and carry it out again in the next class. Due to time restraint on some investigations a discussion will be had about how they could have made the investigation better or any errors which occurred.

When incorporating these types of activities it's important that their aim is not to break up the normal routine but to use activities that she is aware will enhance students' learning of concepts, scientific skills and content. Depending on the content being covered, and the students experience and ability, the lesson approach can range from students following the lead of the researcher and investigations chosen by the researcher to lessons in which students choose their own investigation but based around content that was covered. But the element of play is always included.

In lessons in which content is only covered, ICT is used, discussions and mini whiteboards are also used to engage students and spark interest in the topic. Lecturing style teaching in which the teacher just talks is replaced by students using I-pads to carry out research and gather information, watch videos and mini whiteboards are used as a tool to facilitate students understanding and to jot down answers to questions posed by the researcher. Note taken is now limited in the classroom and all information is explained in class or read by students at home and uploaded to an information platform for them to access.As the development of knowledge and problem solving relies heavily on social interaction of peers, group work plays an important role in the researcher's classroom. If we want students to mimic and act like scientists, they need scientific planning skills but also 21st century skills. Two skills are focused on, the skill of communication and working with others. Both are essential if inquiry science is to take place.

Students carry out all classroom activities and projects in groups. Most lessons and in particular the lessons that have activities/investigations these key skills are embedded. At the start of the year the sub-elements of each skill are explained to students and examples of each given to the student at the start of the year and during lessons in which they are practiced. These skills are displayed on the wall in the lab allowing the researcher to draw attention to them at any stage. Each student has a skills passport in which formative feedback is received from peers, and oral formative feedback is received from the teacher. During investigations good and bad examples of the skill are highlighted and questions are posed to students about why these are good and bad examples or how they could be improved. By highlighting these skills and providing feedback the aim is that students will naturally begin to be more concise of using the skill. The researcher believes that students need to be proficient in the skills of COM and WWO in order to engage with and be successful at inquiry science and that these skills can enhance the development of scientific planning skills that are developed through inquiry science. Hence these key skills of COM and WWO were chosen as the focus of this piece of research.

1.5 Thesis layout

This thesis comprises six chapters. This thesis adopted a methodological approach to planning and implementing a new pedagogical approach with first and second year science students (aged 12-14 years) to address the research question: To what extent are student’s key skills of communication and working with others developed alongside scientific planning skills in a junior cycle science classroom?

Chapter 1 provides an overview of recent changes in international education along with an introduction to curricular changes at lower secondary level in Ireland. The motivation and objectives for this study are presented along with the researcher’s pedagogical approach. Chapter 2 presented the theoretical basis for this research study. The background for inquiry science, how it's implemented and evaluated in the science classroom. The second section of the chapter discusses the key skills they are defined, implemented and assessed. The methodology used for this research project is discussed in Chapter 3. The initial design of the teaching and learning units along with details of how the key skills were monitored and analysed are outlined.

Chapter 4 discusses the implementation and evaluation of the approach adopted with first year science students and presents the findings from this study. In particular changes made to the approach adopted as a results of key findings from the initial implementation will be highlighted. Chapter 5 discusses the implementation of the approach adopted with second year science students. Chapter 6 summarises the findings from implementation of this pedagogical approach with first and second year students (chapter 4 and 5) and presents recommendations for further studies and classroom practice.

Chapter 2 Theoretical Basis

2 Introduction

Today's science students are expected to acquire inquiry abilities and skills which can be relevant to their everyday lives (Baur & Emden, 2021). The development of key skills has been an essential feature of the lower second level (Junior Cycle) curriculum (students aged 12-15 years) in Ireland in recent years. These changes have been embedded and communicated through the statements of learning and curriculum specifications. Teachers are expected to embed the development of key skills into classroom planning, pedagogical approaches and assessment of learning (NCCA, 2012).

Currently in Ireland, there is a national focus on STEM education in both the early year's settings and primary/second level schools to ensure that Ireland has an engaged society and a highly-skilled workforce in place. The policy states:" Teachers *and early years practitioners will adopt an inquiry-oriented approach to their teaching and learning, and their practice will be informed by their engagement in and with relevant research*" (DES 2017, p.15). The reforms underway in the Irish education system recognise that young people require more than the ability to memorise facts and procedures. They must also be able to apply their creativity, knowledge and skills within and across disciplines and in real life situations (DES, 2017). Ireland's STEM education policy 2017-2026 focusses on the range of strengths in STEM education while providing a roadmap to address the areas for development.

The new Junior Cycle Science Specification (nJCSS) for lower second level has been rolled out In Ireland since 2016, this new specification moved away from mainly deductive towards a more extensive use of inquiry-based methods. For the first time inquiry was mentioned in the new science specification as an appropriate teaching methodology to achieve the aims and objectives of the course. Although the new specification allows teachers to employ a variety of teaching strategies depending on the targeted learning outcomes, the needs of their students, and their personal preference, it states inquiry as an appropriate teaching pedagogy. According to the draft specification which was published two years before the new junior cycle science specification was introduced, the rationale of including inquiry is "*to enable students to ask more questions, and to develop and evaluate explanations of events and phenomena they encounter*"

(NCCA, 2015, p5). The aim of the nJCSS specifies that it encourages students to "*to develop a scientific habit of mind and inquiry orientation through class, laboratory and/or off-site activities that foster investigation*" (NCCA, 2015, p7).

This research study focuses on the development and monitoring of the key skills of communication and working with others alongside scientific planning skills of first and second year Junior Cycle Science students. The National Council for Curriculum and Assessment (NCCA) defines communication as a skill that *"helps learners develop good communication skills in all aspects of life, using a variety of media. As well as developing literacy skills it also develops learners' confidence in communicating, expressing opinions, writing, making oral presentations and performing* (NCCA, 2012, p4)" and working with others as a skill that "*helps learners develop good relationships and to appreciate the value of cooperating to reach both collective and personal goals. Students also learn to value diversity and to engage in collaborative work aimed at making the world a better place*2 (NCCA, 2012, p4).

Section 2.1 presents an overview of inquiry based learning (IBL), its role in science education and what inquiry skills have been identified. Section 2.2 discusses what key skills have been highlighted in literature and in international education reports and in particular presents how the key skills of communication and working with others are defined. Section 2.3 discusses approaches to assessing/monitoring skills in science education. The researchers' view on developing/monitoring skills in science is discussed in Section 2.4. Section 2.5 presents the research questions of this thesis.

2.1 Inquiry based learning

This section introduces the origins of Inquiry Basel Learning (IBL) and how it is defined in literature. The levels of inquiry, inquiry cycles and the features of inquiry will be discussed in detail.

2.1.1 What is Inquiry Based Learning?

For the past half century, teaching science as inquiry has been widely promoted in the field of science education (Bruner, 1961). The philosophy of inquiry based learning is based in constructivist learning theories, as described in the work Piaget, Dewey, Vygotsky and Schwab (Bell, 2010). Jean Piaget felt that the main goal of education must not create students who repeat what other have done but to support and help develop students who "*are capable of doing new things…who are creative, inventive and* *discoverers, who can be critical and verify, and not accept, everything they are offered" (*Jervis & Tobier, 1988

John Dewey developed the model of learning known as "the pattern of inquiry" (Dewey, 1938) and was the first to use the word inquiry in education "*Scientific principles and laws do not lie on the surface of nature. They are hidden, and must be wrested from nature by an active and elaborate technique of inquiry*" (Dewey, 1920). While Dewey was the first person to draw attention to the fact that science should be taught as a process and not facts that should be memorised, it was in fact Schwab who believed that science in the classroom should more closely reflect the work of practicing scientists. Joseph Schwab (1966) suggested teaching "science as inquiry" is important in order to produce proficient scientists, able policy leaders, and an informed public. Schwab developed three levels of open inquiry that align with the breakdown of inquiry processes that we see today. His levels differed depending on whether a task provides a problem and method (level 1), only the problem (level 2), or none of these (level 3) (Schwab, 1966).

The use of inquiry-based learning (IBL) in science education has been reported to develop student understanding through investigation and exploration activities (Jeffery et al., 2016; Dudu & Vhurumuku, 2012). Several studies have emphasised that inquiry is an essential component of science learning (Constantinou et al., 2018; Minner, Levy, & Century, 2010; Rocard et al., 2007). Contemporary science reform emphasises that inquiries in science teaching are of great importance and students should be taught science by means of inquiry (Teig et al., 2018, Harlen, 2013).

Inquiry-based science education (IBSE) has been advocated as a common curriculum goal in school science worldwide (Ramnarain, 2016). According to Baur & Emden (2021), students are expected to develop inquiry abilities and skills which can be relevant to their everyday lives. In this view, learning is the process of becoming a member of a community of practice. It is less about acquiring and having knowledge, and more about becoming able to participate in activities which are valued by a community, communicate using the language of that community, and act in ways which conform the community's norm (Aditomo & Klieme, 2020). The value and necessity of IBSE in the current education context are captured by Harlen (2013), who emphasised the need for inquiry-based science education:

> *"The value of IBSE is not a matter that can be decided by empirical evidence, but it is a value judgement that the competences, understanding, interest and attitudes*

> *that are its aims are worthwhile and indeed are necessary in a modern education"* (2013, p. 4).

An IBSE approach provides opportunities for students to design investigations and answer their own inquiry questions, thus allowing students autonomy over their own work. In addition, it provides students with an opportunity to carry out research, solve real-world problems and make sense of their results.

> *"Inquiry-based STM education includes students' involvement in questioning, reasoning, searching for relevant documents, observing, conjecturing, data gathering and interpreting, investigative practical work and collaborative discussions, and working with problems from and applicable to real-life contexts.*" (Anderson, 2002).

This view of the benefits of inquiry are well promoted, that is, approaches that provide students the opportunity to inquire by asking scientifically oriented questions, collect and analyse evidence from scientific investigations, develop explanations of scientific phenomena, and communicate those explanations with their teacher and peers. However there has been much variation in how inquiry based learning is defined. In the National Science Education Standards of the National Research Council (NRC, 1996), the following definition of inquiry was used (p.23):

> *"Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other source of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.*"

Linn, Davis and Bell (2004, p. 4) defined inquiry in terms of the learning processes that students are involved in:

> "*Inquiry is the intentional process of diagnosing problems, critiquing experiments and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments*."

A range of definitions for inquiry have been summarized by Kahn & O'Rourke (2005) and the authors highlighted that they all have common features, such as:

- "*Engagement with a complex problem or scenario, that is sufficiently open-ended to allow a variety of responses or solutions;*
- *Students direct the lines of inquiry and the methods employed;*
- *The inquiry requires students to draw on existing knowledge and identify their required learning needs;*
- *Tasks stimulate curiosity in the students, encouraging them to actively explore and seek out new evidence;*
- *Responsibility falls to the student for analysing and presenting that evidence in appropriate ways and in support of their own response to the problem.*" (Kahn & O'Rourke, 2005)

An inquiry approach is consistent with modern views of the psychology of learning, as it is student centred and sees the student as having an active role in their own learning. However, while psychologists and educational scientists seem to converge on the notion that student involvement is critical to successful learning, there is much debate around how students should be facilitated in the learning process. Bao & Koenig (2019) report:

> *"Based on a century of education research, consensus has settled on a fundamental mechanism of teaching and learning, which suggests that knowledge is developed within a learner through constructive processes and that team-based guided scientific inquiry is an effective method for promoting deep learning of content knowledge as well as developing high-end cognitive abilities".*

2.1.2 Inquiry based science education

In the past decade, serious concerns have been raised about the status and the impact of science education and the decrease of students' interest for the associated science disciplines (Engeln et al., 2014). Across Europe, there is a growing concern that low levels of scientific literacy will impede young people becoming active and responsible citizens (Constantinou et al., 2018). Reports by European Expert Groups have emphasized the need for renewed pedagogies that move away from the traditional mainly deductive teaching styles towards more engaging and cognitively activating forms of teaching (Rocard, 2007; Engeln et al., 2014). Inquiry has played a prominent role in science education reforms worldwide over the past two decades (Crawford, 2014; Furtak & Penuel, 2019). Educational policy bodies worldwide regard inquiry based learning as a vital component in building a scientifically literate community (Rocard et al, 2007; NCCA, 2012) and have been recognized to be appropriate to address the many societal and educational challenges (Rocard et al, 2007). In Europe, expert groups have identified the "inquiry approach" as a

> "*complex process of sense-making and constructing coherent conceptual models where students formulate questions, investigate to find answers, build new understandings, meanings and knowledge, communicate their learning to others and apply their learning productively in unfamiliar situation*" (Beernaert et al., 2015, p. 68).

The inquiry approach provides students with an opportunity to engage in problem based learning, 'hands on' activities and experimental procedures as well as providing an opportunity for students to work with and communicate with peers (Constantinou et al., 2018). Government objectives are committed to encouraging young people into the sciences by improving science teaching (Constantinou et al., 2018). As a result, many educational European programs and projects have been implemented to improve the quality of science education and focus on ways to foster inquiry based approaches in the field of science education. The establishment of inquiry based teaching and learning is an educational policy priority in Europe and this can be seen through the funding of research projects grounded in inquiry based teaching and learning (e.g. ESTABLISH, SAILS, PATHWAY, FIBONACCI, PRIMAS and others as reported in Beernaert et al., 2015).

2.1.3 Levels of Inquiry-Based Learning

Literature reports on different levels of inquiry learning. Schwab (1966) suggests students should ascend through three different levels of openness depending if a task provides a problem and method (Level 1), only the problem (Level 2), or none of these (Level 3) (Schwab, 1966). Herron (1971) adopts this approach but adds a 'zero level' which proves the problem, method and answer to the problem. The most widely accepted classification is the one by Colburn (2004). According to Colburn (2004), there are three main types of inquiry-based learning: structured inquiry, guided inquiry and open inquiry. These three levels allow a teacher to navigate their way through inquiry-based learning, starting with structured inquiry activities and then gradually moving towards open inquiry. As students cannot be expected to have the ability to design and carry out investigations without practice, these levels provide different amounts of guidance which allows students to develop their planning skills and move towards deeper scientific thinking and planning.

Table 2.1, taken from Banchi & Bell, 2008, summarises the level of information given to students depending on the inquiry level they are engaging with.

***Table 2.1*: The three levels of inquiry and the information given to the student at each level (Banchi & Bell, 2008)**

Inquiry Level	**Guiding Question**	**Procedure**	**Outcome**
Structured Inquiry – Students investigate a question provided by the teacher using a given procedure	Given	Given	Not predetermined
Guided Inquiry – Students investigate a question provided by the teacher by designing or selecting their own procedure	Given	Not given	Not predetermined
Open Inquiry - Students investigate questions that are students generated and design or select their own procedure	Not given	Not given	Not predetermined

What is clear from Table 2.1 is that the higher the level the more independent the student is from the teacher and their instruction:

Structured inquiry is along the lines of traditional teaching methods. In a structured inquiry classroom the teacher leads the students as they work through the task that is provided. The teacher will provide all the material needed, the question being researched, detailed instructions on how to complete the task and the research method (Banchi & Bell, 2008). This is a very convenient method for teachers and is seen in many classrooms. However, this approach results in a student who is not actively engaged and becomes demotivated during the process.

Guided inquiry is seen as a combination of structured and open inquiry. The teacher will provide a level of guidance to the students in choosing materials, provide resources and set up the problem to be investigated by asking questions. Unlike structured inquiry, the teacher does not directly give information to the student but allows the student to devise their own procedure to solve a problem, create solutions and make generalisations. This allows the student to gain inquiry skills that will make them independent in the future. Therefore, the activity of asking questions is done by the teacher and the activities of planning the process and acquiring results are done by students (Colburn, 2000; Colburn, 2004; Gormally et al., 2011).

Open inquiry allows the student to take ownership over their own learning and decide what is important in the subject that they are learning. The activities of asking questions, planning the process and reaching conclusions are done by the students, and they are directly responsible for their own learning (Blanchard et al., 2010; Llewellyn, 2002). This approach is completely student centred and provides students with the opportunity to work like scientists. For the students, this approach requires a high level of self-discipline and comfort with self-directed learning and students should be comfortable with guided inquiry before embarking on open inquiry. Yet, concerns are raised regarding whether all levels of students have the capabilities to do inquiry learning to develop conceptual understanding without scaffolding (Song & Kong, 2014). To summarise, structured inquiry is for beginners, guided appears to be the most effective as it provides a level of scaffolding and open is the most creative.

2.1.4 Inquiry Cycle

Inquiry based learning is often organised into inquiry phases that together form an inquiry cycle. Inquiry cycles allow for complex scientific processes to be divided into smaller units. These units are connected logically and aim to guide students and to focus attention to important features of scientific thinking. These units are called inquiry phases and the inquiry cycle refers to how the phases are connected. Although the term inquiry cycle may suggest an order of sequences of phases, it is important to note that inquiry-based learning is not a prescribed, uniform linear process. The inquiry cycle is used as a guidance tool. A review of the educational literature presents a variety of inquiry phases and cycles, such as the 5E Learning Cycle Model (Bybee et al., 2006). This model is based on Piaget's cognitive development model. It was shaped by constructivist learning. The 5E Learning Cycle consists of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation (Bybee et al., 2006). The 5E Learning Cycle is seen as an effective hands-on, minds-on, inquiry-based scientific pedagogy, especially for enhancing understanding (Bybee et al., 2006; Stamp & O'Brien, 2005). The 5 steps for the 5E learning cycle are illustrated in Figure 2.1. It should be noted that the stages of the cycle are somewhat flexible.

***Figure 2.1*: Summary of steps in 5E Learning Cycle (Adapted from Bybee, 2006)**

1. Engage: At this stage the scene is set for the problem to be investigated. A general topic, phenomenon or question is selected to investigate and ignite the interest of the student. This stage is important as it stimulates curiosity among students and invokes their enthusiasm for learning.

2. Explore: At this stage, research groups are decided, roles divided among the group. The students formulate an inquiry question to explore, they generate an hypothesis, formulate a plan, select materials needed, determine the variables, collect data, analyse data, check the validity of their hypothesis, put forth their ideas by working collaboratively, broaden their perspectives by listening to others and move towards creative thinking.

3. Explain: Once the students have explored the concept, the teacher asks questions and makes scientific explanations for the phenomenon they have experienced.

4. Elaborate: This stage provides an opportunity for students to apply what they have learned to new situations. By doing this it makes what is learned more meaningful, and helps students develop a deeper understanding of the concept.

5. Evaluate: In the evaluation stage, students get the opportunity to review and reflect on their own learning, and their work is examined and evaluated.

Another inquiry cycle proposed by White & Frederiksen (1998) also identifies 5 inquiry phases but labels them as Questions, Predict, Experiments, Model and Apply. The main distinction between these two models is the difference in the initial phase. The 5E learning cycle suggests starting with an inductive approach (Engagement & Exploration), whereas the first 2 phases of the White & Frederiksen inquiry cycle suggest a deductive approach (Question & Predict). However, induction and deduction can coexist in the inquiry cycle. A comprehensive literature review of inquiry-based learning framework was carried out by Pedaste et al. (2015). During this review different variations on the inquiry cycle were studied. Pedaste et al., (2015) reviewed 32 different articles which described inquiry phases and the inquiry cycle. The review process resulted in 109 different terms for inquiry phases and due to overlap, they were able to condense the 109 down to 34 inquiry processes. The 34 inquiry processes were then organised into 11 prospective phases and finally merged into 5 general inquiry phases. This complete analysis of the descriptions and definitions of inquiry cycle and phases resulted in a more contemporary view of IBL which combined the strengths of existing IBL frameworks and developed a new inquiry-based learning framework that now included 5 general inquiry phases: Orientation, Conceptualisation, Investigation, Conclusion & Discussion.

2.1.5 Features of Inquiry Based Learning

Many researchers have shown that hands-on activities incorporating inquiry improve science process skills (Turpin & Cage, 2004). Some of the purported benefits of inquiry based learning for students include: improving attitude towards science (Brownell et al., 2012), stimulates interest in science (Mupira and Ramnarain, 2018), improves understanding of concepts (Gott and Duggan, 2002), leads to an understanding of the nature of science (Gaigher, Lederman, and Lederman, 2014), supports the development of higher order thinking (Conklin, 2012), and facilitates collaboration between students (Hofstein & Lunetta, 2003). In a meta-analysis of science inquiry teaching research, there were substantial effects on students' cognitive achievement, attitude to science and process skills following inquiry instruction (Shymansky, et al., 1983). In another meta-analysis on the effects of various science teaching strategies on achievement, the effect size was also in favour of inquiry teaching for the cognitive outcomes of the students (Wise & Okey, 1983).

During an IBL lesson, students learn by using cause and effect, relational and critical thinking and combining both scientific knowledge and operation (Bianchini & Colburn, 2000). The instructive approach of IBL allows students to acquire new information and to improve their analytic and critical thinking skills by discovering and investigating problems in an authentic setting (Hwang & Chang, 2011). The development of critical thinking skills is important as it allows students to draw upon many different resources to explain events and predict outcomes (DiPasquale, Mason & Kolkhorst, 2003). A synthesis of 72 studies carried out by Lazonder & Harmsen (2016) showed that, in order for inquiry to be implemented in the classroom successfully, guidance is pivotal. Guidance allows the learner to act more skilfully during the task, and hence they are more successful in obtaining topical information from their investigations, and score higher on tests of learning outcomes administered after the inquiry.

Further studies are quoted briefly in the next few paragraphs to highlight the range of topics covered and skills developed through inquiry education projects:

A study carried out by Duran & Dokme (2016) showed that science and technology classes taught with an IBL approach have a more positive impact on a student's critical thinking level when compared with lessons taught with the constraints of the course book. These findings concur with the findings of other studies (Mecit, 2006; Wu & Hsieh, 2006). Research conducted by Wilson et al., (2010) involved 58 students from 24 schools. Participants completed a module about sleep, sleep disorders and biological rhythms. Some of the participants received inquiry based instruction and the rest were taught using traditional methods. It was found that the inquiry students obtained significantly higher levels of achievement than those who received traditional instruction. Inquiry approaches were found to be more successful at developing the students' knowledge, scientific reasoning and argumentation (Wilson et al., 2010). Damopolii et al. (2021) have reported on the effects of inquiry-based science learning on a student's level of thinking. Students' thinking levels between classes before and after the implementation of inquiry based science learning were measured using the five levels of SOLO taxonomy. The study showed that inquiry based learning had a better effect on the level of thinking of students than conventional learning (Damopolii et al., 2021).

Although the benefits of using inquiry in the classroom have been highlighted by many (NRC, 1999; Hwang & Chang, 2011), there has been some criticism about the use of inquiry instruction in the classroom. The use of inquiry instruction in the classroom has been challenged by Kirschner, Sweller & Clarke, 2006. They believe that the inquiry approach ignores the structures that constitute human cognitive architecture and therefore is not likely to be effective. Kirschner et al (2006) believes that minimal guided instruction such as inquiry "*appears to proceed with no reference to the characteristics of working memory, long-term memory, or the intricate relations between them* "(pg. 76). This paper also highlighted that one of the major flaws of inquiry was that inquiry doesn't make a distinction between the approaches and methods of research of an expert practicing a profession and students who are "essentially novices". Schmidt et al., (2007), provided a commentary on Kirschner et al.'s work. They agreed with the fact that minimally guided instruction may not be suitable for novices; however they disagreed that it is entirely ineffectual. International large-scale assessments (ILSA) have inquiry to be associated with lower science achievement (Cairns & Areepattamannil, 2017; Chi et al., 2018; Grabau & Ma, 2017) however , according to Sjoberg (2017) IBSE relates positively to interest in science, epistemic beliefs and motivation for science-oriented future careers

Other studies have demonstrated that science teachers encounter considerable challenges in implementing inquiry in their classrooms (e.g. Chichekian & Shore, 2016; Crawford, 2014). Intrinsic factors such as teachers' lack of content knowledge or extrinsic factors such as school ethos, teacher supports, resources, time, class sizes or assessment demands can impede the implementation of inquiry in the science classroom (Bansal & Ramnarain, 2021).

2.2 Key skills

This section introduces the literature on 21st century key skills with a focus on the skills of communication and working with others and the key skills in junior cycle science.

2.2.1 21st Century skills and competencies

Since the 1990s, the inclusion of key skills as an outcome of education has been discussed globally, predominantly in the context of the changing skills required for employment. Individuals need a wide range of skills to face the complex challenges of today's society and changing workplace. Some of the skills needed in order for learners to succeed in the 21st century workplace are not included explicitly in many curricula. However, many reports highlight the need to focus on the development of 'Key Skills/competencies' in order to improve the quality of student engagement and preparation of the next generation of workers.

The interest in these skills is growing amongst education authorities. A UNESCO rapid assessment found that "*almost 90 countries… refer to generic competences in their general education curricula*" (Tedesco, Opertti & Amadio, 2013, p. 11). A scan of 152 countries for the Brookings Institution in 2017 showed that 117 countries (76 per cent) identify specific skills somewhere within their national policy documents, 71 (47 per cent) within the curriculum, and 58 (38 per cent) within mission and vision statements (Roth, Kim & Care, 2017; Care et al, 2016)

The move towards the inclusion of skills in school curricula became evident in the 20th century when many authorities began identifying skills needed for the 21st century. Although core knowledge and concepts remain unchanged and their importance retained, education systems are now being required to equip students to apply their knowledge within the socio-cultural context of their societies (Care, et al, 2019; Kim, Care & Vista, 2019).

The inclusion of skills in schools was spearheaded by three initiatives undertaken by the United Nations, Educational Scientific & Cultural Organization (UNESCO), the Organisation for Economic Cooperation & Development (OECD) and the European Commission (EC). In 1996 the ‘Delors report’ initiated the UNESCO 21st century competence learning discourse which classified them into four pillars of learning – Learning to know, learning to do, learning to be and learning to live together. In 2013, the OECD’s position developed within the DeSeCo project -Definition and Selection of Competencies (OECD, 2013a). The OECD DeSeCo (definitions and selection of key competencies) framework states that key skills are the psychosocial prerequisites for a successful life and well-functioning society (OECD, 2005).This approach to the identification of key competencies has been adopted in a number of countries, such as, Queensland, Australia, New Zealand and Canada. The DeSeCo framework placed the key competencies into three broad categories i.e. interact in heterogeneous groups, use tools interactively, and act autonomously.

The 2009 European Commission’s report (Gordon et al., 2009) highlighted the cross-curricular relevance of key competencies such as mathematics, digital competences, individual and social awareness. Key competences in the EU framework are those that ‘all individuals need for personal fulfilment and development, active citizenship, social inclusion and employment’ (Gordon et al., 2009, p 12). This report moved away from simply placing competences into categories and towards a detailed treatment of implications for teaching and policy. Gordan et al., (2009), emphasized that implementation of key competencies in school practice is a complex and demanding process that calls for new pedagogy of competence development.

The partnership for 21st century learning (P21) describes the skills, knowledge and expertise students should master to succeed in work and life in the 21st century. In 2009, the P21 framework was informed by the business community, education leaders, and policymakers to position 21st century readiness at the centre of US K-12 education. It aimed to begin a national conversation on the importance of 21st century skills for all students. The P21 framework recommended the merging of traditional academic disciplines (reading, writing and arithmetic – the 3Rs) with skills including critical thinking, communication, creativity, and collaboration - the 4Cs.

A major research project Assessment and Teaching of 21st Century Skills (ATC21S) was developed to help define and measure 21st Century skills in education. This research group comprised academics, governments and three major technology companies, Microsoft, Intel and Cisco. This project was set up over concerns that school curricula do not fully prepare students to live and work in an ever-changing society. Employers were faced with entry level workers who lack skills that prepare them to work in an information age society and 21st century employment. Therefore, technology companies Cisco, Microsoft and Intel wanted to accelerate global education reform by sponsoring research such as ATC21S that would help to transform the teaching, learning and measurement of 21st century skills. The concern of ATC21S was not only with the definition and identification of 21st century skills (Binkley et al., 2012), but with the methods appropriate for assessment of these (Wilson et al., 2012), the types of technologies on which these might depend (Csapó, Ainley, Bennett, Latour, & Law, 2012), the teaching approaches that might be deployed (Scardamalia, et al., 2012), and the implications of these for policy change (Darling-Hammond, 2012). ATC21S started by internationally defining 21st Century skills as four broad categories: Ways of thinking, Tools for working, Ways of working and Ways of living in the world. It further identified ten skills as encapsulating all others and accommodating all approaches (Binkley et al., 2012). These are shown in Table 2.2.

The OECD has recently released a paper outlining a new "Learning Framework 2030" that builds on their original key competencies (the DeSeCo project: Definition and Selection of Competencies) (OECD, 2018a) and "encapsulates a complex concept: the mobilisation of knowledge, skills, attitudes and values through a process of reflection, anticipation and action, in order to develop the inter-related competencies needed to engage with the world" OECD, 2018a, p. 6). This evolving learning framework sets out an aspirational vision for the future of education (OECD, 2019b):

> "*How can we prepare students for jobs that have not yet been created, to tackle societal challenges that we cannot yet imagine, and to use technologies that have not yet been invented? How can we equip them to thrive in an interconnected world where they need to understand and appreciate different perspectives and worldviews, interact respectfully with others, and take responsible action toward sustainability and collective well-being*?"

The Learning Compass offers a vision of the types of interdependent competencies that students should require in 2030 and beyond. It envisions that today's students need to be: *"responsible and empowered, placing collaboration above division and sustainability above short-term gain"* (OECD, 2018, p3). The OECD compass highlights that students need to be equipped with a broad range of skills to help them navigate by themselves through unfamiliar contexts. These broad range of skills include cognitive and meta-cognitive skills (e.g. critical thinking, creative thinking, learning to learn and self-regulation); social and emotional skills (e.g. empathy, self-efficacy and collaboration); and practical and physical skills (e.g. using new information and communication technology devices) (OECD, 2018).

It is clear from these five perspectives that there are a range of definitions of 21st century skills (summarised in Table 2.2) and a different view of how they should be categorised and integrated successfully into curricula worldwide. But they all agree that key skills must become a focus of development at all levels across the world and the emerging trends point to key skills development. The approach to embedding key competencies in a number of countries such as Queensland, Australia, New Zealand, Canada and Ireland were influenced by these five perspectives.

This current study focuses on the development of the key skills of communication and working with others.

***Table 2.2*: Comparison of classifications of 21st century skills (Taken from Griffin & Care, 2014) Skills in bold represent categories of skills within the specified framework**

ATC21S	**UNESCO**	**OECD**	**Partnerships 21**	**European Commission**
Binkley et al. (2012)	*Delors et al. (1996)*	*OECD (2013)*	*P21 (2009)*	*Gordon et al. (2009*
Ways of thinking	**Learning to know**		**Learning and innovation**	**Learning to learn**
creativity and innovation critical thinking, problem solving, decision making learning to learn, metacognition			creativity critical thinking problem solving	
Ways of working	**Learning to do**	**Interact in heterogeneous groups**		
communication collaboration		relate well to others co-operate, work in teams manage and resolve conflicts	communication collaboration	communication in mother tongue and foreign languages
Tools for working	**Learning to do**	**Use tools interactively**	**Information media and technology**	
information literacy ICT literacy		use language, symbols and texts interactively use knowledge and information interactively use technology interactively	information literacy media literacy ICT literacy	mathematical, science and technology competences digital competence
Living in the world	**Learning to be Learning to live together**	**Act autonomously**	**Life and career**	
citizenship - local and global life and career personal and social responsibility including cultural awareness and competence		act within the big picture form and conduct life plans and personal projects defend and assert rights, interests, limits and needs	flexibility and adaptability initiative and self-direction social and cross-cultural skills productivity and accountability leadership and responsibility	social and civic competences initiative and entrepreneurship cultural awareness and expression

2.2.2 Key skills in Junior Cycle Science in Ireland

Developing key skills have always been a feature of education and traditionally the focus has been on developing basic transferable skills such as reading and writing, basic arithmetic and practical skills. Also, teachers through day to day interactions support students to develop more generic skills such as confidence and communication.

However, under the new Junior Cycle reform in Ireland, the development of skills need to be planned, assessed and recorded, and students should now be aware that these skills have developed. This focus is expected to support students to become lifelong learners who are equipped with a set of transferable skills that will help them to cope with the challenges in the future. In the new Junior Cycle, students will develop subject specific skills and a general set of skills that are needed to support learners in their personal, social and work lives (NCCA, 2012). These are referred to as the key skills of Junior Cycle. The key skills also support the development of literacy and numeracy, which is required for learners to access the curriculum.

In order for these skills to be integrated into the daily lives of students, students will need to encounter them frequently in a range of contexts. To achieve these key skills will be embedded into the curriculum through the statements of learning and in the curriculum specifications (NCCA, 2012). The NCCA developed a key skills framework for Junior Cycle which embeds skills development into the curriculum through statements of learning and in curriculum specifications. While the terms ‘skills’, ‘competences’ and ‘21st century skills’ are accepted internationally, Ireland uses the term ‘key skills’.

The key skills are embedded in the learning outcomes of all the curriculum specifications and therefore teachers are encouraged to ensure they are built into their teaching approaches, class planning and assessment methods. The key skills identified as being important for all junior cycle students to develop during their first three years of second level education are: managing myself, staying well, communicating, being creative, working with others, managing information and thinking. These skills are linked to the skills required at senior cycle and those already developed for early childhood education and primary education.

2.2.3 Key skills focussed on in this study

The focus of this research was on the development of both the scientific planning skills and key skills of communication and working with others as the researcher believes that these key skills complement the development of inquiry planning skills in the Junior Cycle science classroom.

The approach adopted in this thesis is supported by a recent study carried out by Utaria et al., (2021) that investigated the impact of implementing inquiry based learning integrated with the nature of science (NOS) had on communication and collaboration skills. This study involved an experimental class of 32 students who received inquiry based instruction integrated with NOS and a control class of 31 students who received module based learning. Data on communication and collaboration was obtained through observations and analysed using the Analysis of Covariance test. The results showed a significant difference between the value of communication and collaboration skills of the experimental and control classes. The study concluded that if inquiry is integrated with the 'Nature of Science' it is proven to improve communication and collaboration skills of students. By integrating inquiry with NOS, teachers can help to develop and improve student's communication and collaboration skills (Utaria et al., 2021).

Table 2.4 describes the key skills of communication (COM) and working with others (WWO) as outlined by the NCCA, 2012). The specific subskills of COM and WWO focussed in this study are presented in Figure 2.2 How the development of these skills were implemented/monitored in this study is discussed in more detail in chapter 4.

***Table 2.4*: Key Skills of COM and WWO for the Junior Cycle (extracted from NCCA, 2012).**

Skill	**Description**
Communication (COM)	This skill helps learners develop good communication skills in all aspects of life, using a variety of media. As well as developing literacy skills it also develops learners' confidence in communicating, expressing opinions, and writing, making oral presentations and performing.
Working with others (WWO)	This skill helps learners develop good relationships and to appreciate the value of cooperating to reach both collective and personal goals. Students also learn to value diversity and to engage in collaborative work aimed at making the world a better place.

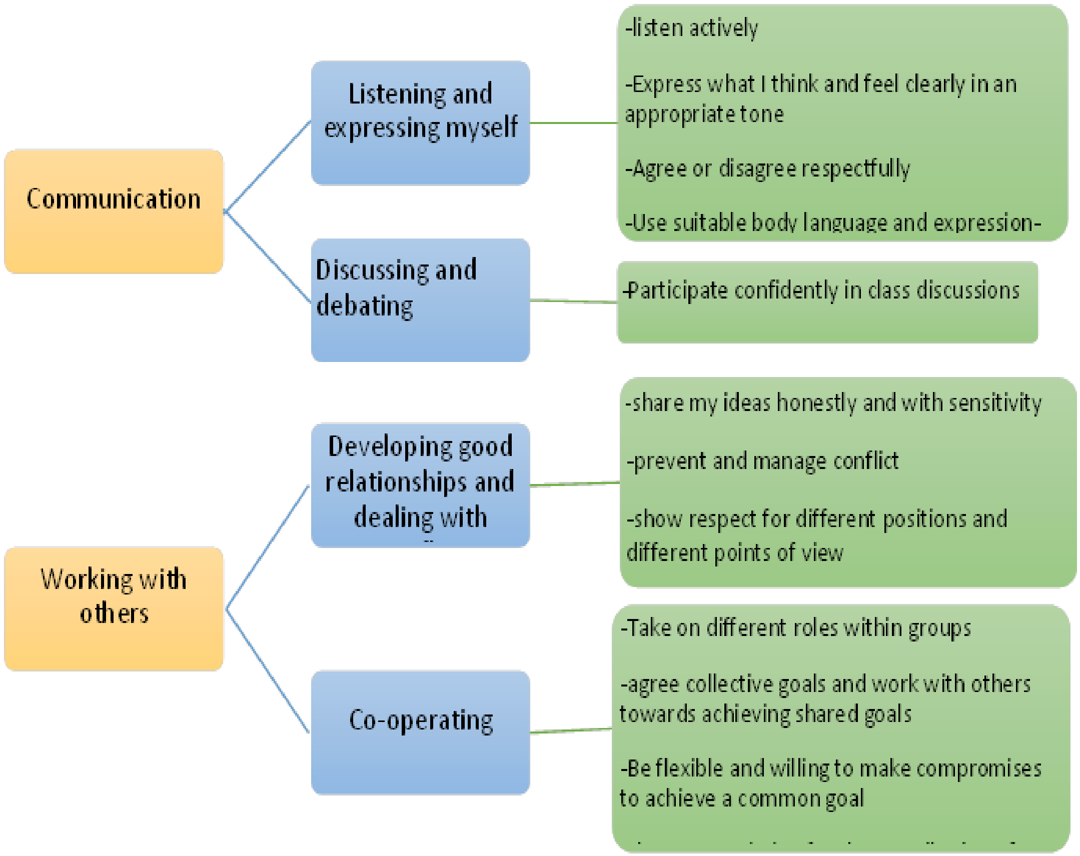


***Figure 2.2*: The elements and learning outcomes that were chosen for this study as described by the NCCA (2012)**

2.3 Monitoring and assessing learning in Science

This section introduces assessment of Inquiry based learning with a focus on peer and self-assessment.

2.3.1 Assessment of learning in Science

Assessment' is an umbrella term that encompasses a range of methods and techniques (Biggs & Tang, 2007). Assessment is seen as the major driving force in education and a defining aspect of any educational system. The assessment process should involve students' participation, as this allows the student to gain a better understanding of what is expected of them and how much they have achieved as a result of their own effort, which motivates them to learn and achieve. As many educators focus on what is to be tested, assessment signals priorities in curricula worldwide (Assist-ME, 2013). Assessment can be viewed from many different perspectives. The European Report "Europe needs more Scientists" (European Commissions, 2004, p137) distinguishes between three perspectives: (1) traditionally, as the function of evaluating student achievement for grading and tracking, (2) as an instrument for diagnosis to give students and teachers continual feedback about learning outcomes and difficulties, and (3) as a means to enable broader knowledge about the conditions behind and influences on students' understanding and competence. In education, assessment involves the collection, interpretation and use of data for some purpose. The purpose and often also the method of data collection may differ. The range of methods can be organised using the summative/formative distinction. Summative assessment is focused on the assessment of the end product whereas formative assessment focuses on the process towards completing the product. However, there is tension between the two modes as summative assessment is used to hold schools accountable for student's achievement (CERI, 2008). Summative assessment which offers feedback in the form of grades only is usually conscientious but often fails to offer guidance on how work can be improved and can reinforce under achievement. , This innovative approach requires teachers to change the way they think about their teaching

Formative assessment is defined as "*the process used by teachers and students to recognize and respond to student learning in order to enhance that learning, during the learning*" (Bell & Cowie, 2001, p. 536). It thus has the purpose of assisting learning and, for this reason; it is also called 'assessment for learning'. Research tells us that formative assessment is essential to learning and it aims to give appropriate and timely feedback to students on their learning.

2.3.2 Assessment of Inquiry Based Learning

It is important that assessment in inquiry based learning must aim to enrich the learning of the student in order to determine what each student has learned and understood and to identify any missing or unclear information (Bogar, 2018). According to Harlem (2013), traditional summative methods of assessment rarely reflect the key goals of Inquiry based science education (IBSE), therefore assessment practices need to be changed to support assessment and learning through Inquiry. According to Harlem (2013) formative assessment is a more appropriate way to monitor and assess inquiry learning. This means using the strategies that promote classroom dialogue, provide feedback to students and encourage students to participate in assessing the quality of their work. However, many teachers struggle with the implementation of formative assessment as it requires them to renegotiate the learning contract (Brousseau, 1984). Teachers can find it time consuming trying to implement formative assessment strategies as they first need to review and reflect on their schemes of work and then need to be able to recognise topics or activities which provide a good opportunity to create a range of good comments.

However, once these activities are found and used teachers then struggle to find follow on activities that allow students to demonstrate the improvements that the teacher had suggested in their feedback (Black et al, 2003)

Assessment consistent with the view of learning underpinning inquiry would be based on what students can do when interacting with peers. Lab based activities that involve scaffolding by teachers and interaction with peers provide excellent opportunities for assessment (Harlem, 2013). Inquiry allows students to develop their understanding of science and scientific skills, through investigative science, carrying out their own research, and actively engaging in discussions with peers and their teacher. Formative assessment provides students with the opportunity to identify and take the next steps in developing their understanding and competence. Therefore, it’s easy to see how formative assessment is essential to the implementation of inquiry. When assessing both the student’s scientific understanding and their inquiry skills, they must be actually involved in inquiry, actively engaged, the questions should be novel, and the knowledge required should be available to them.

According to Barron and Darling-Hammond (2008), assessment systems that support inquiry approaches share three characteristics. They contain intellectually ambitious performance assessments, evaluation tools such as guidelines and rubrics, and formative assessments to guide the feedback to the students and shape instructional decisions (ASSIST-ME, 2013). It is clear from these strategies that formative assessment combined with an evaluation tool in inquiry challenges conventional views of both the process and means of assessment. In order to be done effectively it requires skills and knowledge on the part of the teacher.

IBL has been promoted as an effective method to develop scientific abilities, understood as procedures, processes, and methods used by scientists when constructing knowledge and conducting experiments (Etkina, et al, 2006). One way to monitor the development of these scientific abilities is to use rubrics. Rubrics are guides that enable marking student performance criteria and performance at different levels. They can be also described as descriptive scoring schemes that are developed by teachers or other evaluators to guide students’ efforts (Etkina, et al., 2006). When rubrics are used in science and technology classes, students can clearly understand what is expected from them, and it makes the learning process much more meaningful. When designing rubrics the following criteria are important: Each subsequent level assumes that the previous level's criteria have been met and a. a clear, single criterion is used to distinguish two adjacent levels.

The assessment of key skills brings a new dimension to learning and to assessment. This new dimension challenges our traditional approach to assessment practices and a new approach must be considered. This new approach to assessment needs to empower students to further develop their skills. Teachers need to be mindful that learning is a fluid process and is seldom incrementally linear or stable. Many schools internationally have developed different tools which can be used by educators to recognise student's development of skills. One such approach highlighted by the Hanover research project (2014) is digital badges. Educators have described badges as tools for measuring and recognizing "competencies, skills, training, collaborative abilities, character, personal contribution, participatory energy, leadership and motivational skills, and other so-called 'hard' and 'soft' individual and cooperative talents (Farber, 2013). The nature of the badge system also permits teachers to measure skills progress in specific dimensions, rather than broadly defined ones (Anderson, 2012). The UK Association of Science Education provides a template for students to document their learning in science and is aimed for use by students at the transition between primary and secondary schools (ASE, 2009). The different versions of the Science Passport can be printed out and photocopied for students to write on. Students record personal details in their Science Passport, collecting 'visas' (or 'licences') awarded by the teacher to mark achievement in scientific skills. Investigations started in primary school are completed at secondary school. The use of personalised Learning Passports has increased in recent years to examine student experiences more closely and in particular aim to improve the quality of education for vulnerable children, (Cambridge Assessment, 2020).

When assessing skills development, a formative approach is more suitable for the assessment of skills development as the development of a skill can only be assessed after evidence is collected from a range of performances in different contexts. According to Hipkins (2007): "*A one-off judgement of a skill has little validity therefore the skill must be assessed in a range of contexts"* (p3). According to Hipkins (2007) the most effective way to assess skill development is: "*Assessment for learning which is continuous, interactive, orally communicated, demonstrated and characterised as feedback*" (p5).

Feedback is a vital feature of formative assessment. In order for it to be effective it needs to be timely, specific and include suggestions for ways to improve on future performance.

The feedback should cause thinking to take place (Black and Wiliam, 2004) According to Black et al (2003 p.15) the key components of feedback are: data on the actual level of some measurable attribute; data on the desirable level of that attribute; mechanism for comparing the two levels and assessing the gap between them; and a mechanism by which the information can be used to alter the gap.

Students who are told that feedback will ‘help you to learn ‘learn more than those who are told that ‘how you do tells us how smart you are and what grades you’ll get’ (Black and Wiliams, 2004)

When feedback focuses on how and what they need to achieve allows students to believe they can improve. This approach allows for the development of an atmosphere in which students feel they can achieve by building on performance, rather than comparing themselves to others. Effective feedback should make more explicit to students what is involved in a high-quality piece of work and what steps they need to take to improve (Black and Wiliam, 2004). Feedback can also be effective if it comes from a peer or the student themselves.

Peer Assessment

Peer assessment essentially involves students providing quality feedback on assignments, tasks or tests to other students. Boud & Falchikov (2007) provides a detailed definition:

> “*Peer assessment requires students to provide either feedback or grades (or both) to their peers on a product or a performance, based on the criteria of excellence for that product or event which students may have been involved in determining*” (p.132).

Peer assessment has many positive benefits for both the student and the assessor. It allows students to move beyond just being able to say whether something was good or not to being able to say why. It can also help improve the motivation of students to work more carefully and allows students to communicate in peer discussion in a language that students would naturally use. Students tend to take criticism more seriously from peers compared to teachers and students learn by taking the roles of teacher and examiner of others (Sadler, 1998). However, it is important that the teacher provides the peer with criteria for evaluating and it must be transparent. For peer assessment to be effective students must form the habits and skills of collaboration and be given a chance to practice and gain confidence in peer assessment and to become more competent at it. The evidence suggests that students become better at peer assessment with practice (Boud & Falchikov, 2007).

Self-assessment

Self-assessment is essential to learning (Sadler, 1989). Andrade and Du (2007) define self-assessment as “a process of formative assessment during which students reflect on and evaluate the quality of their work and their learning, judge the degree to which they reflect explicitly stated goals or criteria, identify strengths and weaknesses in their work, and revise accordingly (p.160)”.

In formative assessment it is important that students understand that there is a gap between their desired goal and their present state. Teachers can only guide, but the student must control their own learning and therefore self- assessment by the students must be an important feature of any formative assessment. When trying to develop student’s self-assessment skills the main task is to get students to think of their work in terms of a set of goals, here students begin to develop the capacity to work at a metacognitive level (Black and Wiliams, 2004). By carrying out self- assessment, students get a chance to decide both how to make judgments on their own work and how best to improve and become more aware of when they are learning and when they are not. Students' reflections about their own understanding can also be used to inform future teaching.

While feedback is recognised as effective in supporting student learning, literature mostly reports on the effect of feedback provided by teachers and less is reported on the effect of peer feedback. A recent study by Sortkaer and Reminer (2021) highlights gender differences in how students experience different types of feedback: feedback delivered by teachers, feedback delivered by peers, and feedback given to peers. The authors report that boys perceive more teacher-student feedback than girls do, whereas girls perceive more feedback from peers than boys do, and boys give feedback to peers more often than girls. Furthermore, their results indicate that class composition (i.e., gender balance and the average socioeconomic background of peers) influences feedback practices. The authors further suggest that the feedback practices and gender imbalance may depend on the specific subject and the typical performance of girls and boys in that subject.

2.4 Researchers view on developing/monitoring skills in science

The focus of this research was on the development of both the scientific planning skills and key skills of communication and working with others as the researcher believes that these key skills complement the development of inquiry planning skills in the Junior Cycle science classroom, based on 13 years of classroom experience. The researcher's view of the role of inquiry based learning and developing key skills in science education are outlined in the following sections.

2.4.1 Researchers view of inquiry based science education

In light of the literature discussed above and influenced by the researchers 13 years of experience, the view that the researcher takes of inquiry is that a lesson typically focuses first on a question that can be investigated, followed by group work in which students explore the question been investigated through discussions and collaborative practice. During the collaborative practice, students develop a hypothesis, a detailed procedure, decide on the variables and, working as a group, carry out an investigation to test their hypothesis. The teacher is able to focus students on the development of certain inquiry planning skills by using different levels of inquiry. Initially, the structured inquiry approach can be used to help develop the planning skill of writing a procedure, with a focus on writing a procedure that is clear and easy to follow, contains suitable equipment and is neat, presentable, and legible. Once students have developed this inquiry skill, the level of inquiry can be moved to guided inquiry and then to open inquiry. As the level of inquiry is moved towards open inquiry, the students get the opportunity to engage and develop more inquiry planning skills such as developing an investigative question, writing a hypothesis and deciding variables.

These scientific planning skills are best monitored and assessed using student portfolios which contain pieces of work from activities that allowed students to engage with and demonstrate the inquiry planning skills and also through the use of transparent rubrics which break down the planning skills into subskills for each inquiry skill (planning a procedure, developing a question, writing a procedure and selecting variables). The function of the rubric is to act as a guide to show students how they can improve on and successfully develop each sub-skill.

There are numerous studies that discussed the benefits of inquiry-based learning and these studies showed how inquiry can lead to the development of scientific processing skills and knowledge acquisition, however, there has been little focus given to the development/monitoring of key skills such as COM and WWO in the inquiry classroom. For IBSE to be effective in the science classroom the researcher believes that students need to be proficient in the skills of communication and working with others. This research aims to investigate if developing the skills of COM and WWO can enhance the development of scientific planning skills in the junior cycle science classroom.

2.4.2 Researchers view on key skills in science education

The learning outcomes that must be met by the end of 3rd year are described in the Junior Cycle science specification set by the NCCA.. This research study focuses on the two key skills of communication (COM) and working with others (WWO). This was influenced by both the ATC21S project which highlighted the importance of developing these 21st century skills in students and because the researcher felt that the skills of COM and WWW are important if the inquiry approach in science education is to be successfully implemented in the science classroom. The definition of the key skills of communication (COM) and working with others (WWO) used in this thesis was influenced by the definitions set by the NCCA as presented in Table 2.4.

In this study, the researcher wanted to adopt an approach to capture a more granular and meaningful picture of how the students engaged with the key skills. The assessment of these skills could be recorded on their junior cycle certificate of achievement alongside the results of their final examination in order to provide a holistic account of a student's learning journey over a three year period. The researcher believed that monitoring of the skills could be achieved using a skills passport. This approach would enable students to record both peer and self-feedback on their development of the skills of COM and WWO. This approach to monitoring skills development was influenced by how skills were developed/monitored internationally, in particular the Hanover research project (2014) which uses the idea of digital badges. Although the skill wouldn't be monitored digitally like the badges, the researcher believed that the idea such as a skills passport could be used to help record the development of these key skills.

As highlighted in literature, self-assessment as a form of assessment has attached increased interest in the field of education in recent years paralleling the development of the idea of self-regulated learning. As a fundamental process of self-regulated learning, the researcher believed that self-assessment had the potential to improve student motivation and engagement/autonomy in learning and therefore was a suitable means to monitor the development of the skills of COM and WWO.

2.5 Research Question

An inquiry based learning approach in science education is promoted to provide opportunities for students to work collaboratively and develop a range of inquiry skills (Llewellyn, 2005). Working in groups provides students with the opportunity to develop the skills of communication and working with others while carrying out science activities. This study proposes that the key skills of working with others (WWO) and communication (COM) can be monitored and developed in Junior Cycle Science classes alongside the development of scientific planning skills. When students are conducting investigations in an inquiry lesson, students will be required to work in small groups and hence the skills of communicating effectively with peers in their group and working with others will be helpful in completing the investigation. This research aims to investigate whether the key skills of working with others and communication can be integrated, developed and monitored within the science classroom while also developing student's scientific planning skills. The following chapters in this thesis will present the findings from the approach adopted with 1st and 2nd year Junior cycle science students to address the research question :

> ***To what extent are student's key skills of communication and working with others developed alongside scientific planning skills in a junior cycle science classroom?***

Chapter 3 Methodology

3 Introduction

This chapter gives an overview of the research design which shapes this study. It describes how the research was planned through several phases, the rationale for this design methodology, and the approach used in collecting and analysing the data throughout each phase. Sections 3.1 and 3.2 give an overview of the research study design and the phases involved respectively. The methodology used in identification, monitoring and data analysis of COM and WWO skills is detailed in Section 3.3, while that for scientific planning skills is given in Section 3.4. Analysis of qualitative data is given in Section 3.5, with ethical considerations noted in Section 3.6.

3.1 Overview of the study

The benefits of developing key skills in the science classroom and teaching science through inquiry was discussed in Chapter 2. This study proposes that the key skills of working with others (WWO) and communication (COM) can be monitored and developed in Junior Cycle Science classes alongside the development of scientific planning skills. When students are conducting investigations in an inquiry lesson, students will be required to work in small groups and hence the skills of communicating effectively with peers in their group and working with others will be helpful in completing the investigation. The research question for this study was:

> ***To what extent are student's key skills of communication and working with others developed alongside scientific planning skills in a junior cycle science classroom?***

The following hypotheses were tested:

1. Embedding the key skills of COM and WWO into science lessons and monitoring them periodically using a skills passport will result in development of these skills in 1st and 2nd year science students.
2. These COM and WWO skills can be developed alongside scientific planning skills.

3. Having had explicit experience in COM and WWO skills and planning skills, this will increase students' awareness and implementation of these skills when they conduct their own investigations at the end of 2^{nd} year (EEI)*.

*The EEI (Extended Experimental Investigation) : Here a student will, over a three- week period, formulate a scientific hypothesis, plan and conduct an experimental investigation to test their hypothesis, generate and analyse primary data, and reflect on the process, with support/guidance from the teacher and write it up as a report.

As highlighted in Chapter 2, development of key skills is important if teachers are to help students develop the knowledge, skills and attitudes to face the many challenges in today's world. As stated in Chapter 2, these skills are now part of the Junior Cycle programme along with an inquiry approach in science teaching. The question arises as to how you can integrate and incorporate the development of both the key skills of COM and WWO and inquiry scientific planning skills in the science classroom. The next question which arose was which key skills would be important to focus on in the science classroom. Earlier discussions in chapter 2 highlighted there are three broad categories of key skills, namely, teamwork/communication, ICT literacy and living in the world. When deciding on which ones to focus on in this study, it was important to select the skills that would complement the inquiry science approach. From the discussion on the inquiry approach to science in chapter 2 it is my understanding that the skills of COM and WWO are important for students if they are to actively engage with this approach and therefore it was decided that these skills would be the focus of this research

This study initially focussed on breaking down the key skills of COM and WWO into their subcomponents, linking them to the elements and objectives set out in the nJCSS and then incorporating them into the science lessons in Junior Cycle. The progression in development of these skills alongside their scientific planning skills was monitored across several class groups and longitudinally with one group over two years. The methodology employed is discussed below.

3.1.1 Study Design

The research method employed in this research was a mixed method case study. *"A mixed methods case study design is a type of mixed methods study in which the quantitative and qualitative data collection*, *results, and integration are used to provide in-depth evidence for a case*(*s) or develop cases for comparative analysis*" (Creswell & Plano Clarke, 2018, p. 116). Mixed method design will integrate techniques from both quantitative research and qualitative research and merge them to help answer the research question. By using the mixed method, it allows the research to profit from the strengths of each approach and counteracts their weaknesses (Creswell, 2003; Tashakkori & Teddlie, 1998). Mixed method research often includes a core component, used to answer the research question, (in this research the numerical findings from analysing students work) and a supplementary component used to inform the other method (in this research the qualitative data obtained from interviews of students) and create a deeper understanding of the problem (Morse & Niehaus, 2009).

Case Study as the appropriate methodology

The type of case study chosen for this research is single embedded case study with multiple units of analysis. A case study approach was chosen as it allows an in-depth exploration of a complex issue in a real-life setting and allows the researcher to apply what they have learnt to a real world setting. In this case investigating if the skills of COM,WWO and planning skills can be developed simultaneously in a junior cycle science classroom.The essence of a case study is it tries to illuminate a decision or set of decisions, why they were taken, how they were implemented and with what result (Schramm, 1971). As this case study aims to determine to what extent students' key skills of communication and working with others developed alongside scientific skills in a junior cycle classroom, a case study approach allows the researcher to respond to this research question. A case study involves the investigator directly observing the events being studied and therefore the investigator must work hard to report all the evidence fairly. A case study relies on a range of sources of evidence which helps add depth to the data collection. In this research data was collected from three different sources, students, teachers and the researcher. This brings richness to the data collection and allows for a triangulation approach which contributes to the validity of the research (Yin, 2003).

Case study has been defined in a number of different ways, and from a number of theoretical perspectives. Yin (2003, p13) outlines the case study methodology in terms of a research process; "*A case study is an empirical inquiry that investigates a contemporary phenomenon with its real-life context, especially when the boundaries between phenomenon and context are clearly evident*". Neale, Thapa and Boyce (2006, p4) focuses on the holistic view of an event provided by the case study; "*Case studies are often used to provide context to other data, offering a more complete picture of what happened in the program and why*". It is clear that the need for a case study arises out of the need to understand complex social phenomena. Case studies typically describe a program or intervention put in place to address a problem that the researcher is trying to solve. The main step in conducting a case study is the defining of the case and the case context. In this research; the case was the impact of the approach on science students in 1st and 2nd year at lower second level and the context was the development of the skills of COM and WWO alongside scientific planning skills in the science classroom.

The case study approach chosen involved multiple embedded 'units of analysis' (Yin, 2014). Embedded case studies allow the context as a whole to be analysed while also examining specific subunits. These subunits add significant opportunities for extensive analysis and therefore enhance the insight into the single case. In this research, there are two embedded units of analysis, 1st year students and 2nd year students. The embedded unit of analysis for 1st year is further divided into subunits of analysis for the 1st years in phase 1, phase 2 and phase 3. The embedded unit of analysis for 2nd years is made up of one subunit for the class of 1st years who continued with the programme in 2nd year (see details in Section 3.1.2).

Advantages and limitations of a case study

The main advantage of a case study is that it provides much more detailed information than what is available through other methods and approaches. A second advantage of the case study approach is that it allows for a complete story to be provided by collecting a range of data from different methods and sources (Yin, 2014). This allows for a more in-depth analysis to be carried out. Variations in instrumental and collective approaches in a case study allows for both quantitative and qualitative analysis of data to be carried out.

Yin (2014) discussed three main limitations to case study research. The first highlighted that case studies can often be accused of lacking rigour. Yin (2014) notes that "*too many times, the case study investigator has been sloppy, and has allowed equivocal evidence or biased views to influence the direction of the findings and conclusions*".

As many case studies are focused on a single case or instance using a small number of subjects, there is very little basis for scientific generalisation. The question commonly raised is *"How can you generalise from a single case?"* (Yin, 2014). A case study often produces massive amounts of documentation and therefore can be time consuming to conduct. A final limitation of case study research is what Guba and Lincoln (1981) refer to as *"unusual problems of ethics. An unethical case writer could so select from among* *available data that virtually anything he wished could be illustrated"* (p. 378). Therefore, the researcher must be aware of biases that can impact the final product.

Importance of qualitative data

In this research study, the quantitative data was supported by qualitative data, in the form of interviews and teacher observations/reflections. This section highlights the importance of this data in the case study approach.

Interviews, or “conversations with a purpose” (Merriam, 2009, p.36), are a powerful means of data collection as they elicit narrative data that allows the researcher to investigate people’s views in greater depth (Kvale, 2003). Cohen et al (2007, p29) also adds that interviewing is a ‘*valuable method of exploring the construction and negotiation of meaning in a natural setting’*. The main benefit of interviews is that they enable interviewees to *‘speak in their own voice and express their own thoughts and feelings*’ (Berg, 2007, p.96).

The structure of an interview can be described as being a “continuum ranging from informal or conversational interaction to questionnaire driven highly structured interviews” (Merriam, 2009, p.90). The type of interview chosen for this research is semi-structured, which is considered a flexible version of the structured interview as “it allows depth to be achieved by providing on the part of the interviewer to probe and expand the interviewee’s responses” (Rubin & Rubin, 2005, p.88). When undertaking this type of interview, it is important to use a basic checklist that helps ensure the researcher has covered all relevant areas. According to Berg (2007) a checklist “*allows for in-depth probing while permitting the interviewer to keep the interview within the parameters traced out by the aim of the study*” (p.39).

The interviews allowed the researcher the opportunity to uncover information that is “*probably not accessible using techniques such as questionnaires and observations*” (Blaxter et al, 2006, p.172). It is clear that interviews as a method of data collection have many benefits; researchers should remember that: *“what people say in an interview will indeed be shaped, to some degree, by the questions they are asked; the conventions about what can be spoken about…[...]…by what they think the interviewer wants; by what they believe he/she would approve or disapprove of”.*

As in any research project validity and reliability are of great significance to the findings of any research project. Validity and reliability issues serve as a guarantee of the results of the participant's performance (Dörnyei, 2007). Validity ensures the researcher they are measuring what they are supposed to be measuring and reliability refers to the extent in which a research instrument yields the same results if repeated.

According to Cohen et al (2007) the researcher must take into consideration the following factors which can lead to higher validity by minimising the possibility of bias: "*the attitude, views and prospects of the interviewer; a tendency for interviewer to see the interviewee on his/her own merits; a tendency for interviewers to seek answers to support their preconceived notions; misperceptions on the part of the interviewer with regard to what the interviewee is saying; and misunderstanding on the part of the interviewee with regard to what is being asked*" (p. 150).

The following techniques were used by the researcher in this study to help maintain the validity and reliability when carrying out the interviews with both students and teachers:

- avoiding asking leading questions;
- taking notes not just depending on tape recorders;
- conducting a pilot interview;
- giving the interviewee a chance to sum up and clarify the points they have made. (Alshenqeet, 2014)

Interviews with students and teachers for this research project were carried out in phases 2 and 3 of the project.

The main purpose of interviews with students for this research project was to probe them about their experience of carrying out the Extended Experimental Investigation (EEI) with second year students and Scifest projects with first year students.

In addition to qualitative data in the form of interviews, observation data was recorded during throughout the research to further inform the study. Observations are a way of gathering data by watching behaviour, events, or noting physical characteristics in their natural setting (Hammersley, 2007). Observations allow the observer to directly see the actions of the participants without having to rely on what they say they do and can allow for a relatively objective measurement of behaviour (Tashakkori &Teddlie, 1998). In this research, observation played a significant role in understanding the multifaceted situation

3.1.2 Study group

The study was carried out in a co-educational second level school in North County Dublin. The researcher has been teaching science there for 13 years and is a well-established teacher.

The study was carried out in three phases (detailed in Section 3.2). The first phase involved two 1st year science classes who were following rJCSS. In phases 2 and 3, the 1st year students were following nJCSS. This allowed the researcher to monitor the development of the key skills of COM and WWO along with scientific planning skills throughout 1st year and as students progressed from 1st to 2nd year in science.

It should be noted that the researcher was also the class teacher for a number of these classes and was involved in team-teaching in others – details shown in Figure 3.1.

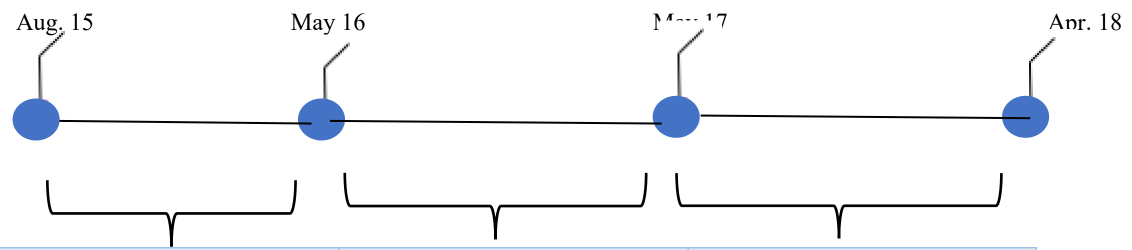
3.2 The research phases and timeline

In total there were three phases to the study, preceded by a preliminary phase. The preliminary phase involved the review of literature, design of the evaluation tools and lesson approaches. Each of the phases was a yearlong trial. Figure 3.1 shows the timeframe for Phases 1-3 and maps out the class groups involved.

Table 3.1 gives an overview of the main phases of the study, the purpose of each phase, number of participants and the data collected at each phase. Data collection involved a skills passport, student work, teacher observations, student project work (Scifest* /EEI), and student interviews. *Scifest is the largest second-level STEM fair programme in Ireland which aims to promote Science, Technology, Engineering and Mathematics (STEM) education through the provision of a forum for students at local/regional/national level to present and display their scientific investigations.

Each phase is now briefly outlined. The methodology used in identification, monitoring and data analysis of COM and WWO skills is detailed in Section 3.3, while that for scientific planning skills is given in Section 3.4. Analysis of qualitative data is given in Section 3.5.

Figure 3.1: **Time frame for phase 1-3**



Phase	**Phase 1**	**Phase 2**	**Phase 3**
Specification	rJCSS^	nJCSS^	nJCSS
1^{st} years	K1a K1b	P1a P1b	K1c
2^{nd} years *			P2a F2b C2c

***Note: Group P2a followed the programme for two years, Group F2b followed the programme in 1^{st} year only and normal teaching instruction in year 2 and group C2c followed normal teaching instructions for 2 years**

^Note: rJCSS refers to the 2003 science specification and nJCSS refers to the to the 2016 specification

Table 3.1: **Overview of purpose, participants and data collection for each phase of study.**

Phase	Purpose	Participants	Data collected	Data Type
Preliminary phase	Development of suitable data collection methods and lesson sequence.			
1	To assess the suitability of the lessons and the skills passport and to assess the coding system for peer and self-feedback Modify for Phase 2.	Class groups (K1a & K1b) Students (N = 39) Teacher (N=1)	Student work Teachers observation Skills passport	Qualitative Qualitative Mixed
2	To trial modified lessons, collection methods and coding system for peer and self-feedback. To introduce the assessment of scientific planning skills. Trial an evaluation rubric for scientific planning skills.	Class Groups (P1a & P1b) Students (N=36) Teacher (N=2)	Student work Teachers observation Skills passport Projects (Scifest) Student interviews (Scifest)	Mixed Qualitative Mixed Qualitative Mixed
3	Use adapted skills passport and scientific planning rubric for year 1 and 2. Data collected with a new first year group and 3 groups of 2nd years. Evaluate continuity from 1st to 2nd year.	**1st year cohort** Class group (K1c) Students (N =20) Teacher (N=1) **2nd year cohort** Class groups (P2a, F2b, C2c) Students (N =50) Teacher (N=3)	Student work Teachers observations Skills passport Projects: 1st year (Scifest); 2nd yr (EEI) Student interviews: 1st year (Scifest); 2nd yr (EEI) Interviews (Teachers)	Mixed Qualitative Mixed Qualitative Mixed Mixed

3.2.1 Research phases

Phase 1

The focus of phase 1 of the study was the identification, development and monitoring of the key skills of COM and WWO with a focus on the sub-skills for 1st year which had been determined by students (Section 3.3). This phase involved two 1st year class groups, taught by the teacher researcher, and several activities were implemented in which the focus of the activity was the development of these skills. A document was developed – a skills passport – for students to note their development of the skills throughout the year. The main aim of phase 1 was to test the skills passport to determine if it was suitable to monitor the development of the skills of COM and WWO. This yearlong study also allowed time to test the suitability of the activities chosen that would support the development of the skills of COM and WWO. These activities are outlined in Chapter 4. The data collected from this cohort over one year was used to identify any potential practical/logistical problems when using the skills passport and the assessment of the feedback sections in the passport.

Phase 2

The focus of phase 2 was to embed the development of skills throughout the year across many classes, rather than focussing on particular activities in a few classes. This phase also focussed on the development and assessment of scientific planning skills. The scientific planning skills were divided into subskills and an evaluation rubric was trialled. Due to the introduction of the nJCSS, some lessons and activities used in Phase 1 were modified to suit the science department's yearly plan.

The students developed projects at the end of the year – called Scifest project – where they developed their own investigation on a topic of their choice. The Scifest project was considered a good way to monitor the scientific planning skills developed.

Phase 3

Phase 3 involved two different year groups: a new 1st year class group and 3 2nd year class groups.

1st Year class: The focus with this group was to trial the new activities that would provide more opportunities for students to develop their skills of COM, WWO and planning skills and to place greater emphasis on the feedback section in the skills passport and on some of the skills that students struggled with in phase 2. Some 1st year lessons and activities were modified to suit the department's yearly plans.

2nd Year: The main focus of the study with the 2nd year group was to determine if the skills as developed in 1st year (COM, WWO and Scientific Planning Skills) could be extended in 2nd year and monitored through the use of a skills passport and student work. Additionally, if these skills were evident in their end of year projects (EEI). Three groups of students were involved - one class group had followed the programme in 1st year, and were continuing with the programme in 2nd year, with the same teacher (P2a in Figure 3.1); another group had followed the programme in 1st year but in 2nd year had a different teacher and was following that teachers own programme (F2b in Figure 3.1); the third group had not been involved with the programme in 1st year (C2c). All of these groups carried on an investigation on a topic of their choice at the end of the year (EEI) and this was used to determine any differences between the groups in terms of their scientific planning skills and COM/WWO skills.

3.2.2 Notation used

To help track the data, individual change and to ensure information remains confidential, a coding system was put in place. The student's codes allowed the student, class, year and the phase they were introduced to be identified. The first number is the phase they were introduced, the second number is the year group, the third letter distinguishes between classes in the same year group and the last two numbers is the student's number. Example student 32C01 was introduced in phase 3, was a 2nd year class, class group C and students number 1.

The teacher observations were coded to help identify which observation was used, the class group, which lesson it involved and which teacher. Example: (O1, P1a, cookie, P) indicates the observation was the first observation with class P1a during the cookie activity by teacher P. Only teachers P and K provided observations for the research.

When discussing the class group, the notation used indicates the specific teacher, the year of the group and a letter distinguishes between classes in the same year group e.g. (K1a) denotes teacher K , a 1st year class and group a. Table 3.2 gives an overview of the notations used and some information on the group dynamics of the classes involved.

Table 3.2: **Overview of the notations used and the group dynamics**

Group name	Year	Phase	Teacher	Group dynamics
K1a	1st	1	K	Completed 1 year of the programme. This class group was made up of 18 students (4 male and 14 female). Mixed ability class, positive group dynamics
K1b	1st	1	K	Completed 1 year of the programme. This class group was made up of 23 students (10 male and 13 female). Mixed ability class, positive group dynamics
P1a P2a	1st 2nd	2 3	P P	Completed two years of the programme. This class group was made up of 16 students (10 male and 6 female). Mixed ability class, positive group dynamics
P1b F2b*	1st 2nd	2 3	P F	Completed 1 year of the programme and normal instruction year 2. This class group was made up of 18 students (9 male and 9 female). Mixed ability class, positive group dynamics
C2c	2nd	3	C	Normal instruction year 1 & 2. This class group was made up of 16 students (4 male and 12 female). Mixed ability class
K1c	1st	3	K	Competed 1 year of the revised programme. This class group was made up of 20 students (13 male and 7 female). Four of the male students had diagnoses of ASD and one male with general learning difficulties. This group were very enthusiastic about science and many of the students were friends outside of the classroom. The class was mainly dominated by the boys who were very outspoken when compared to the girls. The class was mixed ability

* Change of teacher in 2nd year.

3.3 Identification, Monitoring and Evaluation of COM and WWO skills

In this section, the methodology used in identification of the subskills of COM and WWO are discussed and how these fit in with the NCCA stated skills for Junior Cycle (Section 3.3.1); how these skills were monitored through the use of the skills passport and changes that were made to this for each phase is discussed in Section 3.3.2; finally, how the data was collected and analysed is given in Section 3.3.3.

3.3.1 Identification of subcomponents of COM and WWO skills

As skills development added a new dimension to the science department planning in school, teachers expressed at planning meetings in school that it is difficult to visualise how the skills and learning outcomes would be manifest in 1st and 2nd year and how the skills would develop as students' progress from 1st year to 3rd year. To help overcome this problem and make it easier for teachers to monitor the key skills at different stages the researcher broke these down into appropriate learning outcomes for 1st and 2nd year students. This was done by working with students in 1st year (Phases 1and 2) and 2nd year (Phase 3). At the beginning of the year, a discussion was had with students about what they thought was important when working with others or communication as a scientist and how these skills could be used effectively. Each student's answers were compiled and agreement was reached between the students and the teacher as to the main subskills that would be focused on. This list of subskills was also shown to experienced teachers in the school to determine if they agreed with the sub-skills and felt these sub-skills would be age appropriate for students to develop.

Table 3.3: Sub-skills of COM and WWO (1st year students and 2nd year students)

Year	Communication	Working with Others
1st year	• Make eye contact when talking • Active listening • Don't talk over anyone • Use quiet voices • Back up opinions	• No messing • Take turns talking • Staying with your group • No fighting/Be friendly • Contribute ideas to the group •
2nd year	• Respond honestly & sensitively • Speak with confidence • Speak clearly • Ask questions to clarify misunderstandings • Respond constructively	• Create a supportive atmosphere • Take on different roles • Help group achieve their goals • Engage in group discussion • Suggest solutions to problems

The subskills identified and agreed upon are shown in Table 3.3 for both 1st year and 2nd year. These subskills were then mapped against the elements set out by the NCCA (2014) in Table 3.4, which shows the sub-skills for 1st and 2nd year against those that are set out for Junior Cycle. There is some overlap identified, hence, these subskills were deemed appropriate for 1st and 2nd year students.

Table 3.4: Mapping sub skills of COM and WWO to Junior Cycle Programme Outcomes

Skill	***Skills identified by NCCA* (2014)***	***Sub skills 1st yr.***	***Sub skills 2nd yr***
Communicating (COM)	Listen actively	Active Listening	
	Use suitable body language and expression	Make eye contact	
	Express what I think and feel clearly in an appropriate tone	Use a quiet voice	Speak clearly & use appropriate language
	Agree or disagree respectfully	Back up opinions	Respond honestly & sensitively
			Respond constructively
	Participate confidently in class discussions	Don't talk over anyone	Speak with confidence
			Ask questions to clarify misunderstandings
Working with Others (WWO)	Prevent and manage conflict	No fighting/be friendly	Suggest solutions to problems
	Show respect for different positions and different points of view	Take turns talking	Create a support & positive atmosphere
	Take on different roles within groups		Take on different roles
	Agree collective goals and work with others towards achieving shared goals	Staying with your group	Help the group to achieve their goal
	Contribute to decisions as part of a group	Contribute ideas to the group	Engage in group discussions
		No Messing	

* Reference NCCA – Key skills of Junior Cycle

The sub-skills of COM and WWO presented in Table 3.4 will be monitored by the teacher/researcher at various stages over the school year with first- and second-year students.

3.3.2 Monitoring of COM & WWO skills

Informed by the literature discussed in Chapter 2, the researcher designed an assessment tool in the form of a skills passport that focused on self-evaluation as well as peer and self-assessment throughout the year. It was important that the skills passport would show continuity over many activities and would provide feedback, thus allowing students to get an insight into what they have done well, what they needed to improve and guidance on how to make improvements. As discussed in section 2.3.1 assessment systems that support inquiry approaches share three characteristics, i.e., they contain intellectually ambitious performance assessments, evaluation tools such as guidelines and rubrics, and formative assessments to guide the feedback to the students and shape instructional decisions (ASSIST-ME, 2013). The researcher believes that the structure and use of the skills passport assessing the sub-skills of COM and WWO satisfies only the second and third of these criteria.

The complete skills passport for 1st year and 2nd year is shown in Appendices A and B, respectively. The layout and mode of use was similar with each class group. On the first page of the passport, students could rank themselves on the sub-skills listed, using the emoji's e.g. see Figure 3.2, which shows the first page of the skills passport for COM subskills for 1st year students. At the start of the year, students completed this page for the particular subskills of COM / WWO (noted as SA1) and again, on a similar further page, at the end of the year (SA2). After watching the students practice the skills, the teacher/researcher also ranked the students on the sub-skills. This assessment was based on inference from what they were in a position to observe. At the start of the year, the teacher ranking would be discussed with the students and an agreed assessment (noted as AA) rank was decided. This AA would be the starting point for the student. The teacher also ranked the students at the end of the year (noted as FA) which due to time restraints was not discussed with students. The analysis methods for this data is given in Section 3.3.3.

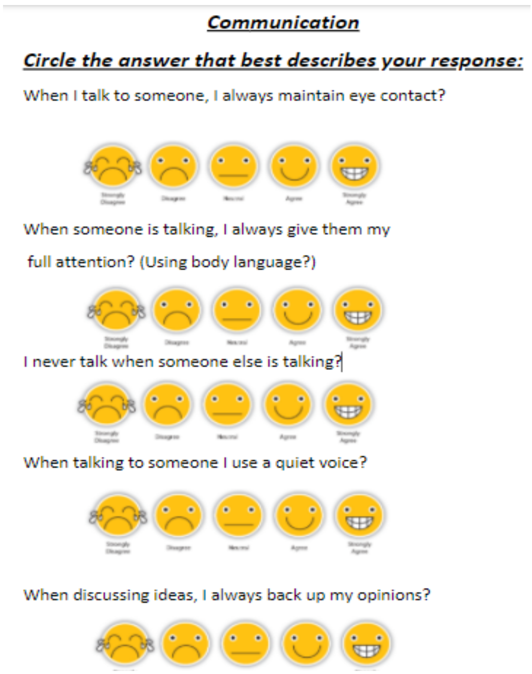


Figure 3.2: **First page of Skills passport for 1st year, showing the subskills of communication.**

During the year, students carried out a range of activities which allowed students to practice and /or demonstrate their skills of COM and WWO. The skills passport was used to monitor the subskills throughout the year. When using an assessment tool it is important that the task the students are carrying out while being assessed must be specifically designed for the assessment of a skill. The tasks should provide students with the opportunity to demonstrate the skill. This is important as skill development is usually performance based and inferred from behaviours and choices of a student in a particular setting. Details of the activities and tasks carried out by the class groups are given in Chapters 4 and 5. In order for the assessment of key skills to have validity the skill must be assessed in a range of contexts and therefore each the layout of the passport was flexible to allow for particular skills to be highlighted and focused on.

The main pages in the skills passport focussed on subskill evaluation through peer and self- feedback. Figure 3.3 shows the layout of these pages of the passport. The success criteria section highlighted the sub-skills in which students will be assessed on during a task. Criteria for assessing any learning outcomes must be made transparent to students to allow them to have a clear understanding of both the aims of their work and what it means to complete it successfully (Black and Wiliam, 2004). Before they are assessed on any skills the teacher will provide support to students on how they can attain the criteria. This involved acting out good and bad examples of the skills and also class discussions.

Each skill was assessed by a peer and when a student is observed carrying out one of the criteria they get a tick in the box. The function of this was not for grading purposes but to highlight to the assessor and student what they might need to improve on.

The next section is for peer feedback. Here a peer gave written feedback to the student. Students were told that the feedback should mainly focus on what the student is doing well, but also include tips for improving. By focusing feedback on what needs to be done can encourage students to believe they can improve and increase motivation. In order for peer assessment to be successful students need to be given plenty of opportunities to practice and will also need guidance about how to behave in a group. At the start this can be time consuming but it's a valuable exercise as it is likely that students will accept comments on their work from peers, but may not take the comment from the teacher as seriously. This is a good learning experience for both the students and the peer assessing the work as it teaches the student to move beyond just being able to say if something is good or bad but teaches them the importance of elaboration and explaining why.

The final section allows the students to self-assess; this section is important as it actively involves the student in their learning process. To get them thinking they first use the traffic light system to self-assess. They tick either the green, yellow or red light to indicate their level of achievement of the skill. By doing this first, while the students are filing out the self-assessment section, the teacher can walk around and get instant feedback from the student. The ability to self-assess in a meaningful way takes time, as students need to be able to take responsibility for and recognise their own learning. Over time students will build confidence in their ability to assess and become more aware of when they are engaging with a skill and when they are not.

3.3.3 Analysis of Data obtained from the Skills Passport

The students ranked themselves at the start of the year (SA1) and again at the end of the year (SA2) for the relevant subskills of COM and WWO on the skills passport, using the emojis as shown in Figure 3.2. The responses were then translated to 1-5 (1 being 'strongly disagree' to 5 meaning 'strongly agree'). At the start of the year the teacher also gave a ranking for each student from 1 to 5 (where 5 indicated achievement of that subskill) and, following discussion with the student, an agreed ranking (AA) was determined (scale of 1-5). The student data from the end of the year (SA2) was again translated into numerical values, alongside the teacher final assessment (FA) on the same scale. The rankings for each student were entered into excel and a paired t-test was carried out to see if there was any significant difference between the AA and FA - this was done to gauge if the students had improved on the particular sub-skills. Individual improvement on each subskill was determined by comparing the magnitude of the increase from AA to FA. As the group sizes were small, it was not possible to do meaningful statistical analysis. However, comparison of SA1 with AA ratings and also SA2 with FA ratings, give some information on the subskills that students may be more self-confident in or overly confident in!

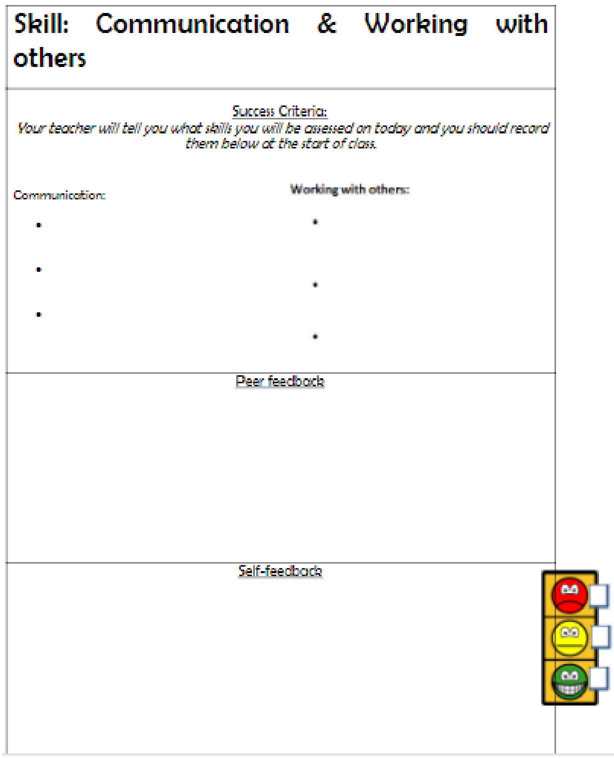


***Figure 3.3*: Layout of the feedback section in the skills passport used during phase 1**

The main pages of the passport provided opportunities for students to note peer and self-feedback on a number of monitored activities throughout the year. After each monitored activity, the students swapped their skills passport and firstly received feedback from their peers. Once completed, the passports were returned and the student was given the opportunity to read the feedback and then give their own self-assessment. The skills passports were stored in the science lab. The number of monitored activities varied for the different phases and classes in the study. These are noted as relevant in Chapters 4 and 5 for each cohort.

The nature and quality of the peer and self-feedback in the skills passports was evaluated as follows. In Phase 1, the nature of both the peer and self-feedback noted in the passport was coded on a 3 point scale, as:

0 – section was blank or comments irrelevant;

1 – positive comments on the skill;

2 – negative comments on the skills.

This allowed the researcher to determine if the students were engaging with the subskills in a positive manner and if peer and self-feedback was informative. In Phase 2, additional scaffolding was introduced during class time to help students provide more constructive feedback (details are discussed in Chapter 4). For the evaluation of the nature and quality of the feedback, a 5 point coding was used, as given in Table 3.5.

Table 3.5: **Coding used in evaluation of peer and self-feedback in Phases 2 &3**

Scale		Detail
1	Positive Informative	Feedback highlights what the students is doing well , what they need to improve and relevant tips on how they can improve
2	Informative	Feedback highlights what the student is doing well, what they need to improve on , but the tips on how to improve are not appropriate or relevant
3	Uninformative	Feedback highlights what the student is doing well but not does tell them what they need to improve or how
4	Irrelevant/Not Appropriate	Skills focused but not the correct skill/Not skills focused -No constructive comments on skills development
5	Didn't fill in	No Feedback - Left blank

The feedback on each monitored activity was coded and displayed on graph. This data is discussed in Chapters 4 and 5. The methods as described above for Phase 2 were also implemented in analysis of Phase 3 data.

3.4 Identification, Monitoring and Evaluation of Scientific Planning Skills

In this section, the scientific planning skills are introduced. The breakdown of the planning skills into their elements is set out in Section 3.4.1, how they were monitored during the year in Section 3.4.2 and finally, how the data was collected and analysed is given in Section 3.4.3.

3.4.1 Sub elements of the scientific planning skills

Developing skills in planning an investigation was seen as very important for 1st and 2nd year students as, within the science curriculum, students must devise, plan and conduct their own investigation at the end of 2nd year - called EEI. Hence, the focus in this works on planning skills. These skills were broken down into achievable elements for first and second years. This was done through discussions with experienced teachers about what they felt would be achievable based on the students age and experience in science. Informal discussions were held with teachers and fellow researchers in the field of science education on the breakdown of the planning skills and the level at which to assess them. Four elements of planning were agreed i.e., developing a question to investigate, generating a suitable hypothesis, devising a suitable procedure, and appropriate consideration of variables.

Each of these elements were further discussed to determine what sub-elements characterised these elements e.g. if a 1st year student proposed a good procedure, it would be ‘neat’, ‘clear and easy to follow’ with ‘appropriate equipment’ noted. Each of the elements were discussed and the sub-elements agreed for each year group. These are summarised in Table 3.6. It should be noted that some sub-elements were relevant for both year groups.

Table 3.6: **Elements of scientific planning skills for 1st and 2nd year science students.**

Skills	1st year Science*	2nd year science
Question	**Q1-Clear and Understandable -** Is the question clear in terms of the English language ***Q2-Doable and appropriate*** – Is it possible to investigate the question within the context of the activity and in terms of time, resources and students ability ***Q3-Quantifiable* –** Can measurements to taken	**Q4-Cause and effect relationships** - Does changing one 'thing' affect something else **Q5-Specific vs General** - Specific questions state what needs to be done in detail which allows someone else to replicate the investigation **Q6-Lead to taken action -** Can an investigation be carried out or do I have to rework the question before starting
Hypothesis	***H1-Is it a statement (Not a question).*** It expresses propositions ***H2-Justification* -**Based on prior knowledge /scientific knowledge or observation ***H3-Justification must be clear***	**H4-Justification must be valid**
Procedure	**P1-Clear and easy to follow**- using number sequence ***P2-Suitable equipment included-***Either listed in procedure or diagram **P3-The work is neat, presentable, and legible.**	**P4-Provides detail -**that is appropriate to test the hypothesis and question and allows to be repeated **P5-Measurable amounts are included and units.** The procedure includes all measurable amount and correct units.
Variables	***V1-Independent***- Is there one independent variable identified, appropriate and measurable? ***V2-Dependent* -**Is the dependent variable identified, appropriate and measurable? **V3-Controlled -**Can all controlled variables be held at a steady value during the experiment? (some are identified, appropriate and measurable)	**V4-Explained in scientific language.** Are the variables explained using the correct terminology **V5-Controlled -**Can all controlled variables be held at a steady value during the experiment? Are they all identified, appropriate and measurable?

*Sub elements in italics listed under 1st year were also considered in 2nd year.

3.4.2 Monitoring of the elements of the scientific planning skills

in the study conducted several monitored activities that were particularly chosen to allow the students to show the development of these skills. Students also had opportunities to use these skills in other lessons throughout the year, but they were not monitored. The student work in these monitored activities was collected and analysed.

Each class group conducted a range of activities that allowed the planning skills to be demonstrated; students had to write up scientific reports which would contain different planning elements. From these activities, particular activities were chosen to monitor the development of the planning skills. Additionally, at the end of the year, students conducted their own investigations i.e. devised their own question to investigate, planned and carried out the investigation. They then completed their project report in a format that they chose. The project was a Scifest project for 1st year students and was the EEI investigation for 2nd year students.

The students work gave an insight into their understanding of the planning skills and how they were used when planning their investigations. By collecting a range of pieces of work throughout the year the researcher was able to track students' development in different elements of the planning skills and visually see what elements they found easy and which ones they struggled to master. This allows the researcher to make any changes for the next phase of the project.

3.4.3 Analysis of Data from Student work - Planning Skills

Samples of the students work were collected throughout each phase as well as their Scifest / EEI projects at the end of the year. The purpose of this was to monitor the students' development of scientific planning skills and determine which elements of each planning skill students struggled to achieve and if there were patterns / trends between class groups.

Using the elements for scientific planning shown in Table 3.6, all student work was first numerically coded for each element. As the research was determining if students had achieved the element or not a binary system was determined to be more suitable than using a ranking scale which would rank levels of achievement. For example, if the student's investigation question was 'clear and understandable', then it was coded as '1'; if it was not, then as '0'; and if it was not given as 'm'. Tables 3.7 and 3.8 show some specific examples of 2nd year EEI investigations and how the planning skills of forming a question and writing a hypothesis, respectively, were coded.

As the analysis of the scientific planning skills was driven by the researchers' own interpretation of the data, it was decided that interrater reliability would be suitable. Interrater reliability is a measure of agreement between two or more coders of data. The researcher along with three other colleagues in the field of science education each coded a selection of the students' projects. Once coded, a discussion was had about the assigned codes, any discrepancies discussed and an agreement on a final code for each piece of work was decided.

Table 3.9: **Examples of the coding used for forming a question**

	Elements for forming a question					
	Clear and Understandable – Is the question clear in terms of the English language	Doable and appropriate – Is it possible to investigate the question within the context of the activity and in terms of time , resources and students ability	Cause and effect relationships – Does changing one thing effect something else	Specific questions state what needs to be done in detail which allows someone else to replicate the investigation	Lead to taken action- Can an investigation be carried out or do I have to rework the question before starting	Quantifiable – Can measurements to taken
Example 1 :What happens to your heart rate if you run for 30 sec , 1 min and 1min 30 sec ?	1	1	1	1	1	1
Example 2 : Is Diet coke really better for you than normal coke ?	1	0	0	0	0	0
Example 3: What material is the most dense ?	1	1	0	0	0	0

Table 3.10: **Examples of the coding used for writing a hypothesis**

	Elements for writing a hypothesis			
	Is it a statement (Not a question). It expresses propositions	Justification -Based on prior knowledge /scientific knowledge or observation	Justification must be clear	Justification must be valid
Example 1 :We think the golf ball would travel further on the smoother surfaces because the rougher material cause more friction slowing the golf ball down when all other variables are kept constant	1	1	1	1
Example 2: We think chewing gum will help you concentrate because scientists have proven it in the past	1	0	0	0
Example 3 :I think the Brennans bread will mould faster, due to the sugar levels and the wheat. When I looked at the nutritional information on the Brennans bread and compared it to the gluten-free bread, I realised the sugar levels contrasted. There was more sugar in the Brennans bread. All other factors are controlled.	1	1	1	0

The codes were then colour coded (green- 1, red – 0, orange – m, pink –student was absent) and displayed as a 'heat map' for each element for each student, compiled across all the activities monitored. This allowed the researcher to determine any pattern in the development and see what elements students struggled with most and also map the progress of individual students. Figure 3.4 shows the heat map for the element of forming a question for one particular 1st year group – full results and discussion of this data is given in Chapters 4 and 5.

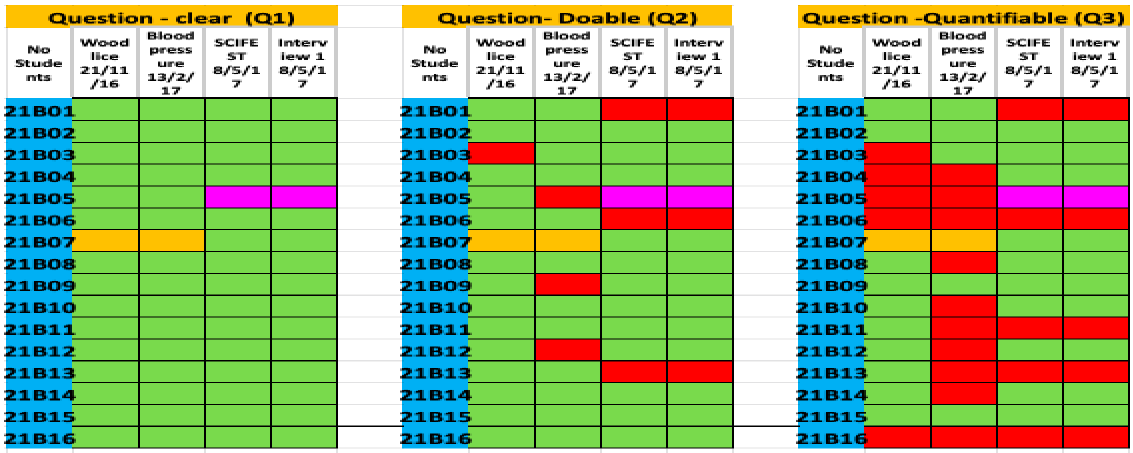


Figure 3.4: **Heat map for the element forming a question**

3.5 Additional data through Interviews and Observations

Interviews with students and (teachers,) teacher's reflections / observations were used to support the quantitative data collected.

Student Interviews

The teacher-student interviews were conducted at the end of each phase after the students had completed their Scifest (1st years) or EEI (2nd year) projects. The interviews were held to seek clarification from the students on aspects of their planning skills and on how they implemented skills of COM and WWO.

Prior to the commencement of each interview, a list of interview questions was created which contained the topics to be explored throughout the interview for both the students (Appendix C) and teachers (Appendix D). The checklist acted as a guide and helped to divide the interview into three main sections, an introductory section which set out the nature of the research, followed by ice breaker questions which lead onto the main body of questions and a closing section of questions.

The icebreaker questions allowed the researcher to help the participant feel comfortable and at ease and were general and broad questions about their experience. Students were asked generally about their experience of carrying out the EEI/Scifest and teachers were asked generally about their views of both key and scientific skills development. The main body of the student interview related in detail to how they carried out their EEI/Scifest project, asked about the scientific planning skills they used and about how they communicated and worked as a group. The main body of the teacher's interviews probed about their views on what was important to develop in science students in relation to key skills and planning skills, their input into the EEI planning sections and problems or barriers they encountered with the new junior cycle Science course and the EEI. The final section of both interviews ended with general questions enquiring if they had any further comments.

Both the student and teacher interviews were conducted in the school during school hours by the researcher. The researcher conducted the interviews and had prepared questions which were available to parents on request. The interview was semi-structured, allowing for flexibility in the discussion and to accommodate the participant's level of comfort. The interviews were recorded and transcribed and coded by the researcher afterward. In total, 39 group interviews with students were conducted and 4 interviews with teachers over the course of the study. Students were interviewed in the groups in which they carried out their Scifest/EEI projects

The sections of the interview on the skills of COM and WWO were isolated as qualitative data and used to support findings from data obtained through the skills passports. These are recorded in this thesis as direct quotes, as relevant to the discussion. The following example is a direct quote from the group of students who were interviewed about their Scifest project: "*we were all so involved and excited about the project and had so many ideas to get out" (21B08, 21B12, 21B14).*

However, the students responses to the sections on the scientific planning skills were coded using the same methodology as shown for planning skills. These codes were also colour coordinated and displayed in the heat map, this can be seen in the last column of the heat map in Figure 3.4. This data was useful to determine student knowledge on aspects of their projects – particularly if they had omitted information from their project submissions.

The teacher interviews were also transcribed and coded. The individual teacher's responses were coded and used to back up any findings related to their class or to provide an insight into their approach that lead to the results from chapter 4 and 5. Their response helped give an insight into the learning environment of each of the classes that was involved in the project with the exception of class K1a who had the researcher as a teacher.

Teacher Observations

Two teachers, K and P, noted their observations periodically throughout the year. In Phase 1, the observations were made by the teacher/researcher and were used to gain an in-depth review of the suitability of the activities and the skills passport. In Phases 2 and 3, both the researcher/teacher K and teacher P recorded observations both during and at the end of the lessons in which the monitoring of the skills of COM, WWO and planning skills were taken place. These were recorded roughly and typed up and coded at late date.

At the end of each assessment activity throughout phases 1, 2 and 3, the teacher recorded observations about how the students engaged with each other during the group activity, any observations during the group work was noted , how they engaged with using the passport and the suitability of the activity to monitor the skills of COM , WWO and planning skills. Each observation was numbered and coded depending on the class, the activity they were from, and the teacher. Example: (O9, K1b, floating/sinking, K) refers to observation 9 during the floating and sinking activity with class K1b and recorded by teacher K. These observations provided a commentary on difficulties or successes encountered during the sequencing of the lesson or with student engagement with the skills.

3.6 Ethical considerations and Limitations

Ethical considerations

This study received approval from The Research Ethics Committee (REC) of Dublin City University (DCU). In compliance with DCU ethical requirements a plain language statement was provided to participants and the guardians of participants under 18 years old (See Appendix E). The main function of these forms was to provide the participants with information about the research and to highlight its main aims. Participants were also provided with an opt – out letter which informed participants that although they could not opt out of the class they could decide at any time to not partake in the research.

Confidentiality/Anonymity

Confidentially is an important issue and was respected at all stages of the research project. Participant's identity will not be revealed or published. However, despite anonymisation of both setting and participants the necessity of revealing my own identity means it becomes possible to locate the site of the research. In the transcription of the interviews the researcher used pseudonyms. All information is in a secure file, answers saved on a password protected laptop. Data will be stored up to 12 months following completion of the project and then will be destroyed by the principal investigator.

Due to the small sample of teachers, they were made aware that anonymity could not be guaranteed but that all data was coded and only the researcher and supervisors had access to the data.

Personal Bias

For this research project the researcher had a dual role as both researcher and teacher of some of the class groups. The researcher had 13 years' experience teaching science from 1st to 6th year and the initial interest in carrying out the research was due to issues noted during her professional practice. Although there are many benefits to being a research practitioner such as easy access to participants, there are also challenges that present when a researcher practitioner works within their own research setting. The potential for personal bias is high and as a result the researcher must carefully look and reflect on their own experience and be aware and question the impact this might have on the research design and on the collection, interpretation and presentation of the data (Polit & Tatano Beck, 2009). As some of the participants were known to the researcher as members of her teaching group, this was a potential area of personal bias in particular when conducting the interviews with both students and teachers and could potentially influence the dialogue. Fortunately, these issues can be overcome by reflecting on existing beliefs and experiences and adapting a level of reflectivity that alleviates the impact of her own professional autobiography and helps foster confidence in the validity of the research (Patton, 2002). Transparency of approach is paramount and regular meetings with a supervisor to discuss and reflect on every stage of the research were important to combat personal bias.

Chapter 4 Evaluation of implementation with first year groups

4 Introduction

This chapter discusses the development, implementation and evaluation of the programme with first year students over the three phases of the study. For each phase, the lesson sequence is given, followed by the results of the evaluation and the implications for the next phase. The overall discussion and implications of the implementation with first year groups is given in Chapter 6.

4.1 Phase 1 Implementation

The main purpose of phase 1 was to determine if the skills passport developed (as discussed in Chapter 3) could be used alongside particular inquiry lessons to monitor the development of two skills, communication (COM) and working with others (WWO), with first year students. Phase 1 aimed to answer the following research questions:

> Q1.1: What sub-skills of COM and WWO did students identify?
>
> Q1.2: Was the skills passport a suitable method to track students' development of the sub-skills of COM and WWO?
>
> Q1.3: Did the student's self-assessment of each subskill agree with the teacher assessment?
>
> Q1.4: Was peer- and self-assessment captured effectively on the skills passport?
>
> Q1.5: Were the particular activities chosen suitable, i.e. did they provide opportunities for students to communicate and work with others?

Two class groups (K1a and K1b) were involved in Phase 1. The scheme of work for the science department had already been agreed and therefore the specific activities chosen for this group had to fit into this plan. An overview of the activities is given in Section 4.1.1 and a more detailed outline of the activities is in Appendix F.

To introduce the students to the project and the skills, at the start of the year a class discussion took place between the students in class K1a and K1b and teacher K. They discussed why it is important for scientists to communicate effectively and to work as a team and the ramifications if scientists are lacking in these skills. The discussion included how miscommunication can occur and how it can be avoided. Students were then asked in pairs to write down what they thought would help a scientist be successful at communicating or working with others. The answers were compiled by the teacher on the whiteboard and the most frequently recorded answers became the sub skills for the skills of communication and working with others. These sub skills became the focus for the year and can be seen in Table 4.1 (as shown in Chapter 3, Section 3.2)

Table 4.1: **The sub-skills for the skills of communication and working with others**

Skills	Subskills
Communication	-Make eye contact when talking -Active listening -Don't talk over anyone -Use a quiet voice -Back up opinions
Working with others	-No messing -Take turns talking -Staying with your group -No fighting/Be friendly -Contribute ideas to the group

Figure 4.1 shows the implementation of activities and formative assessment throughout the school year. At each point students used the skills passport in which they received peer feedback and had the opportunity to reflect on how they had engaged in the skill in the form of self-feedback. Teacher K also recorded observations during each of the activities which helped give an insight into how students engaged with the activities and passport, the suitability of the activities and any changes which needed to be made for Phase 2.

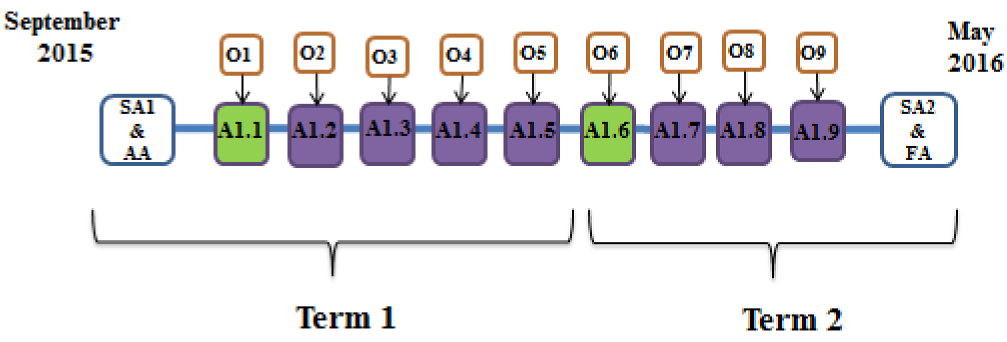


***Figure 4.1:* General outline for Phase 1.** (SA1 - Student assessment 1, AA - Agreed assessment, SA2 - Student assessment 2 , FA - Final assessment , A - Activity, O - Observation)

As discussed in Chapter 3,at the start of the year the students ranked themselves on each of the subskills (SA1). The teacher also ranked each student and following discussion with each student, they agreed on the ranking (AA). During the first term, students were monitored in the skills of COM, while WWO was focussed on in term 2. At the end of the year students ranked themselves on each criterion (SA2). The teacher also ranked the students on how they had developed in these skills (FA). Due to time restraints no discussion was had between student and teacher regarding the final rankings.

Figure 4.1 shows a general outline for Phase 1, where A1.1 and A1.6 were activities where students had an opportunity to practice the skill and receive verbal feedback from the teacher. The other activities included a monitoring section where students received peer and self-feedback in the skills passport.

4.1.1 Lesson sequence

An overview of the activities and skills practiced (P) or monitored (M) with both class groups during the year is given in Table 4.2. Both class K1a and K1b followed the same programme and had the same teacher (Teacher K).

Each of the activities is described in detail in appendix C. During the activities where the skills were monitored, the teacher walked around and questioned the groups on their work while also providing verbal feedback on how they were engaging with the skill. At the end of the activity the students swapped their passports with members of their group and their peer gave feedback and then returned the passport and the student filled out the self-feedback section in their own passport.

4.1.2 Results of Evaluation

Data from the skills passport was combined for both class groups and anonymised. The evaluation involved the analysis of the numerical ranking data (for SA1, AA, SA2 and FA), nature of the feedback (both self and peer) and teacher observations.

Differences between rankings given for SA1 and AA, SA2 and FA, and AA to FA were determined. T- tests was used to determine if these differences were statistically significant. The T-test compares the mean of one sample with the mean of another sample to see if there is a statistically significant difference between the two. If the p-value is equal to or below 0.05 then a conclusion can be made that there is a significant difference between the two samples. This means the difference between the two means is a result that is not attributed by chance.

Table 4.2: **The activities and skills practiced or monitored in Phase 1**

Topic	*Activities /Approach*	*P/M^*	*Skills Developme nt^^*
Introduction to how scientist work	1.1 Cookie mining inquiry experiment**	P	Communic ation Working with others
Measurement	1.2 Inquiry: Measurement and paper planes	M	Communic ation
Variables /Fair testing etc.	1.3 What Varies* 1.4 Fair testing*	M	Communic ation
Living Things/ Cells	1.5 Classification of living things*	M	Communic ation
Ecology	1.6 Woodlice*	P	Working with others
Microscope/cells	1.7 Scaling pictures*	M	Working with others
States of matter	1.8 States of matter*	M	Working with others
Density/ Flotation	1.9 Floating and sinking*	M	Working with others

**Activities adapted from CASE (Adey & Shayer (1981). **Inquiry activities. ^ P – practice, M – monitored. ^^Subskills noted in Table 4.1 listed collectively as Communication and Working with others in this table*

From the skills passport data analysed for COM, there was general agreement in the ranking assigned between SA1 and AA at the start of the year and between SA2 and FA at the end of the year, for each of the communication sub skills, showing general agreement between student ranking and teacher ranking.

However, there were significant differences between the initial agreed AA and the final assessment at the end of the year (FA) indicating an improvement on each sub-skill for COM. Figure 4.2 shows the change in the ranking for each subskill, from AA to FA. Most students improved by one point on the scale (e.g. ranking changed from 1 in the AA to 2 in the FA or from 4 in the AA to 5 in the FA). Over 68% of the group improved in one or more sub skills; note there was one student whose rank decreased by 1 in two subskills.

From the skills passport data analysed for WWO, the t-tests showed no significant difference between SA1 and AA ranking for the subskills *'take turns talking'*, *'no fighting'* and *'contribute ideas'* but there was significant differences for the subskills *'no messing'* and *'staying with your group'*, with the student ranking higher than the teacher ranking.

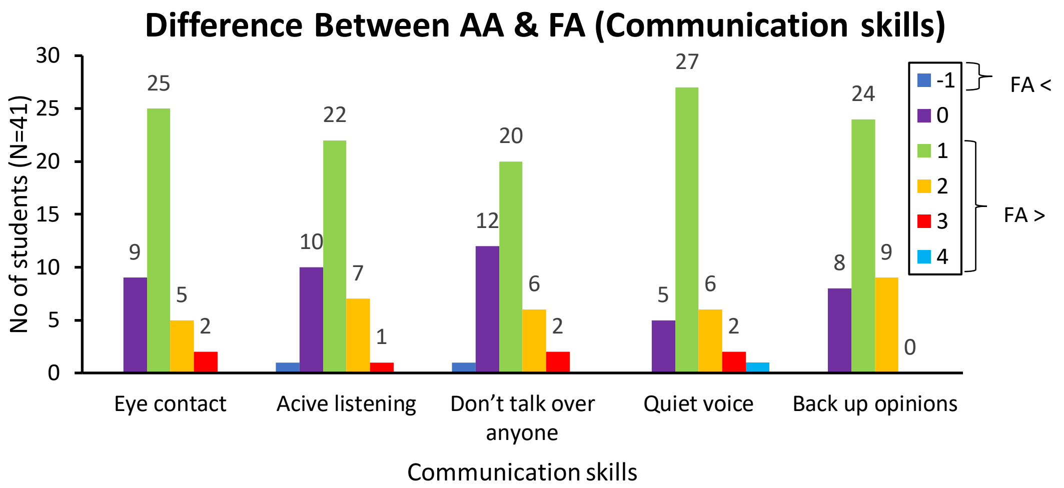


Figure 4.2: **Communication Skills - Difference between the agreed assessment (AA) and the Final Assessment (FA) for Phase 1**

For the subskill *'no messing'*, 24% (17% male and 7% female) of the students gave a different ranking to that of the teacher, with 19% of them ranking themselves higher, including all the male students. This could indicate that a possible gender effect, with a female teacher more likely to have the same interpretation of "no messing" as a female student. Likewise for the subskill *'staying with your group'*, 21% (10% male and 11%

female) of the students gave different rankings to that of the teacher, with 19% of them ranking themselves higher, including all the male students. This shows the importance of having the agreed assessment element as it helps to validate 'the gap' and to help students to become more aware of implementing the subskills effectively.

There were also differences at the end of the year between SA2 and FA for subskill of '*staying with your group'* (*p=0.03*) and '*no fighting/ being friendly'* (*p=0.01*). For subskill of *'staying with your group'*, 33% (14% male and 19% female) of the students gave different ranking to the teachers, with 26% of them ranking themselves higher, including all the male students. Interestingly, for the sub-skill *'no fighting/ being friendly'*, 14% (4 % males and 10% female) of the students gave a lower ranking to that of the teacher.

Figure 4.3 shows the change in ranking between AA and FA for each of the subskills of WWO. From t-tests, there was a significant difference between AA and FA for each of these subskills. The greatest increases were for subskills *'no messing'* (70% increase) and *'take turns talking'* (68% increase). The subskill *'no fighting/being friendly'* showed the least increase as the majority of the students had the maximum ranking for this subskill in the AA.

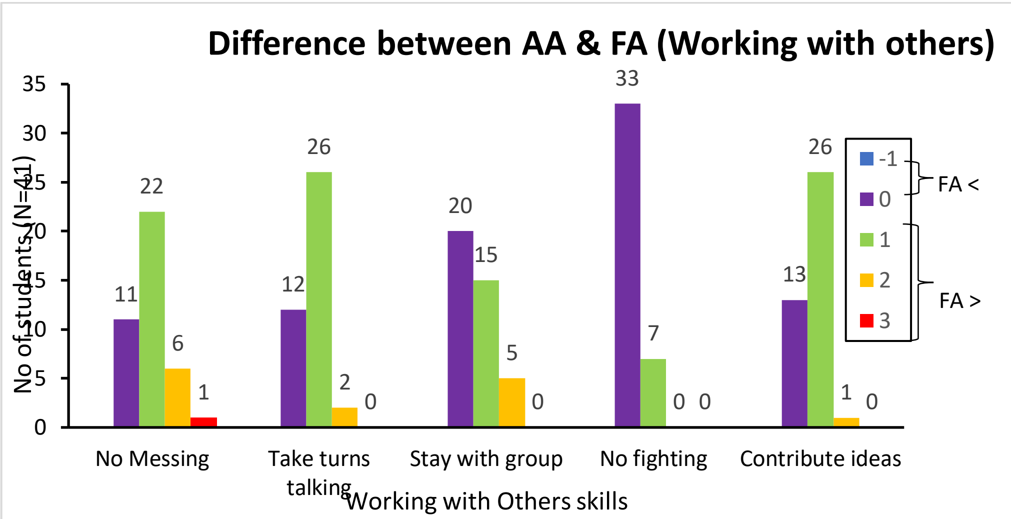


Figure 4.3: **Working with Others Skills - Difference between the agreed assessment (AA) and the Final Assessment (FA) for Phase 1**

At the end of the year, the nature of the feedback that the students received in the peer-feedback or gave themselves in the self-feedback sections of the passport was coded and analysed. The feedback was coded as 'positive comment' on the subskill (how well the student was doing when engaging with a particular sub-skill), 'negative comment' on the subskill (how the student didn't engage with the sub-skill) or 'no comment or irrelevant comment' . Table 4.3 shows the results obtained from the analysis of the peer and self-feedback sections of the skills passport. The majority of feedback recorded in both the peer and self-feedback sections of the passport for the sub-skills of COM and WWO was either left blank or the feedback was irrelevant. This would indicate that students weren't providing any feedback that would enhance the learning of their peers or themselves.

Table 4.3: **Nature of Peer and Self-feedback responses for each subskill**

Skill	Peer - feedback			Self-feedback		
	Negative*	Positive*	None *	Negative*	Positive*	None*
Communication						
Make eye contact when talking	32	28	40	15	10	75
Active listening	11	33	56	8	18	74
Don't talk over anyone	15	35	50	6	22	72
Use a quiet voice	7	22	71	2	10	88
Back up opinions	21	29	50	12	15	73
Working with Others						
No messing	8	20	72	7	24	68
Take turns talking	10	25	65	8	35	57
Staying with your group	9	19	72	9	22	69
No fighting/Be friendly	0	26	74	0	31	69
Contribute ideas to the group	12	31	57	9	40	51

Observations/Field notes

During each activity (as noted in Figure 4.1) the teacher researcher noted observations to aid in the evaluation of the activities and the skills passport. The observations also allowed the researcher to record any issues such as student engagement with the peer and self-assessment feedback section, time issues etc.

Generally the researcher felt that the activities selected helped the students to practice and demonstrate the skills of COM and WWO. With regards to activity 1.5 'Classification of living things' the researcher noted:

> "*Really good activity to support the communication skill. Some of the items such as clouds, seaweed and fire generated a lot of discussion among the groups. Students had to use all the criteria set out for communication to come to an agreement as a group. This allowed students to especially demonstrate the 'backing up opinions' criteria*" (O5, K1a, Living things, K).

Initially the researcher noted that students struggled to pull in previous knowledge and apply it to real life examples. However, as the term progressed students were able to apply what they were doing in class to real life examples.

> "*When working on the density problem students started to discuss how they had solved other problems as a group. Students suggested applying it to a real-life situation in order to get a better understanding of the concept …. Students started to research the Titanic and how it sank*" (O9, K1b, Floating/sinking, K).

The researcher also noted students' difficulty with engaging with the peer and self-feedback section of the skills passport. It was noted during Observation 2 (O2) that students:

> "*Needed prompting to help fill out the peer feedback section" (*O2, K1a, paper planes, K*)* and *"Students struggled to record anything relevant in the peer/self-feedback sections" (*O3, K1a, What varies, K*).*

By the sixth observation it was noted that:

> *"Students were able to fill out the peer/self-feedback section themselves without prompting*" (O6, K1b, Woodlice, K).

Although by observation 6, students were seen to engage with the peer/self-feedback sections, the data shows that 53% of the peer feedback sections were left blank or irrelevant feedback given and 62% of the self-feedback sections were left blank or irrelevant feedback noted.

4.1.3 Conclusions from Phase 1

Looking at the results from phase 1 we can begin to answer the research questions set out in Section 4.1. The subskills of COM and WWO were identified by the students and given in Table 4.1 **(Q1.1)**. The classroom discussion was useful as it placed the subskills in the context of the work of scientists, thereby emphasising these skills within the science classroom. Also, the subskills identified could be mapped on to the Junior Cycle key skills, as discussed in Chapter 3.

Due to the significant difference between the agreed assessment (AA) at the start of the year and the final assessment (FA) at the end of the year, it is clear that students did improve on the skills of COM and WWO through each of the subskills during phase 1 **(Q1.2).** Some made bigger jumps up the ranking scale than others but all students improved. The skills passport was an effective way to capture this ranking. Comparing the students assessment (SA1) and the agreed assessment (AA) between the teacher and student at the start of the year, statistically there was no significant difference between them for the subskills of COM or for the following WWO sub-skills *'take turns talking'*, *'no fighting/be friendly'* and *'contribute ideas'*; showing agreement in ranking by the student and teacher. This was not the case for the WWO sub-skills *'no messing'* and *'stay with your group'*. Where there was disagreement, the male students in particular ranked themselves higher compared to the teacher ranking, which was lower. This was not as evident in the female cohort. This may be due to the behavioural aspect of these skills and male students perceiving themselves to be better behaved **(Q1.3).** This impact of gender was not expected and something that the researcher identified to examine in phase 2 to see if gender is a factor in students' under or over estimating their rankings.

In peer and self-feedback sections for the skill of COM, students commented on the subskill *'make eye contact'* most in their skills passport and least about *'using a quiet voice'* and for WWO the subskills of *'contribute ideas'* was commented on mostly with *'no messing'* the least **(Q1.4).** The nature of feedback improved as the year progressed once students had the opportunity to practice; however greater support is needed for students to fully engage with this process and to reduce the amount of irrelevant or missing feedback. A modification of the skills passport is required to more effectively encourage feedback **(Q1.4)**.

Looking at the results and how the students improved from the start of the year it is clear that the skills passport is effective at monitoring the skills as it provides a platform for the skills to be noted periodically and recorded and by doing so highlights their importance with students. However, it is clear from the observations and the quality of feedback received that it needs to be redesigned to allow it to support students to give more meaningful peer and self-feedback and reduce the amount of feedback that was missing or irrelevant **(Q1.4).**

Finally, the activities that were included specifically to give opportunities for students to work with each other and to communicate were considered appropriate and supported the development of the skills. The activities would be used in phase 2 plus the addition of other activities which would support the development of inquiry planning skills which will also be developed and monitored during phase 2 **(Q1.5).**

4.1.4 Implications for phase 2

Following phase 1, it was clear that several changes were necessary, particularly in the design of the skills passport for phase 2. The redesigned skills passport (shown in Figure 4.4) dealt with the practical problems experienced using the skills passport noted by the researcher's observations in phase 1, such as:

- "*Remove the boxes beside the criteria for each skill as they are causing confusion for students*" (O1, K1a , Cookie, K)
- "*Prompts needed in the skills passport for both peer and self-feedback*" (O1, K1a, Cookie, K)
- "*Remove the teacher feedback section as due to time restrictions it is not possible to leave feedback*" (O3, K1b, What varies, K)
- "*Instead of working on one set of criteria and skill per term i.e. communication for term 1 and working with others from term 2, split between them between the terms as students are mastering some elements quicker or had mastered them already such as the behaviour elements and therefore are not fully engaging with the passport* "(O5, K1a, living things, K)
- "*Passport needs to be stabled and pages numbered to prevent students filling in the wrong sections or losing sheets*" (O5, K1a, living things, K)

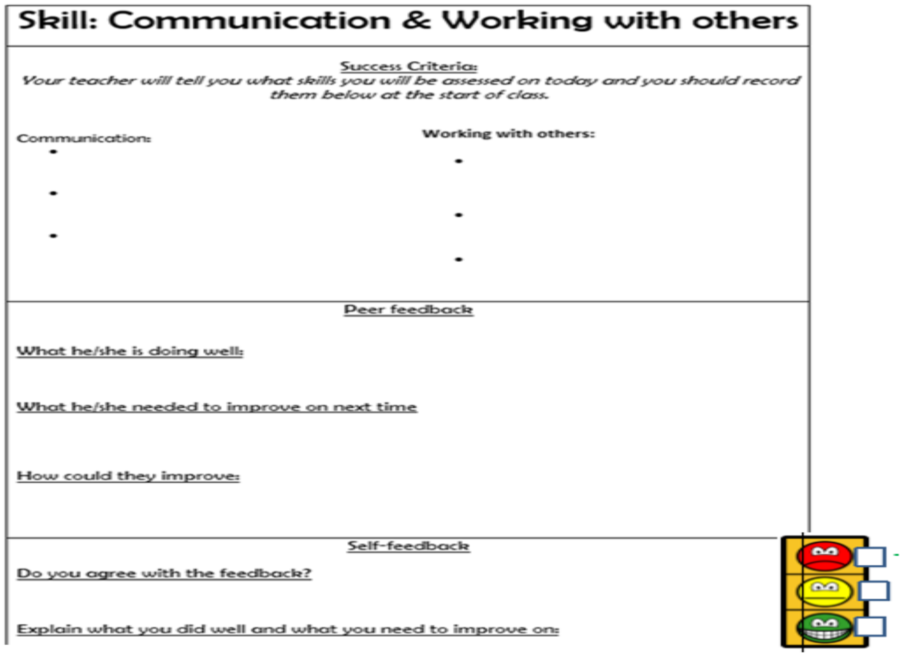
Specific guidelines were introduced in the peer/self-feedback sections of the passport that highlighted how students should give feedback. In the peer feedback section, students were given clear questions that they could answer. Here peers were asked to comment on what the student had done well, what they needed to improve on and suggestions on how they could improve. Focusing the feedback on what needs to be done can encourage students to believe they can improve and increase motivation. For peer assessment to be successful students need to be given more opportunities to practice. Although at the start this can be time consuming but it is a valuable exercise as it is likely that students will consider comments on their work from peers more seriously than those of their teacher. The teacher feedback comment section was removed as it was time consuming to complete and was considered better to remove that to leave blank.

In the revised self-feedback section, students would now have to comment on what they did well and what they felt they needed to do to improve. They could also note whether they agreed or not with the peer feedback given. This would help involve the students in their own learning process and provide them with opportunities to reflect on how they had engaged with the skill. The traffic light system used in Phase 1 was retained - if they are happy with how they use the skill they tick the green light; if they aren't sure they tick the yellow light and if they think they need more help they tick the red light.

While the students are filing out the self-assessment section the teacher can walk around and give instant oral feedback to the student; however, due to time restraints this was difficult to do during every activity during phase 1. Therefore, time must be allocated into the lessons to allow for this process to take place in phase 2.

The analysis methodology for the peer and self-feedback was extended to consider 5 aspects, rather than 3 to give a more detailed rich account of the type of feedback that was received. In phase 2, the focus was on increasing the extent of the feedback; this would be achieved by spending more time in class focusing on the feedback sections to help support students, and giving the particular questions on the skills passport to help them. A further change in Phase 2 was the timeline for focus on the subskills. Instead of focusing on one skill per term (in Phase 1, COM in term 1 and WWO in term 2) it was decided to work on a combination of skills from both COM and WWO. For phase 2 a new dimension was added to the study. Alongside the development of the subskills already identified (key skills), an inquiry approach was incorporated into teaching which targeted development of scientific planning skills.

The benefits of inquiry have already been discussed in Chapter 2. The addition of inquiry based activities will not only facilitate the development of key skills but also allow for the development and assessment of scientific content and scientific planning skills. Activities based on the inquiry approach would be designed and embedded into classroom planning. Due to addition of more activities and the involvement of more teachers, a manual was designed which contained the activities that would be used to monitor and develop both the skills of COM, WWO and scientific planning skills. The manual acted as a step by step guide for the teachers when using the activities with their classes. At the end of phase 2, students will complete a project and participate in Scifest. This project will be used as the final assessment point for the planning skills which were introduced for phase 2. Students would also be interviewed at the end of the year about their Scifest projects, the planning skills and the skills of COM and WWO.



Skill: Communication & Working with others

Success Criteria:
Your teacher will tell you what skills you will be assessed on today and you should record them below at the start of class.

Communication:
-
-
-

Working with others:
-
-
-

Peer feedback

What he/she is doing well:

What he/she needed to improve on next time

How could they improve:

Self-feedback

Do you agree with the feedback?

Explain what you did well and what you need to improve on:

Figure 4.4: **Revised design of the skills passport for Phase 2**

4.2 Phase 2 Implementation

The main aim of phase 2 was to embed the development of skills throughout the year across many classes, rather than focussing on particular activities in a few classes. In addition to the use of the redesigned skills passport, the lesson sequence and content were revised (see Section 4.2.1) and the analysis of the skills passport data (Section 4.2.3) was extended. Additionally, this phase also incorporated a new dimension to review the development and assessment of scientific planning skills; a rubric to help with the assessment of these planning skills was trialled. Phase 2 aimed to answer the following research questions:

Q2.1 Did integration of the skills of COM and WWO allow students to develop each subskill?

Q2.2 Comparing SA1 with AA and SA2 with FA for COM and WWO, was there agreement and was gender a factor in any disagreement?

Q2.3 Did the revised coding system provide further details in relation to peer and self-feedback?

Q2.4 In relation to the planning skills, was the method used useful to help monitor their development? What areas require further investigation?

Two class groups (P1a and P1b) were involved in Phase 2 with P as their main teacher and some team-teaching with P and K teachers. Both groups covered the same sequence of lessons. The general scheme for Phase 2 is shown in Figure 4.5. The yellow box indicates COM and WWO skills while the blue box indicates the planning monitored during these activities. The first six activities as used in Phase 1 (A1.1-A1.6) were included in Phase 2, with one additional activity (A2.0), but the order of the activities was adapted to fit in with the scheme of work decided by the school science department. These activities were chosen as they were also suitable to monitor the development of the scientific planning skills as well as COM and WWO. The outline of all the activities in Phase 2 can be found in appendix H.

In this Phase, the sub-skills that complement each other were grouped together. In Term 1, the following skills would be focused on: COM- *Make eye contact*, *Don't Talk over anyone*, *Active listening* and WWO - *Contribute ideas*, *Take turns talking* (indicated as COM & WWO *) and in Term 2, COM - *Use a quiet voice*, *Back up opinions* and WWO - *No Fighting/be friendly*, *No messing*, *Stay with your group* (indicated as COM & WWO**) (Figure 4.3).

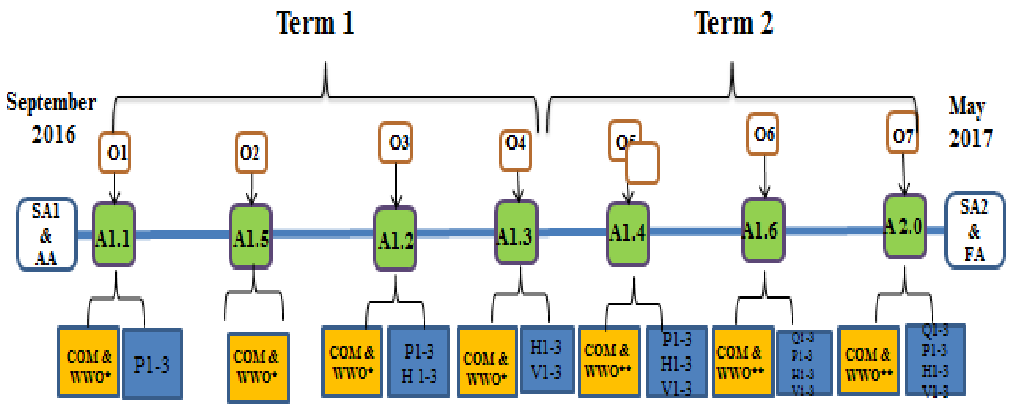


Figure 4.5: General outline for phase 2. (SA1 - Student assessment 1, AA - Agreed assessment, SA2 - Student assessment 2 , FA - Final assessment , A - Activity ,O – Observation, COM &WWO* , COM & WWO ** -, P – Procedure, H – Hypothesis, V – Variables, Q – Question)

4.2.1 Lesson Sequences

As in Phase 1, during the first week of lessons, students were asked to discuss the importance of effective communication and team work by scientists. Skills required were discussed and the range of subskills agreed as in Phase 1. The particular subskills were then grouped as above for monitoring during the activities.

An overview of the lesson sequence and skills focus during Phase 2 is given in Table 4.4. The class groups involved in Phase 2 were following the new Junior Cycle Science Specification, and hence many inquiry based activities were added. These inquiry activities also help with the development and monitoring of both the skills of COM, WWO and the planning skills. As highlighted in Chapter 2, the inquiry approach encourages students to ask questions, work collaboratively and creatively, and provides many opportunities for group work. Table 4.2 includes how the content knowledge linked to the Junior Cycle outcomes. Activities in which the skills were monitored through the skills passport or the planning skills graded by the teacher are also included in the table. Also, both class groups completed a Scifest project at the end of the year, these projects were conducted in small groups.

Analysis of the results of the data collections will now be discussed - results obtained through the skills passport in Section 4.2.2 and the Planning Skills in 4.2.3.

Table 4.4: **Phase 2 lesson sequence for 1st year science**

Weeks	Learning outcomes linked to the Junior Cycle*	Content Knowledge	Activities	Skills focus	
				Key Skills	**Scientific Planning skills**
1	Introduction to science/Laboratory (NOS 3)	Understand rules of the lab / Understand safety hazards in the lab Identify general lab glassware/apparatus Correct cleaning of glassware Reporting breakages/accidents Safely and correctly use BB Bunsen burner (BB) licence.		Introduction to the key skills. **WWO and COM**	
2	Working like a scientist (NOS 1 & NOS 3)	Introduction to designing, planning and conducting investigations.	**Activity**: 1.1 Cookie mining	COM & WWO *	Writing a procedure Listing suitable equipment
3-5	Living things, Microscope & Cells (BW1)	**Week 3**: Identify the characteristics of living things Draw and label plant/animal cell diagrams and organelles **Week 4:** State functions of the Organelles Know the main differences between a plant and animal cell Label the diagram of a microscope and understand the function of each part. **Week 5:** Prepare a plant and animal slide Investigate structures using a microscope	**Activity**: 1.5 Classification of living things	COM & WWO *	
6-8	Measurement (PW1 & 2)	**Week 6:** Select and use correct measurement tools for length, mass, time, temperature, area and volume **Week 7**: Calculate and/or measure the listed Use units correctly **Week 8** Design and plan an investigation to answer the following question Does the area of the paper used to make a paper airplane affect the distance it can travel?	**Activity: 1.2** Paper planes	COM & WWO *	Writing a procedure Suitable equipment Hypothesis

9	NOS 3 Variables	Understanding the terms independent variable, control variable, dependent variable Identifying the independent dependent and controlled variables in an experiment. -Identify relationships between variables	**Activity 1.3: What varies**	COM & WWO *	Forming Hypothesis Variables (Practiced)
10	Fair Testing NOS3	How to ensure fair testing. Changing the Independent variables and the impact on dependent variables	**Activity : 1.4** Fair test (COM & WWO only)	COM & WWO **	writing a procedure forming a hypothesis, Variables(Practiced)
11-13	Ecology BW5	**Week 11** -Know what a habitat is, - how they vary and how different habitats support different organisms -Know that habitats can be affected by environmental factors, light, availability of water, number of nutrients present -Adaptation, examples and how they can help the plant or animal survive **Week 12** -Competition, examples and how they can help the plant or animal survive -Interdependence, examples and how they can help the plant or animal survive -Conduct a habitat study -Draw and understand food chains **Week 13** -Investigate the behaviour of woodlice	**Activity: 1.6** Woodlice	COM & WWO **	Forming a Question writing a procedure, forming a hypothesis, Variables
17-23	Systems BW4	-Label the parts of the circulatory system -Describe the function of the blood and its components -Explain the function of the heart and its interaction with the rest of the body systems -Identify the structures of the heart -Describe what the word digestion means -Distinguish between the two types of digestion -Describe and distinguish between mechanical and chemical digestion -Describe what happens to food when it is broken down	**Activity** : 2.0 Blood pressure	COM & WWO **	Forming a Question writing a procedure, forming a hypothesis, Variables and fair testing.

		- Label the respiratory system and state the functions of each part -Understand how the three systems interact -Understand the positive effects of exercise on the heart -Know what the pulse is and how to measure it -Know what factors can affect the workings of the circulatory system -Carry out an investigation to determine if exercise impacts the pulse rate			
23-28	SPACE	No researcher input			
	Scifest ^				Forming a Question writing a procedure, forming a hypothesis, Variables and fair

*the following skills were the focus- COM- *Make eye contact*, *Don't Talk over anyone*, *Active listening*. WWO - *Contribute ideas*, *Take turns talking*

** the following skills were the focus - COM -*Use a quiet voice*, *Back up opinions*. WWO- *No Fighting/be friendly*, *No messing*, *Stay with your group*

^ both class groups took part in Scifest, this was done both in school and at home, however only a few class times were dedicated to their projects and the majority of work was done at hom

4.2.2 Results of Evaluation from the skills passport

This section will look at the development of the skills of COM and WWO. Overall differences between the Agreed Assessment (AA) at the start and the Final Assessment (FA) at the end will be analysed. Comparison of the students ranking (SA1) with the agreed assessment (AA) and also the final SA2 with the FA will be analysed particularly to determine if gender was a factor. Finally, the nature and quality of the feedback in the peer and self-assessment sections of the skills passport will be analysed.

Comparison of the average ranking from the start of the year (AA) to the end of the year (FA). shows that students improved on every sub-skill for COM and WWO (Figure 4.6). An independent t-test showed that the difference for each subskill was significantly different ($p \leq .05$). The next section will look at the skills of COM and WWO in more detail.

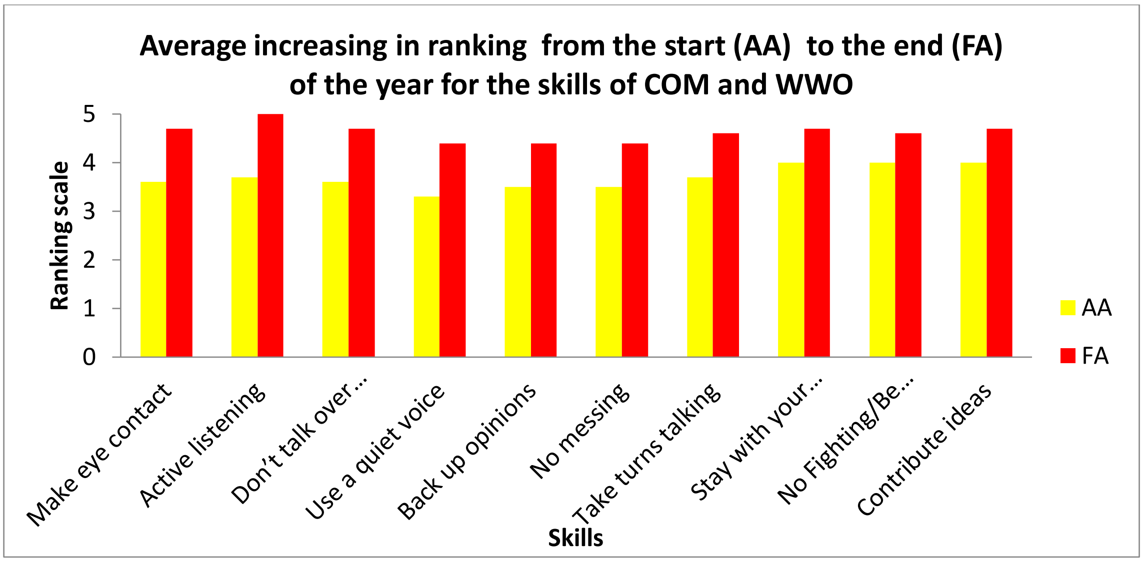


***Figure 4.6*: Average ranking for each subskill – Class groups P1a and P1b** (AA-agreed assessment, start of the year; FA – final assessment at end of year)

4.2.2.1 Individual sub skills

Figure 4.7 shows the magnitude of the change in ranking between the Agreed Assessment (AA) and the Final Assessment (FA) for the COM subskills. The columns represent the number of points the students moved on a 5 point scale from the start to the end of the year. The majority of students increased by one point on the scale while no student decreased on the scale. Also the most improved skills were '*active listening*' and making '*eye contact*'.

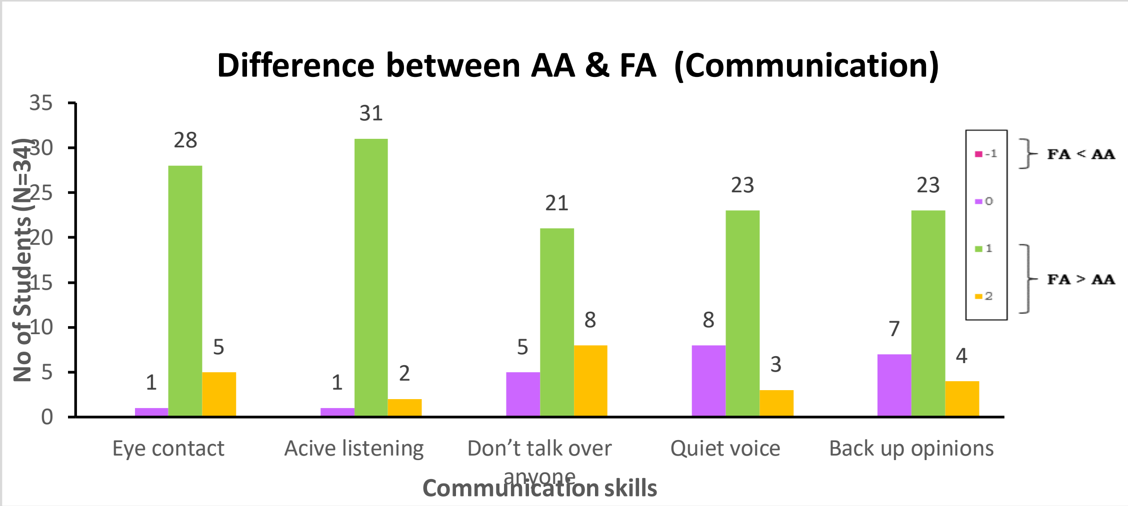


***Figure 4.7*: The difference in ranking between the agreed assessment (AA) and the Final assessment (FA) for the sub-skills of communication for class groups P1a & P1b.**

At the end of the year students were interviewed in groups about their Scifest projects and asked what skills they used to help them complete their project. In terms of the communication skills, 9 (out of the 10 project interviews) mentioned '*eye contact*', while 8 (of the 10) mentioned '*active listening*'. '*Don't talk over anyone'* was mentioned by 6 of the groups.

At the start of the year the teacher noted in her observations that students struggled with making eye contact:

> "*Initially students did not like the idea of looking at peers when talking as they found it uncomfortable. We explained they didn't have to stare at a student but more glance when talking*" (O1, P1a, Cookie, K)

but by the end of the year students were giving oral feedback during group work to students who were not engaging with the skills of eye contact or active listening:

> "*Students were able to verbalise if they thought someone in the group wasn't making eye contact or active listening*" (O5, P1b, The fair test, K).

It was also mentioned how listening skills were also focused on and discussed:

> "*Students had to be reminded to stop what they are doing and give the speaker full attention when they are talking. The students were distracted by the iPad which they shouldn't be using*" (O4,P1a, What Varies ,P)

> "*Discussion was held at the end on making eye contact and active listening*" (O1,P1b, Cookie,K).

Figure 4.8 shows at the change in ranking between the agreed assessments (AA) and the Final assessment (FA) for the sub-skills of WWO. The columns represent the number of points the students moved on a 5 point scale from the start to the end of the year. While again the majority of the students increased by 1 or more points, a significant number (up to a third) showed no change. This was because many students were already ranked 5 on the scale at the start of the year for the behavioural elements of WWO.

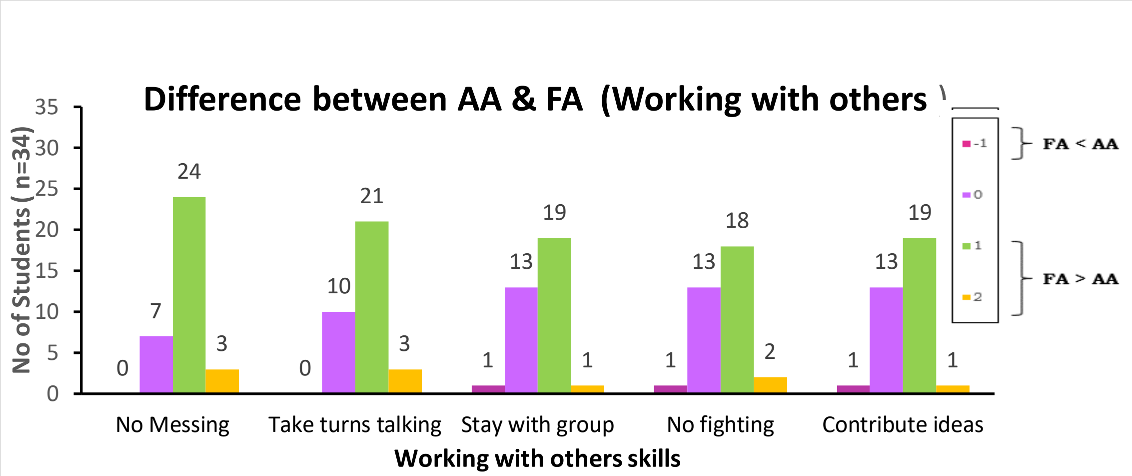


***Figure 4.8:* The difference between the agreed assessment (AA) and the Final assessment (FA) for the sub skills of working with others for class groups P1a & P1b..**

Interestingly, during the Scifest interviews when asked how they worked together and what skills they used, only 2 groups mentioned '*Take turns talking*'.

4.2.2.2 Investigation of gender on ranking

Table 4.5 compiles the difference in ranking between the student self-assessment (SA1) and the agreed assessment (AA) at the start of the year for each of the subskills, based on gender. It shows the number of males/females who ranked themselves higher (over) the AA or below (under) the AA. Table 4.5 also includes the same comparison at the end of the year, between SA2 and FA.

From Table 4.5,it is clear that the teachers and there students ideas have converged There is general agreement across all skills; however, in terms of '*eye contact'*, 7 females underestimated their ranking while 7 males overestimated their ranking. Also 6 males overestimated their ranking for the sub-skill '*backing up opinions'*. At the end of the year, these numbers had decreased.

Table 4.5: **Difference between assessments. Looking at over and under estimating between students (class groups P1a & P1b).**

Sub Skill	Agreed*	Female Under*	Male Under*	Female Over*	Male Over*
Eye Contact	17 (25)	**7 (5)**	1 (1)	2 (0)	**7 (3)**
Active List	22 (27)	4 (2)	2 (2)	2 (3)	4 (0)
Don't Talk over	28 (29)	0 (0)	1 (3)	3 (1)	2 (1)
Quiet Voice	27 (28)	2 (0)	1 (1)	3 (2)	1 (3)
Back up opinion	21 (27)	1 (0)	2 (2)	**4 (1)**	**6 (4)**
No Messing	18 (28)	2 (0)	2 (1)	3 (2)	**9 (3)**
Take Turns Talking	28 (29)	0 (2)	2 (2)	2 (1)	2 (0)
Stay with Group	31 (30)	0 (1)	1 (1)	1 (1)	1 (1)
No Fighting/Be friendly	16 (29)	**6 (2)**	3 (1)	2 (1)	**7 (1)**
Contribute ideas	29 (30)	1 (1)	0 (2)	2 (1)	2 (0)

*first number relates to difference between SA1 and AA at the start of the year. Number in brackets refers to the difference between SA2 and FA at the end of the year. Total number of students is 34, 15 female and 19 male

In terms of the WWO subskills at the start of the year, 9 male students over estimated their rankings on the behavioural subskills '*No messing*'. For the subskill '*No fighting, be friendly'*, 7 male students over estimated while 6 female students underestimated their ranking compared to the AA. By the end of the year, There is less disagreement, suggesting a greater understanding of the subskills.

Counting individual instances of disagreement, for the COM subskills, there were 12 incidents of females and 7 incidents of males underestimating their ranking with14 incidents of females and 20 incidents of males overestimating their ranking at the start of the year. These numbers changed to 7, 9, 7, and 11 respectively at the end of the year – all decreasing except one.

Likewise for the WWO subskills, there were 17 incidents of underestimating (9 female, 8 male), and 31 of overestimating (10 female and 21 male). These numbers reduced by the end of the year (to 6, 7, 6, 5 respectively). Care must be taken with these numbers as, in some cases, the same student would have under/overestimated in a number of subskills. Also the numbers are really too small to draw conclusions regarding possible gender effects; suffice it to conclude that students developed a greater shared meaning of the subskills with the teacher throughout the year.

4.2.2.3 Observation data on skills of COM and WWO

Similar to phase 1, there was a significant difference between the AA and FA, showing that students improved on each subskill for COM and WWO. The most improved sub-skills were 'making *eye contact'* when talking and *'active listening*'. Observation notes highlighted that the teacher drew the student's attention to these:

> " ..the *person who is recording the notes has to be reminded to look up from their work when group discussions are taken place*" (O1, P1a, cookie, P)

> "*Students had to be reminded to stop what they are doing and give the speaker full attention when they are talking*" (O4, P1a, what varies, P)

This may account for why they are the most improved and also the most frequently mentioned by students in their Scifest interview. During these interviews at the end of the year, students mention 'eye contact', 'backing up opinions' and 'active listening' as the most used skills. Students noted *'don't talk over anyone one'* as the most difficult skill to use, but they suggested:

> *"not talking over each other difficult. We were all so involved and excited about the project and had so many ideas to get out*" (Students, 21B08, 21B12, 21B14)

Teacher observations highlighted instances of good communication within the groups:

> *"During the activity I could hear students saying to peers "you are not making eye contact" and "could you please look like you are interested in what I'm saying*" (O3 , P1a,paper plane, P)

> "*The students within two groups started fighting among themselves about the answer to one of the questions (Is a cloud living?), in both groups a student intervened and asked them to back up their opinions, using knowledge from the topic on living things they made a good attempt at backing up their opinions.*" (O3, P1a, paper plane, K)

Looking at the subskills for WWO, the most improved sub-skills were '*no messing*' and '*take turns talking*'. It is noted that many of the WWO subskills could be considered as behavioural elements and many students ranked themselves at the top of the scale on these at the start of the year. In the observations noted by the teacher it is mentioned that the student's behaviour was excellent, and no one was "messing". It was however noted that when students were faced with a challenge they couldn't overcome, some initially tried to leave their group to get the answer:

> "*The activity is really challenging the students; instead of working together some students are leaving their groups to go see what other students are doing, they were however stopped as students are not allowed to leave their seats in the lab. These students were asked to go back to their group and advised to each contribute an idea and to work with their peers to solve the problem correctly. The greater proportion is all working together to try and solve the question*" (O5, P1a, fair test, K)

In Observation one from class P1a it was also highlighted that some of the weaker students were slower to contribute ideas, however at the end it was noted that everyone in the groups was contributing to group discussions.

> "*some really good in-depth discussion taken place, students are very well behaved, and most students seem to be contributing ideas, the weaker students are slower to contribute ideas on the experiment*" (O1, P1a,cookie,K)

During the Scifest interviews, students mentioned some difficulties they encountered while working with peers and as a group:

> "Some *students worked better than others and this is something we need to improve on so everyone contributes ideas. The work wasn't evenly spread out. But the students who did work together, worked well and this made it an enjoyable experience*" (Students, 21B03, 21B15, 21B09)

The value of collaboration with peers was evident and students mentioned the benefits of working collaborating on the Scifest project and the benefits it had such as sharing ideas, cooperation and developing positive peer relationships:

> "We *went to each other's houses to work on the project and we became good friends. If we didn't like something we discussed it and compromised*" (Students, 21A18, 21A02)

"*We worked good as we are friends, this helped us feel comfortable sharing ideas and listening to each other's ideas*" (Students, 21B04, 21B07)

However, one group did mention sharing ideas as a negative as it resulted in them talking over each other

"*Hard to stay together*, *difficult to listen to all ideas and include them. Talking over due to excitement"* (Students, 21A04, 21A08, 21A03)

During the interview, students also highlighted the benefits of working as a group such as playing to each other's strengths and sharing out of roles and how this helped the productivity of the group and general expertise.

"*Divided up the tasks such as drawing, details, research and we played to each other's strengths*" (Students, 21B08, 21B12, 21B14)

"We *both had different jobs and got it done faster*" (Students 21A18, 21A02)

"*Let everyone do different sections of the project, and therefore they were an expert on their section*" (Students, 21A04, 21A08, 21A03)

4.2.2.4 Quality of Feedback given in the skills passport

The peer and self-feedback noted on the skills passports was categorised under 5 headings (as discussed in Chapter 3), namely:

- Positive Informative (Feedback highlights what the students is doing well, what they need to improve and relevant tips on how they can improve),
- Informative (Feedback highlights what the student is doing well, what they need to improve on, but the tips on how to improve are not appropriate or relevant),
- Uninformative (Feedback highlights what the student is doing well but not does tell them what they need to improve or how),
- Irrelevant (Feedback skills focused but not the correct skill/Not skills focused; No constructive comments on skills development),
- Missing feedback (Left blank).

In this section, the peer feedback will be discussed first, followed by the self- feedback.

Peer feedback

The peer feedback noted on the skills passport for each of the 6 monitored activities was examined and categorised, depending on the nature of the written comments. Figure 4. 9 shows the nature of the comments for each activity (total number of students is 34). The first three activities (Cookie, Living things and Paper planes) took place in Term 1 so these will be discussed first.

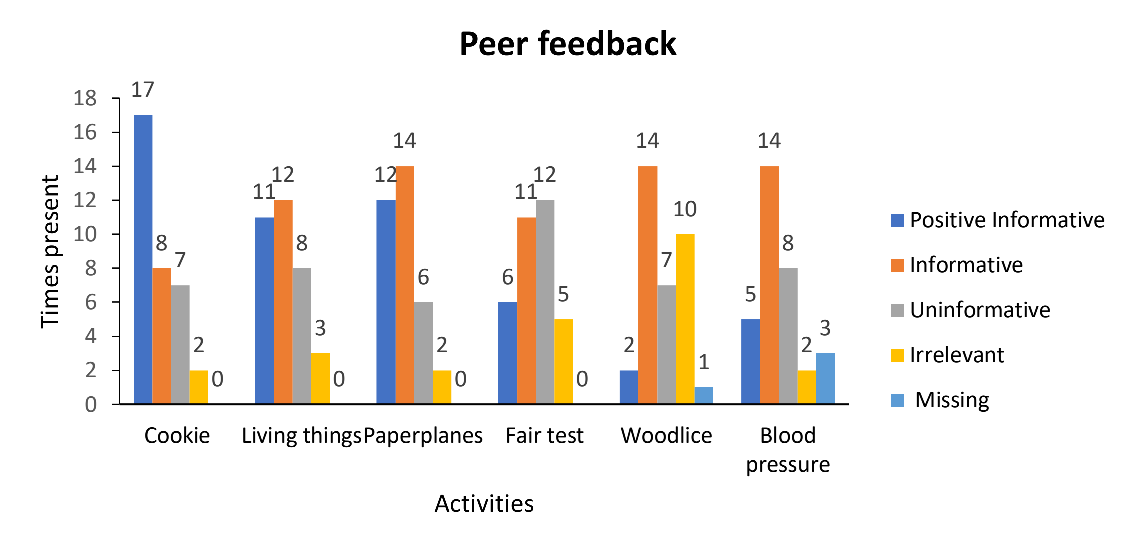


Figure 4.9: **Classification of Peer feedback as recorded on the skills passport (class groups P1a & P1b).**

From Figure 4.9, it is clear that the majority of the feedback for the first three activities was positive informative and informative. From the teacher's observations a lot of teacher support was given in relation to giving feedback during Term 1 and the teacher spent time at the end of the lessons giving feedback to students and advising them on how to give good feedback. In particular, time and explanations were given for the first activity:

> *"A lot of time was spent going over the peer feedback section and oral feedback was given to students" (*O1,P1a, Cookie, P)
>
> "*Time was spent given feedback to students on how to give feedback to students and what positive informative should include*"*(*O1,P1a, Cookie, K)

and teachers also walked around and checked each students passport:

> "*P and K went around and checked all the peer feedback and ensured each section was done correctly*" (O1, P1b, Cookie, P).

It is also noted that although a lot of time initially was spent on supporting students to give peer feedback this was not the same experience for self-feedback

"Didn't *have enough time to do the same for the self-back section*" (O1, P1b, Cookie, K and P).

As Term 1 progressed, there was a slight shift towards informative feedback rather than positive informative feedback. Therefore, students were receiving feedback that didn't include tips on how to improve. Time in class was highlighted in a number of observations:

"*students had only about 5 minutes to fill out the passport. They need about 15 minutes usually*" (O2, P1a, living things, P), (in this instance the fire alarm had gone off)

"*More time spent on the activity due to the great discussions. Limited time for filling out the passport*" (O2, P1b, living things, P)

"*no teacher support given*" (O2, P1b, living things, K).

During the same lesson it was highlighted by teacher K that students in class P1a didn't know how students could improve on certain sub-skills and this would account for the increased in informative feedback that we see during activity 2,

"*When I highlighted the importance of given tips on how the students could improve, the students responded that they didn't know how the student could improve" (*O2, P1a, living things, K)

By the third activity, the same issues are highlighted:

"*Too much time spent on the peer feedback section*" (O3, P1b, Papers Planes, K)

"*I had to remind students on 3 occasions how to correctly fill out the feedback section. I had time to check the feedback and highlight to 3 students that their feedback wasn't done correctly as they had not highlighted how the student could improve*. (O3, P1a, Papers Planes, P)

"*Students seems to struggle to give good tips on how students can improve and many are leaving it blank or leaving irrelevant comments*" (O3, P1a, Papers Planes, K)

Looking at Term 2 data in Figure 4.9 (Fair Test, Woodlice, Blood Pressure) there is a decrease in positive informative feedback and an increase in feedback that was uninformative or irrelevant especially. Teacher observations noted the issue of time again:

"*students spent longer than expected on the activity, they were fully engaged and as a result less time was left to fill in the passport and it was rushed*" (O5, P1a, The fair test, P)

"*Fire alarm went off at the end of the activity, we lost 10 minutes of class time*" (O5,P1a, The fair test, K)

Although time was not an issue for class P1b but that they had "No teacher support when filling out the passport" (O5, P1b, The fair test, K)

It is clear from Figure 4.9 and the teacher observations that students are struggling to give positive informative feedback without the support of the teacher. Both time and teacher support plays a major role in the quality of peer feedback students receive. The level of support from the teacher decreased as the term progressed and so did the amount of positive informative feedback. Another factor to consider is the sub skills that were focused on during Term 2, many of the skills were behavioural elements and as noted earlier, both classes had no behavioural issues and many students had mastered these WWO subskills at the start of the year and therefore this would have made it difficult for students to give feedback that contained tips on how to improve.

Self-feedback

After students had received peer feedback they then had an opportunity to read the feedback and give themselves self- feedback. The self-feedback was categorised under the same headings as the peer feedback and is shown in Figure 4.10 for each of the activities.

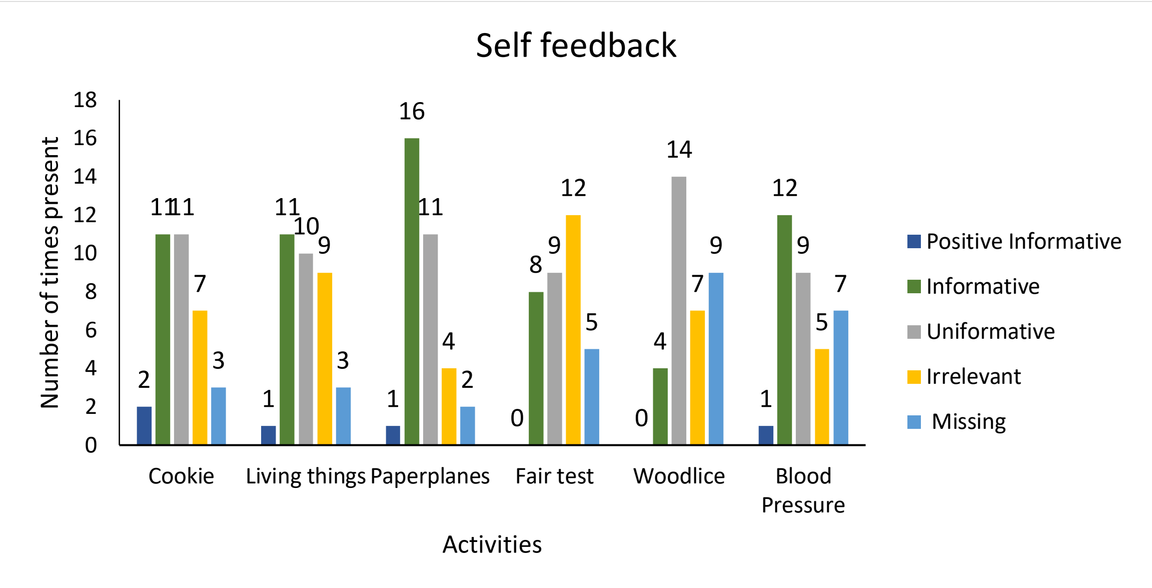


Figure 4.10: **Classification of Self feedback as noted on the skills passport (class groups P1a & P1b)**

Looking at Figure 4.10, there is little positive informative feedback overall and an increase in irrelevant and missing feedback as the year progressed. It was highlighted on the teacher observations 1 that the students struggled with the self-feedback and not as much time was devoted to support this:

> "*When students received their passports back from their peers there were a lot of questions from students about how they should answer the self-section. Students spent a lot of time staring at the space for self-feedback. Up to this point I had spent much more time on peer feedback*" (O1, P1a, Cookie, K)

and when talking about the time available to dedicate to peer feedback P noted

> "*Didn't have enough time to do the same for self- feedback back section, which is where the students struggled*"(O1,P1a, Cookie, P)

Spending too much time filling out the peer feedback section seems to be a common theme for term 1. Teacher P highlighted in observation 3 with class P1b that they seem to spend a lot of time reading the peer section comments and they seem to "*like reading the peer section" (*O3,P1b, Papers Planes, P)

In term 2 again, teacher observations note how time can be an issue and the self-feedback section which was done last was rushed.

> "Students *are spending too much time filling out the peer section and not leaving enough time for the self-feedback section*" (O4, P1b, Fair test, P)

> "Students *gave oral feedback to their peers who limited the time spent on self-feedback*" (O5, P1a, Woodlice, K)

It was also noted by teacher P that there seems to be a correlation between the quality of peer feedback given and the quality of self-feedback noted and also the engagement with the self-feedback section:

> "*if a student gives good peer feedback the students is more likely to engage with the self-feedback section and give good self-feedback" (*O4, P1a, What Varies, P).

A key point to note here is that time and support is required to help students in terms of peer feedback but also for self-feedback. This will be further discussed when the implications for Phase 3 are considered.

4.2.3 Scientific Planning Skills

A number of activities were selected to monitor the students' scientific planning skills, as shown in Figure 4.3; specifically they were A1.1 (Skills of writing a procedure), A1.2 (Skills of writing a clear hypothesis and procedure), A1.6 and A2.0 (Skills of writing investigative question, hypothesis, procedure and control of variables). Additionally, the Scifest projects completed by the students are the end of the year were all examined for all four skills (skills of writing investigative question, hypothesis, procedure and control of variables). Student groups were also interviewed on their Scifest projects, and were questioned on these skills. As described in Chapter 3 the data was analysed and coded for each skill. This data was used to generate a map of how each student progressed on each skill throughout the year – see Figures 4.11 to 4.14. For convenience, all the data is presented together for each skill. In these figures, a green box indicates that the students have demonstrated that element of the skill, yellow indicates a partial achievement, while red indicates did not demonstrate achievement of the skill. The purple boxes denote missing data (e.g. student was absent for that activity). Each skill is now considered.

Writing a procedure

Figure 4.11 summarises the progression for each student in 'writing a procedure'. During the first activity A1.1 students struggled to write a procedure that was clear and easy to follow, however this was students first time to write a procedure and the teacher used this assessment to determine their knowledge of procedure writing from primary school and offered little assistance. "*This activity allowed students to get used to writing up basic lab reports and practicing writing procedures. Some of the procedures were not numbered and wrote more like a paragraph rather than step by step*" (O1, P1a, Cookie, K). By the end of the year, students were able to write a procedure that was clear, easy to follow, contained suitable equipment and was neat, presentable and legible.

The activities chosen acted as a successful assessment point for assessing students on the skills of writing a procedure; this was noted in the teacher's observations:

> "*Nice activity to introduce writing a procedure as students from all levels could get involved* "(O1, P1a, Cookie, and P)

> "*This activity also allowed the students to expand on their procedure writing skills as it had many steps to be included.*" (O3, P1a, Papers Planes, K)

> "*Students enjoyed planning this investigation and came up with some very detailed procedures* "(O6, P1a, Woodlice, P)

Looking at the Scifest projects, however, 3 of the students in class group P1a did not write a 'clear and easy to follow' procedure; nevertheless, when interviewed on their procedure, these students were able to clearly describe their procedure in a clear and concise manner. These students knew the correct way to structure the procedure but perhaps didn't feel it was important to do so in their write up.

<u>Writing a hypothesis</u>

Figure 4.12 summarises the progression for each student in 'writing a hypothesis'. The hypothesis had to be a statement which had a clear justification. This skill appears to be a difficult one for these students to master. Although they understood that the hypothesis must be a statement / justified statement, they struggled with writing a justification that was supported with either prior/scientific knowledge or observations. Many students justified their hypothesis by writing justification such as "*because it said it on the internet*" or "*because I think so*" or "my *teacher said*". With the first year groups, the justification didn't have to be valid, however, they still had to be supported by prior/scientific knowledge or observations.

Teacher observations noted the difficulties of a justification:

> "*from walking around many didn't understand the idea of a justification or what that meant. I had to explain it to some groups and therefore couldn't give a clear justification" (*O3, P1a, Papers Planes, P)

and that this may relate to prior knowledge or experience:

> "*More time needs to be spent on forming a hypothesis. I think students are missing the scientific content knowledge to be able to give a clear justification" (*O3, P1b, Papers Planes, K)

> "*As students had encountered woodlice in their everyday lives I think it was easier for some of them to write a clear justification" (*O6, P1b Woodlice, P)

More students were able to write a justification for their Scifest projects and only 5 students could not explain their hypothesis when interviewed (all in class group P1a). Three students who did not give a clear justification in their Scifest project in class P1b could expand in the interview:

"we *predict the most expensive boots would kick the furthest as they cost more and are made of better, more lightweight material therefore easier to kick"*

This would indicate that students are more likely to give a hypothesis that has a clear justification when carrying out an investigation they have chosen, such as their Scifest projects. This may be due to the students picking a question to investigate that's based on an area they are interested in and therefore will have knowledge or observations to back up their hypothesis.

Identification of Variables

Figure 4.13 summarises the progression for each student in noting control of variables. This skill was introduced during Term 1 with activity 1.4 (What varies), which was particularly suitable:

*"Great and easy way to explain variables. I think this is the first group I have ever had that understand it so early. PowerPoint used was very useful. Students were able to relate variables to past experiments which were impressive for 1st years" (*O4, P1a, What Varies, P)

Students carried out two activities (A1.6 and A2.0) in which 'variables' were monitored. Dependent and control variables was an issue for a number of students. Identifying more than one control variable was highlighted in teacher observations:

"*Students struggled to list more than two control variables. Many students just gave one" (*O6, P1a, Woodlice. K)

Teacher prompts were effective: "what are you changing2, "what are you measuring", "what stays the same". Scifest projects gave students the opportunity to devise their own investigations and decide on variables. Both class groups could clearly identify the independent variable; however, many students in class P1a struggled with dependent and control variables, while the control variables was only the issue for class group P1b. Both class groups had the same instruction, so there is no obvious explanation for the differences between the groups. Although most students were able to identify one control variable, the criteria for this was to state two. The interview gave the students the opportunity to explain their approach, e.g with students 2B102 and 21B04, these students only recorded one control variable in their write up but during their interview mentioned four control variable " *Same amount of drink, equally dirty, same time, same location*" (Students 2B102 and 21B04, Scifest). This shows that (some) students did understand the concept but failed to include details in their reports.

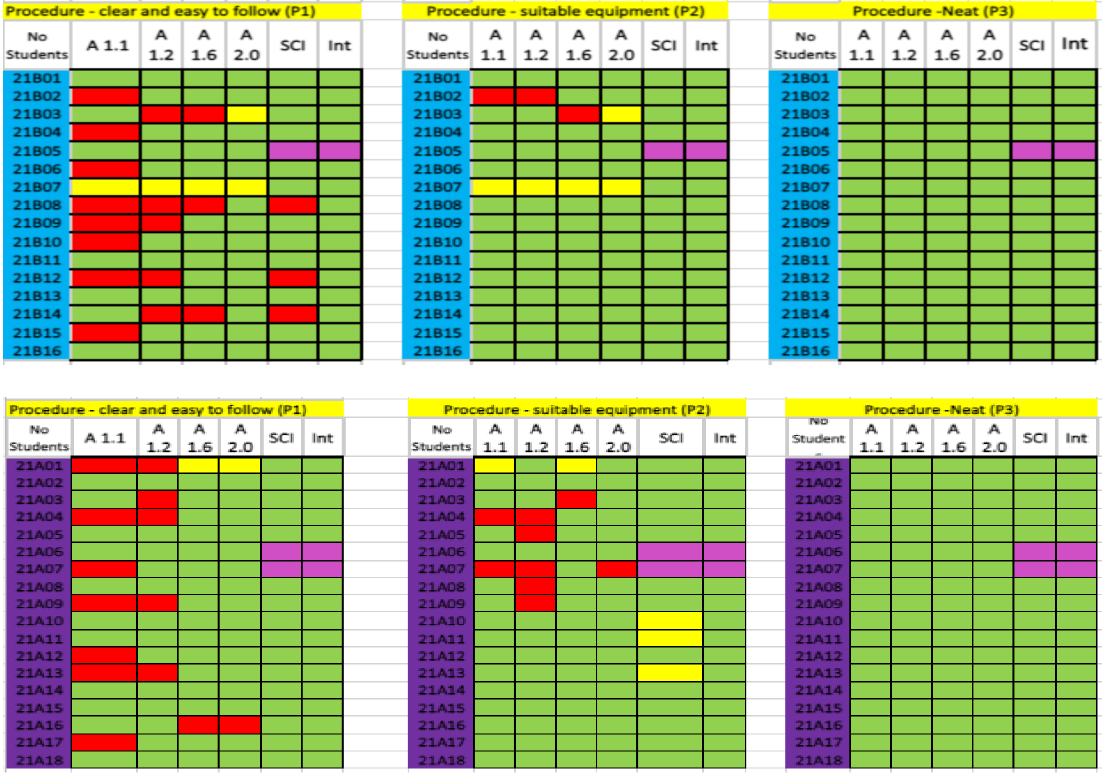


Figure 4. 11: **Student progression in skill of writing a Procedure (Top P1a, Bottom P1b)**

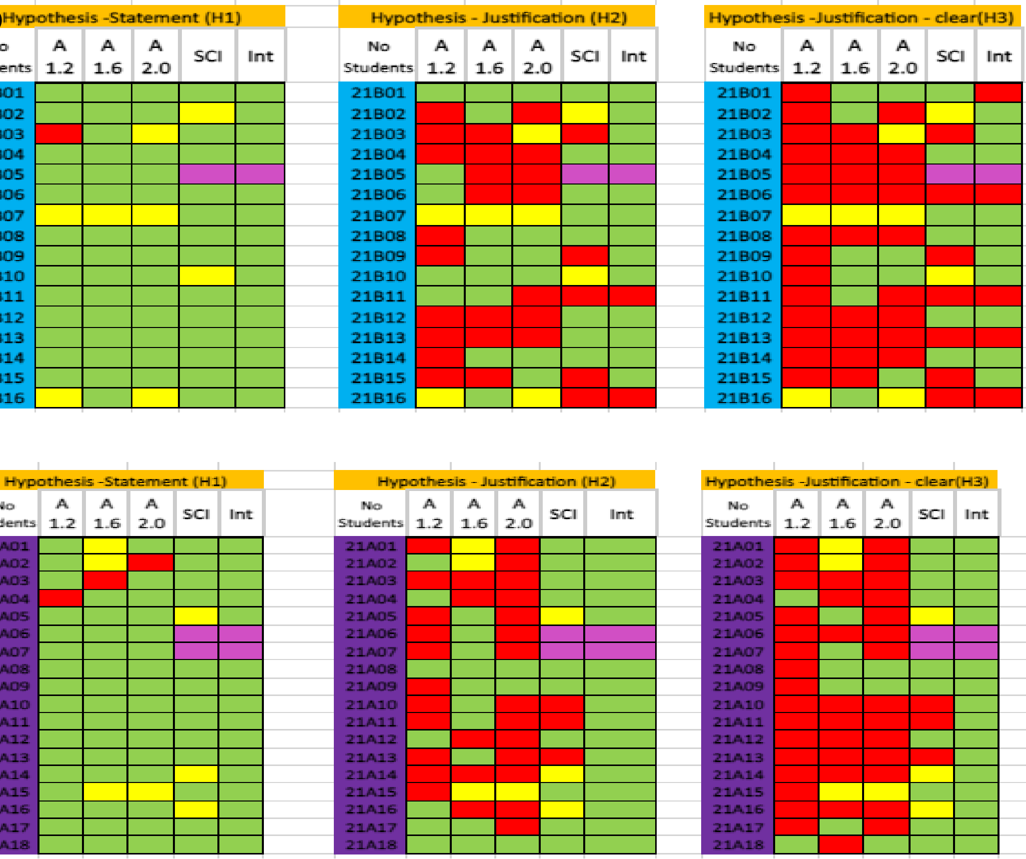


Figure 4.12: **Student progression in skill of writing a Hypothesis (Top P1a, Bottom P1b)**

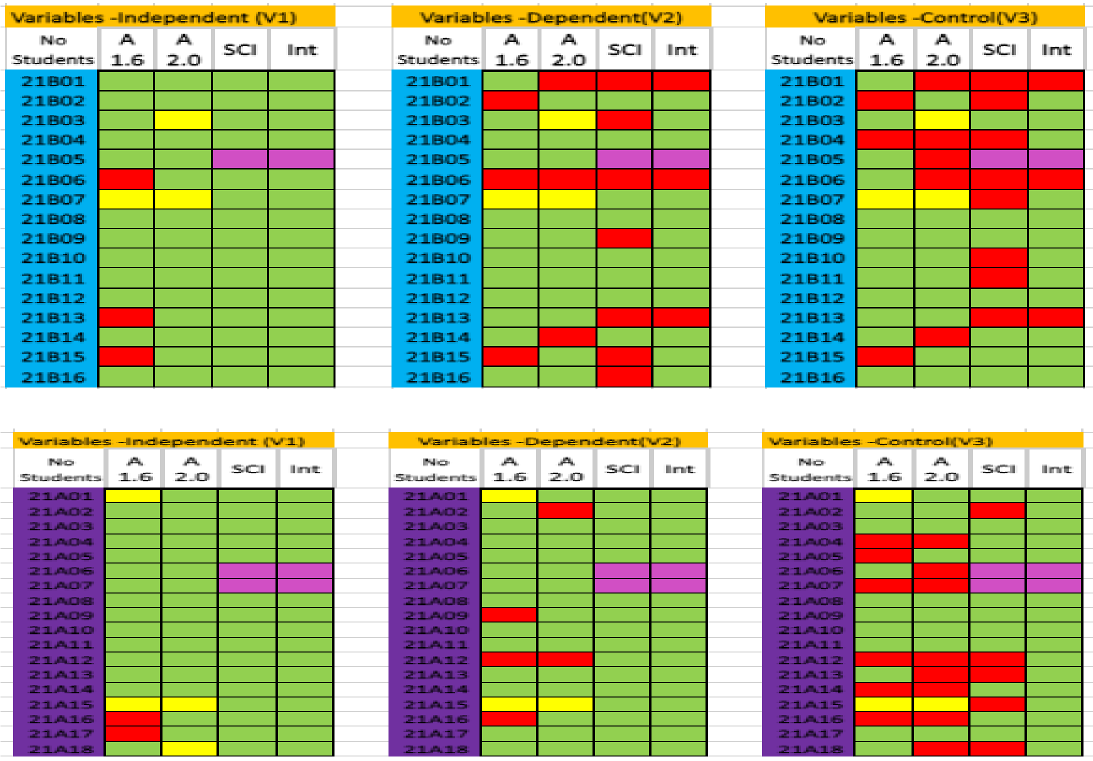


Figure 4.13: **Student progression in skill of noting control of variables (Top P1a, Bottom P1b)**

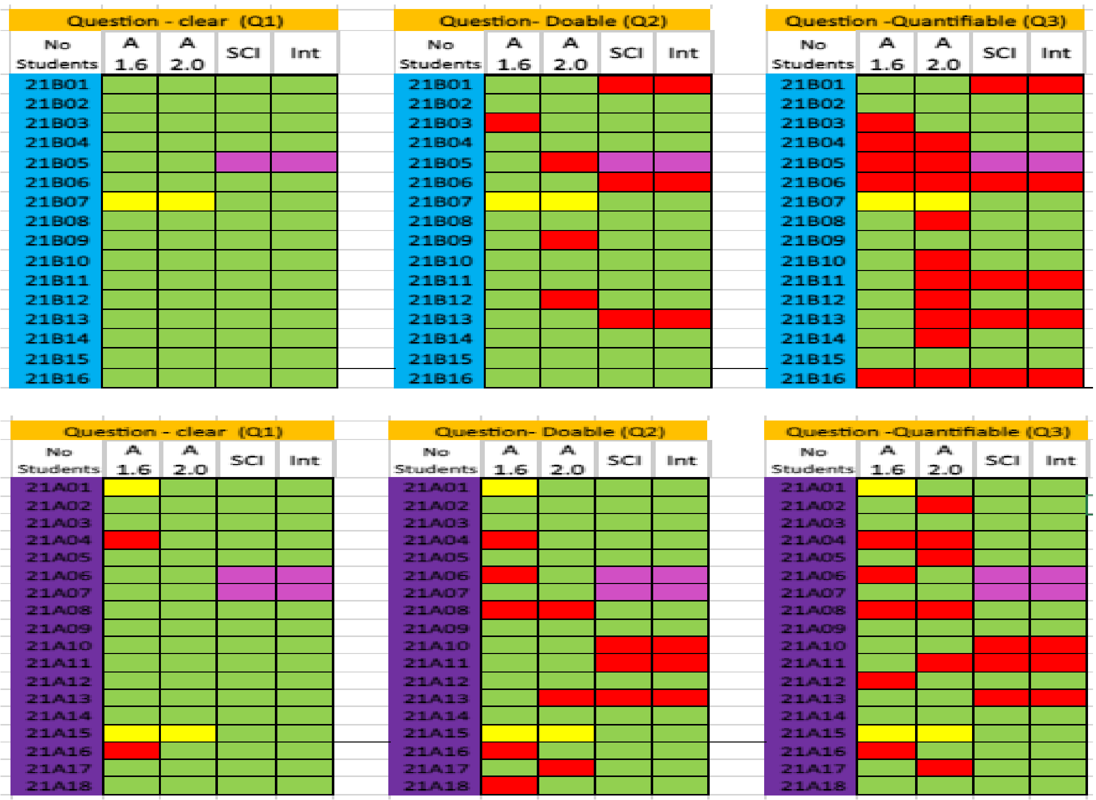


Figure 4.14: **Student progression in skill of forming a valid question (Top P1a, Bottom P1b)**

Proposing a valid Question

Figure 4.14 summarises the progression for each student in terms of formulating a valid question to investigate; the question had to be clear, doable and data quantifiable. It was noted that the activity A1.6 provided a good opportunity for students to practice the skill of writing a question that was clear, doable and quantifiable and to be assessed in this skill:

> *"Good activity to practice writing a question, students are finding it fun and are excited to get to pick the direction of their investigation" (*O3, P1a, Papers Planes, K).

The majority of students were not able to write a question that was quantifiable during activity A2.0. Looking at the questions written for this activity, students had in most cases left out a piece of information such as a timeframe for collecting data or not expanded the question out to allow for data to be collected. Example: "*What happens to your heart rate if you run?*" In order to make it quantifiable the student could have included a time frame -*What happens to your heart rate if you run for 30sec, 1 minute and 1minute 30seconds*.

By the end of the year it is clear that the majority of students were able to write a question that was clear, doable and quantifiable in their Scifest projects. For the few that could not, they also could not expand on the questions during the interview. It should be noted that devising project questions can be difficult for students and many students would have got their question after 'googling' science fair project questions on the internet. Therefore, it is possible that the results shown for the writing a question for Scifest may not be a true reflection of their ability.

4.2.4 Conclusions from Phase 2 and Implications for Phase 3

From the proceeding sections, it is clear that the skills passport was suitable as a means to monitor and support students in development of COM and WWO skills. Clear improvements in ranking of each subskill was observed. The skills passport also allowed a dialogue between teacher on student on each of the subskills at the start of the year to arrive at an agreed assessment (AA). In Phase 2, the COM and WWO subskills were more integrated within the programme and so we can conclude that integration of COM and WWO allowed students to develop each of the subskills **(**referring back to the research questions posed at the beginning of section 4.2 **- Q2.1).** In this phase, a revised coding system was used to analyse the peer and self feedback. This coding system was useful as it identified that lack of suggestions/tips on how to improve. The key issue of sufficient time and guidance for students to give effective peer and self-feedback needs to be addressed in Phase 3. Therefore, in Phase 3, although the layout of the peer and self-feedback section of the skills passport will not be changed, more time is built into the lessons to allow students time to both read and reflect on the feedback section. Additionally, more prompting posters will be displayed in the lab and perhaps liaise with other departments such as SPHE incorporate feedback into their lessons. The revised coding system was beneficial to help to identify the issues (**research question Q2.3**).

When analysing differences between student ranking of particular subskills versus teacher rankings, small effects were seen that could be related to gender. However, the numbers involved are really too small to make significant claims **(research question Q2.2).**

In terms of planning skills, in general students were able to address general question for investigations, writing a hypothesis, writing procedure and noting variables by the end of the year. However, variables and hypothesis were still more difficult for all students to understand and, in some cases, the activity created problems for the students in terms of showing these aspects. Specific issues were: question with quantifiable data; write a hypothesis with clear justification; variables, particularly control variables. The methods used to monitor these was successful in identifying the role of the activity and possibly the familiarity of the student with the context (**research question Q2.4**). These will be further discussed in Chapter 6.

Phase 2 was also the first year of teaching the new Junior Cycle Science programme, and teachers spent a lot of time reflecting on their department plan at the end of the year. The lesson sequence and content of Phase 2 were reviewed by the Science Department in the school and some changes suggested in terms of fitting in with the overall structure and content of first year and the desire to provide student with more opportunities to practice their skills of scientific planning, COM and WWO.

Based on informal conversation between the science teachers and the researcher, it was decided that some of the text heavy topics such as ecology and space would be moved out of the 1st year programme and replaced with topics that allowed for more inquiry activities to be included. Therefore, 'measuring physical observables' would be added as it was felt this topic would allow for the introduction of more hands-on inquiry activities. This allowed the researcher to add in more inquiry activities which would help with the development and monitoring of the scientific planning skills but also the skills of COM and WWO. The researcher decided that the lessons on variables, fair testing and measuring physical observables would be merged as this would allow for a range of suitable activities to be included. Two new activities would be designed by the researcher for the new school term, focussing on "providing a clear justification for their hypothesis" and developing a "question that was quantifiable", these new activities (Parachute and zip line) would be used to provide more opportunities to develop these skills.

It was also decided with the science department that instead of having Scifest as an extracurricular activity it would now be embedded into the departments plan, replacing the topic of "space" and students would spend 6 weeks at the end of first year planning, carrying out and showcasing their own investigations. With the exception of the 'woodlice activity' and the 'activity on magnification' and the addition of two new activities, all other activities and approaches would remain unchanged for phase 3.

4.3 Phase 3 Implementation

The purpose of phase 3 was to trial the new activities that would provide more opportunities for students to developed their skills of COM, WWO and planning skills and to place greater emphasis on the feedback section in the skills passport and on some of the skills such as 'backing up opinions' that students struggled with in phase 2. All results were analysed as in Phase 2.One class group of 1st year students was involved in this Phase and were taught by the teacher and researcher K. The timeframe for phase 3 can be seen in figure 4.15

Phase 3 aimed to answer the following research questions:

Q3.1 Did students develop the skills of COM and WWO similar to phase 2?

Q3.2 Did the new activities added, help student's development of the skills of 'developing a question' and 'writing a hypothesis'?

Q3.3 Did the extra time provided in class dedicated to the peer and self-feedback sections of the passport result in less missing or irrelevant feedback?

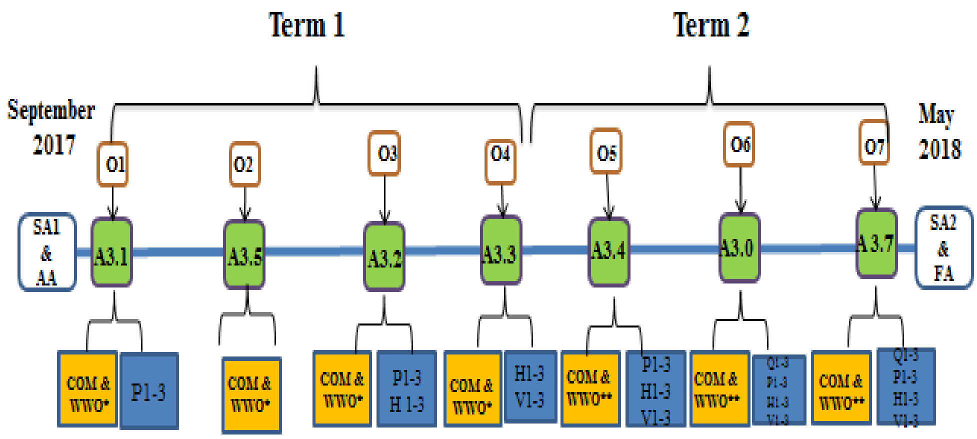


Figure 4.15 : **Timeframe for phase 3**

4.3.1 Lesson Sequences

As mentioned in Section 4.2.4 the majority of lesson sequence remained unchanged from phase 2. Variables , fair testing and measurable observables were merged, the same approach for teaching the topics of variables , fair testing and density was followed the same as phase two but two new activities 'zip line' and ' parachute were added. Table 4.6 shows the content that was covered in the merged lesson and what skills were focused on. The detail of the new activities can be found in appendix I. The 'zip line' activity was used to monitor the skills of COM and WWO in the skills passport and also the planning skills of writing a question , forming a hypothesis , writing a procedure and identifying variables.

Whereas the activity 'parachute' was used to practice these skills.

Table 4.6: Lesson sequence for phase 3

Weeks	Learning outcomes linked to the Junior Cycle*	Content Knowledge	Activities	Skills focus	
				Key Skills	Scientific Planning skills
1	Introduction to science/Laboratory (NOS 3)	Understand rules of the lab / Understand safety hazards in the lab Identify general lab glassware/apparatus Correct cleaning of glassware Reporting breakages/accidents Safely and correctly use BB Bunsen burner (BB) licence.		Introduction to the key skills. **WWO and COM**	
2	Working like a scientist (NOS 1 & NOS 3)	Introduction to designing, planning and conducting investigations.	**Activity**: 3.1 Cookie mining	COM & WWO *	Writing a procedure Listing suitable equipment
3-5	Living things, Microscope & Cells (BW1)	**Week 3**: Identify the characteristics of living things Draw and label plant/animal cell diagrams and organelles **Week 4:** State functions of the Organelles Know the main differences between a plant and animal cell Label the diagram of a microscope and understand the function of each part. **Week 5:** Prepare a plant and animal slide Investigate structures using a microscope	**Activity**: 3.5 Classification of living things	COM & WWO *	
6-8	Measurement (PW1 & 2)	**Week 6:** Select and use correct measurement tools for length, mass, time, temperature, area and volume **Week 7**: Calculate and/or measure the listed Use units correctly	**Activity: 3.2** Paper planes	COM & WWO *	Writing a procedure Suitable equipment Hypothesis

		Week 8 Design and plan an investigation to answer the following question Does the area of the paper used to make a paper airplane affect the distance it can travel?			
9-15	Systems BW4	-Label the parts of the circulatory system -Describe the function of the blood and its components -Explain the function of the heart and its interaction with the rest of the body systems -Identify the structures of the heart -Describe what the word digestion means -Distinguish between the two types of digestion -Describe and distinguish between mechanical and chemical digestion -Describe what happens to food when it is broken down - Label the respiratory system and state the functions of each part -Understand how the three systems interact -Understand the positive effects of exercise on the heart -Know what the pulse is and how to measure it -Know what factors can affect the workings of the circulatory system -Carry out an investigation to determine if exercise impacts the pulse rate	**Activity 3.0:** Blood pressure	COM & WWO **	Forming a Question writing a procedure, forming a hypothesis, Variables and fair testing.
17-23	-Measuring physical observables (PW3) -Variables (NOS 3) -Fair Testing	-Understanding the terms independent variable, control variable, dependent variable -identifying the independent dependent and controlled variables in an experiment. -Identify relationships between variables. How to ensure fair testing. Changing the Independent variables and the impact on dependent variables -Give the formula for calculating density. Give two units for density--Use the formula to calculate the density/ mass/ volume of an object	**Activity 3.3: What varies** **Activity : 3.4** Fair test **Activity 3.6 &3.7:** Zipline Parachute	COM & WWO * COM & WWO ** .	Writing a procedure, -Forming questions -Forming a hypothesis -Variables and fair testing

		-Give the formula for calculating speed. Give the unit for speed -Use the formula to calculate the speed/ distance/ time of an object -Define force. Give the unit for force			
23-29	Scifest				Forming a Question writing a procedure, forming a hypothesis, Variables and fair

*the following skills were the focus- COM- *Make eye contact*, *Don't Talk over anyone*, *Active listening*. WWO - *Contribute ideas*, *Take turns talking*

** the following skills were the focus - COM -*Use a quiet voice*, *Back up opinions*. WWO- *No Fighting/be friendly*, *No messing*, *Stay with your group*

4.3.2 Results

Analysis of the results of the data collections will now be discussed - results obtained through the skills passport in Section 4.3.2.1 and the Planning Skills in 4.3.2.2. The analysis methods were as in Phase 2, so only key results are highlighted.

4.3.2.1 Results of Evaluation of COM and WWO subskills

Similar to phases 1 and 2, we can see from Figure 4.16 that students ranking increased on every sub-skill for the skills of COM and WWO from beginning of the year to the end.

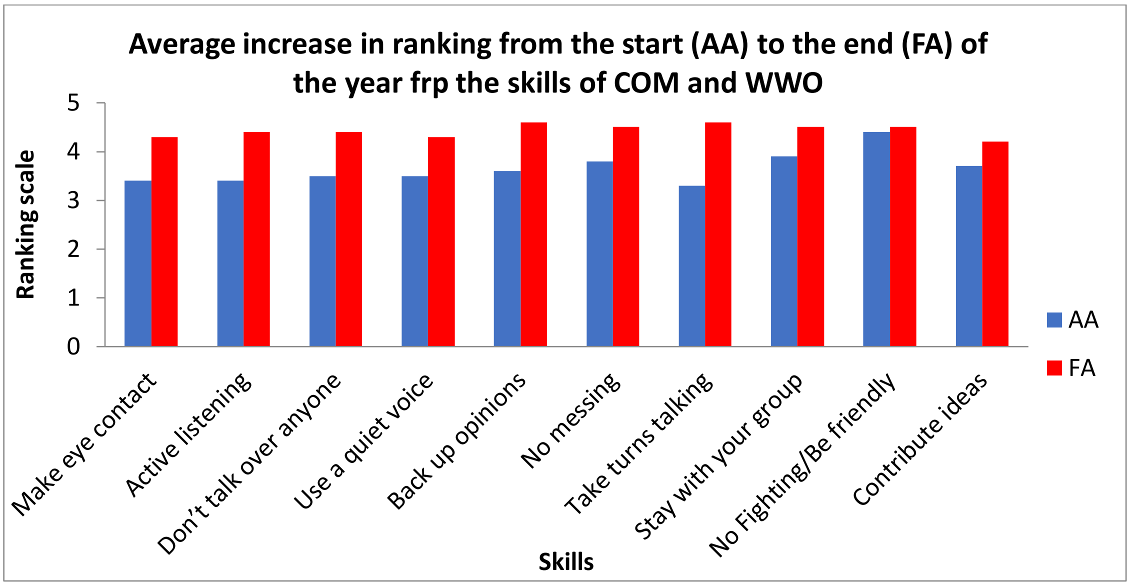


Figure 4.16: **Average ranking for each subskill – Class group K1c** (AA-agreed assessment, start of the year; FA – final assessment at end of year)

Also, as in previous phases, looking at the magnitude of the change in ranking for COM skills, all of the students increased by one or two points between AA and FA (Figure 4.17). The increase in the subskill of '*back up opinions'* is noteworthy as at the start of the year the teacher emphasised the importance of the phrase "I *think* .... *Because* ..." when using this skill. This phrase was also made into a poster and put up on the skills notice board. This is captured in one of the teacher's observations:

> "*Walking around I can see students not using the backing up opinion skill correctly as students aren't given a reason why. I referred back to the skills board with the phrase "I think ... Because..." This simple reminder highlighted to students how to use the skill correctly.* (O3, K1c, K)

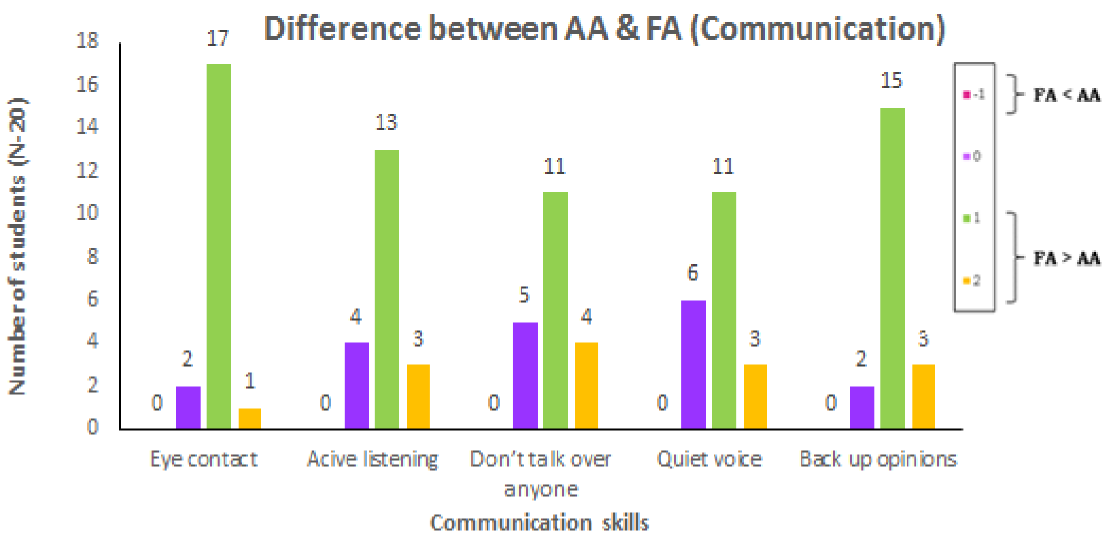


Figure 4.17: Difference in ranking between the agreed assessment (AA) and the Final assessment (FA) for COM for the class K1c

At the start of the year, students struggled with the idea of making eye contact and it was noted that students

> "*had to be shown how to give effective eye contact. Students said they feel uncomfortable making eye contact*." (O1, K1c, cookie, K).

The teacher noted that she finds '*eye contact'* the easiest subskill to give instant feedback on:

> "*I find myself given a lot of verbal feedback to students on eye contact as it is the easiest one to spot while walking around*" (O2,K1c , blood, K).

The teacher also noted students giving their peers oral feedback on eye contact:

> "*Overheard 3 different groups of students who are given tips to students about how to improve eye contact" (*O4,K1c , Zipline,K) .

These subskills were highlighted by students when asked in their Scifest interviews "Were there good communication skills used?" All groups spoke positively about the benefits:

"*At Scifest we didn't talk over each other when presenting* "(Students 31A10, 31A09)

and

"*If we had to improve an idea we would help the other person by making eye contact , listening to each other , didn't talk over and we could hear each other and used the correct voice tone*" (Students 31A01, 31A02)

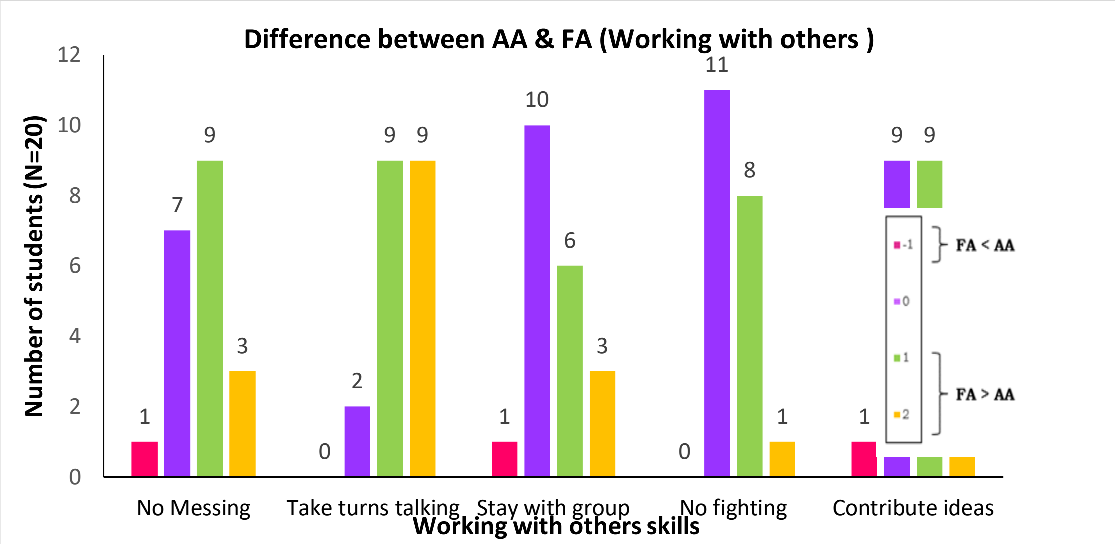


Figure 4.18: Difference in ranking between the agreed assessments (AA) and the Final assessment (FA) for WWO for the class K1c

Figure 4.18 shows the difference between the agreed assessment (AA) at the start of the year and the final assessment (FA) at the end of the year for the sub-skills of WWO.

The results from phase 3 are very similar to the result from the phase 2 in terms of the subskills of WWO. Particularly '*taking turns talking'* was the most improved sub-skill. Again during the observations the teacher reported very little behavioural issue during the lessons; hence many were had a ranking of '5' at the AA at the start of the year for the behavioural elements '*no fighting'*, '*no messing'* and '*stay with your group'*. However, it was noted twice in the observation that one group in particular, moved between groups when the activities were taken place:

"*Apart from one group who are loud and kept walking over to other groups all the other groups are working away quietly* "(O1, K1c, cookie, K)

"*one group* [same group as above] *are walking around and are going over to other groups*"

but these students were corrected by their peers

"for leaving their groups to go to others or speaking too loudly and asking them not to" (O4, K1c, Zip line, K)

The effect of gender on students' self-ranking of the subskills was examined briefly and results compiled in Table 4.7. The majority of students' rankings agreed with the teachers ranking. Similar to phase 2, a number of the male students over estimated their SA1 ranking for sub-skills '*Eye contact*' and '*Active listening*', '*No fighting/be friendly*' and '*Contribute Ideas*' and underestimated. their ranking for the sub-skills '*Don't talk over anyone*', '*Take turns talking*' and '*Stay with your group*'. Some female students underrated themselves for the sub-skills '*no messing*' and '*No fighting/be friendly*'.

At the end of the year, similar to phase 2 the numbers over and under estimating decreased and the majority of rankings between the student's second ranking and the teacher's final ranking agreed.

Table 4.7: **Difference between assessments. Looking at over and under estimating between students (class groups K1c).**

Sub Skill	Agreed*	Female Under*	Male Under*	Female Over*	Male Over*
Eye Contact	13 (18)	1 (1)	1 (0)	0 (0)	**5 (1)**
Active List	13 (17)	3 (0)	0 (1)	0 (1)	**4 (1)**
Don't Talk over	11 (17)	3 (2)	**5 (0)**	0 (0)	1 (1)
Quiet Voice	14 (17)	1 (1)	1 (0)	2 (1)	2 (1)
Back up opinion	15 (18)	1 (0)	1 (2)	1 (0)	2 (0)
No Messing	14 (17)	3 (0)	2 (1)	0 (1)	1 (1)
Take Turns Talking	11 (17)	2 (2)	**4 (1)**	2 (0)	1 (0)
Stay with Group	12 (14)	2 (1)	3 (2)	0 (0)	3 (3)
No Fighting/Be friendly	10 (19)	**4 (1)**	2 (0)	0 (0)	**4 (0)**
Contribute ideas	12 (19)	1 (0)	2 (1)	1 (0)	**4 (0)**

*first number relates to difference between SA1 and AA at the start of the year. Number in brackets refers to the difference between SA2 and FA at the end of the year. Total number of students is 20, 7 female and 13 male

The sample size in this study is too small to make any further comments on gender effects of students' self-ranking.

4.3.2.2 Observation data on skills of COM and WWO

There was no significant difference between SA1 and AA for all the COM subskills so therefore the students and the teacher agreed on the starting point. There was, however, a significant difference between AA and FA indicating that all students improved in every subskill. The majority of students increased by 1 point on the scale. The most improved skill was '*eye contact*' and '*backing up opinions*' with 18/20 students improving by one or two points on the scale. The WWO subskills also improved during the year with majority increasing by 1 point, except for *‘take turns talking*’, where 9/20 students increased by 2 points on the scale.

Teacher observation noted that most students were well behaved and worked quietly .It was noted that this was due to students not wanting to share their ideas with other groups:

> “*most groups working quietly in different corners of the lab, they don't want other groups to hear their ideas and are correcting students for leaving their groups to go to others or speaking too loudly and asking them not to* “(O4, K1c, Zip line, K).

The Scifest interviews were informative with regards to these subskills. When asked to list the top things they learnt, many groups mentioned “learning to communicate effectively”:

> “*to use eye contact and listen to others ideas*” (Students 31A13 and 31A11),
> “*really listen to others*” (Students 31A18 and 31A03)
> “*that when you are talking to someone to look up and not down at something*” (Students 31A07 and 31A04)

WWO subskills were also highlighted when asked what was important when working together:

> “*Not to mess or talk over the other person, take turns talking and contribute ideas*” (Students 31A10 & 31A09)
> “*Sharing ideas and letting the other person speak and pay attention*” (Students, 31A11 & 31A13)
> “*Give each other support* “(Students, 31A01 &31A02)

All the groups said they liked working with others and gave a variety of reasons:

> “*It’s more fun, when you are doing it with someone*” (Students 31A10 & 31A09)

> “E*asier, less stressful... half the work load*” (Students 31A07 & 31A04)

> “*You have more confidence working with someone beside you* “(Students 31A01 &31A02)

> “*Get to use each other’s strengths* “(Students 31A11 & 31A13)

4.3.2.3 Quality of Feedback given in the skills passport

The peer and self-feedback noted on the skills passports was categorised under 5 headings and carried out in Phase 2.

<u>Peer feedback</u>

The peer feedback was analysed into the 5 categories and shown in Figure 4.19. The majority of feedback given by peers was informative, i.e. the feedback highlights what the student is doing well, what they need to improve on, but the tips on how to improve are not appropriate or relevant. It was noted during the cookie activity (O1, K1c, cookie, K) that students were given tips on how to improve but they didn't highlight these in their peer feedback

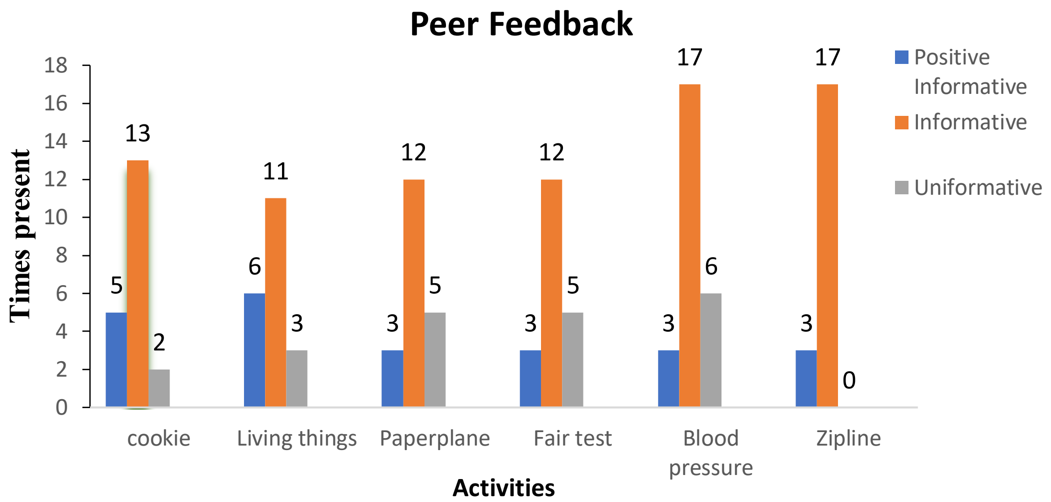


***Figure 4.19*: Classification of Peer feedback as recorded on the skills passport (Class K1c).**

There was also evidence of good tips for 'active listening', where one student wrote, *"You need to wait one second after they stop talking and then talk"*. The researcher recorded in the observation that when the sub-skills changed for term 2, students struggled to give tips on how to improve and in particular for the behavioural elements as students were well behaved and didn't need to improve:

> *Although students are aware they need to give tips, they don't seem to know how students can improve on certain skills such as 'back up opinions'. Many of the skills for term 2 are behavioural skills 'quiet voice', 'stay with group' and 'no fighting'. As students are well behaved it is difficult for students to give tips on*

*how to improve if all students are not shouting, staying with their groups and not fighting. (*O3, K1c, Paper Plane, K)

Self-feedback

As in Phase 2, after students had received peer feedback they then had an opportunity to read the feedback and give themselves self- feedback. The self-feedback was categorised under the same headings as the peer feedback and is shown in Figure 4.20 for each of the activities.

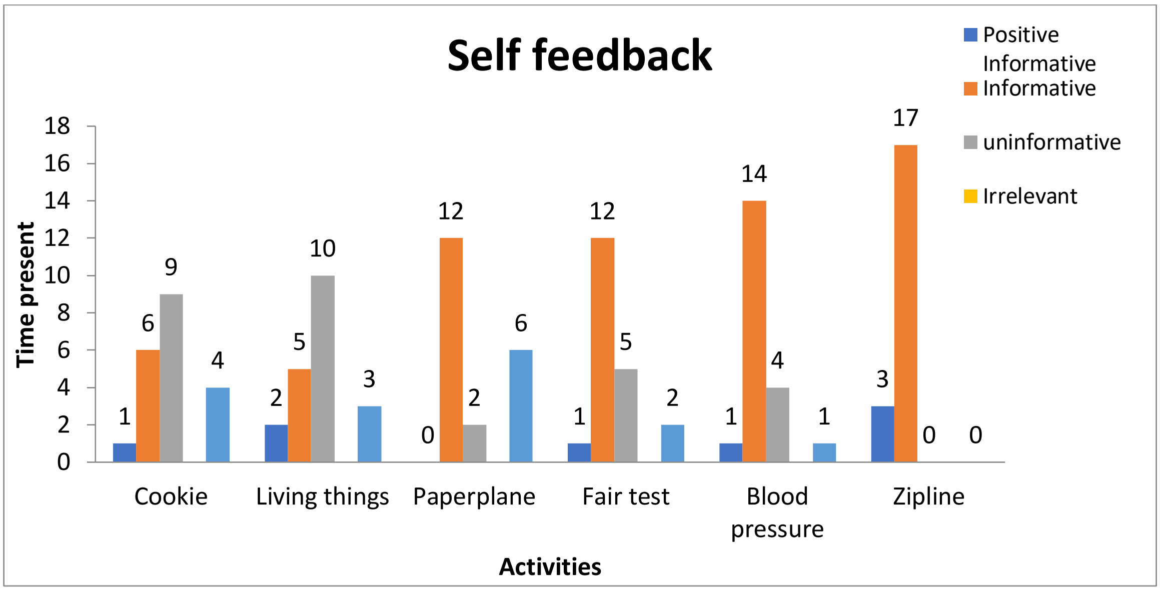


Figure 4.20: Classification of Self feedback as recorded on the skills passport (Class K1c).

Comparing these results in Phase 3 to those in Phase 2, there was a slight increase in the number of students giving positive informative self-feedback. As the year progressed, there was a large increase in the number of students given informative feedback when compared to last year's group. This may be due to the increased awareness placed on the self-feedback section and more time dedicated to it.

> "*Students spent time reading the peer feedback and had plenty of time to fill in the self-feedback section and I observed many students discussing what they did well and how they could improve. But glancing at a few of the passports students then wrote uninformative feedback*" (O1, K1c, cookie, K)

The researcher mentions how they had spent more time having a class discussion around peer feedback and tips on how to fill out this section:

"*I spent 5 minutes discussion the self-feedback section and explain to students that they must reflect and write down how they thought they had engaged with the skill and what and how they could improve*" (O3,K1c , Paper Plane, K)

As the year progressed we can see a decrease in the number of uninformative and missing comments. Clearly the additional time devoted in class to feedback was effective in giving students time to complete these activities correctly.

4.3.3 Scientific Planning Skills

This section looks at the development of the planning skills for class K1c. Similar to phase 2 the tables indicate how students improved as they progressed throughout the year and also the activities in which they were monitored for the planning skills. A green box indicates that the students achieve that element, red means they didn't achieve, yellow they didn't include and pink they were absent. The cohort of students are of mixed ability and it should be noted that Students 31A08, Students 31A09, Students 31A15, Students 31A16, and Students 31A17 are on the SEN register.

Writing a procedure

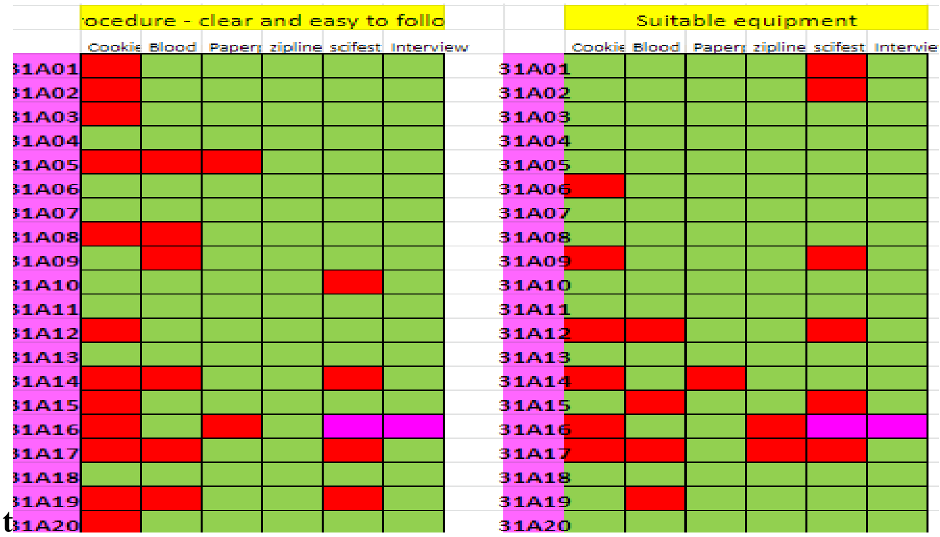


Figure 4.21: Students progression in the skills of writing a procedure

At the start of the year many students were not able to write a procedure that was clear and easy to follow. However, it was noted in the teacher observations during activity 1, that students were given very little guidelines or support from the teacher as this was used to gauge their ability when writing a procedure.

"*This activity was great at gauging students' ability at writing a procedure from primary school as it was a fun hands on activity and suitable to all levels. I had no input.*

*When asked, how many had done this before, many had not and were always told what steps to follow by their primary school teacher. Students made a good attempt at writing a procedure, however many were not written in logical order or step by step. Many were able to draw a labelled diagram" (*O1, K1c, cookie, K)

As the year progressed the number of students who were able to write a suitable procedure increased. By the end of the year, they were able to apply this to their Scifest projects. During their interview, when asked what you think is important when carrying out a scientific investigation three groups mentioned the procedure:

"*It is important to have a proper procedure*" (Students 31A07 and 31A04)

"*It's important to write down every step you take because if someone wanted to copy this in the future they'd have to see what we did.* " (Students 31A11 and 31A13)

"*I think it's important to make sure there is a detailed procedure in place to get results*." (Student 31A09)

Any student who didn't achieve any of the elements in their projects was able to successfully achieve it at the interview stage. This highlights the benefit of interview students on their work, as many students had just forgotten to record elements such as suitable equipment.

Hypothesis

Looking at the graphs, three students (31A20, 31A11, 31A04) were able to write a hypothesis that was a statement and had a clear justification and 12 students were able to write a hypothesis that was a statement that was justified but not clear, i.e. backed up by prior/scientific knowledge. Similar to phase 2, students struggled to write a hypothesis that had a justification backed up by prior /scientific knowledge or an observation. The researcher noted in observation 2, that the order in which the activity was done may have prevented them from writing a clear justification as they hadn't covered the content:

"*As we hadn't done any theory on the impact of exercise on the heart before doing the activity students were lacking the content knowledge to be able to write a justification that was backed up. Those who were able related it to an observation "my heart beats faster and I breathe heavy when out running as I need more O2 around the body" the majority of the class were not able to link it to a real life situation unless told, or wrote statement like I can feel my heart beats faster when playing football*" (O2, K1c, Heart, K) The teacher wrote a similar statement during observation 3, "Still *struggling with making* *a justification that is backed up, students are writing justified statements just lacking the backing up my prior/scientific knowledge or an observation "(*O3, K1c, Paper Plane, and K). By the end of the year 17 students were able to write a hypothesis that was a statement, with clear justification for their Scifest project.

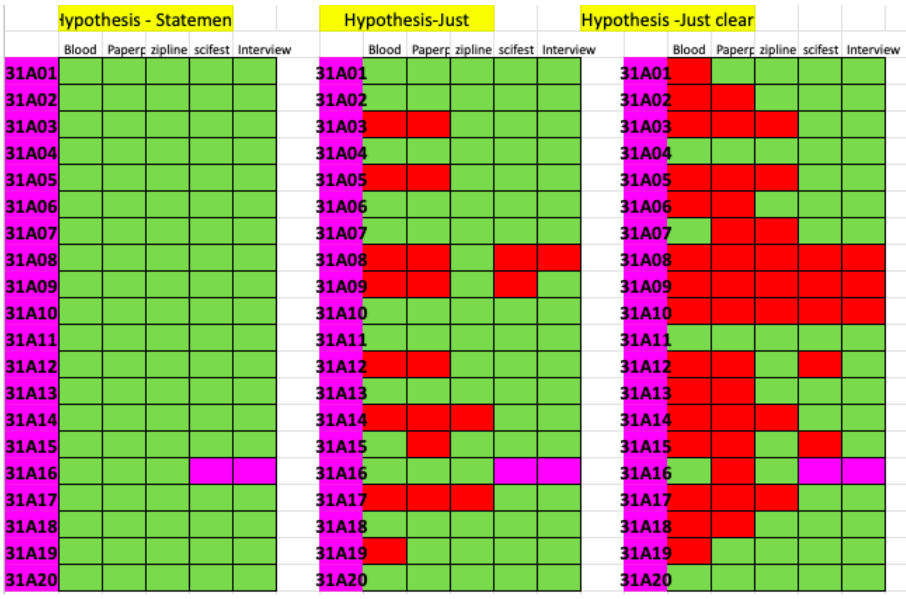


Figure 4.22: Students progression in the skills of writing a Hypothesis overview

<u>Question</u>

Students by the end of the year were able to write a question that was clear and doable and the majority were able to write a question that was quantifiable. In one of the teacher's observations it is noted that time had been spent on writing a question and that the teacher saw good examples while walking around.

"*Had spent the class previously focusing on the idea of writing a good question, students got the chance to see examples of both good and bad questions. The bad ones we had worked together to turn them into questions that were clear, doable and quantifiable. I referred back to this class before the activity and asked students to apply what they had learnt to today's lesson. Walking around me has seen many good examples of question writing" (*O3, K1c, Paper Plane, K)

During this activity 12 out if 20 students were able to write a question that was clear, doable and quantifiable.

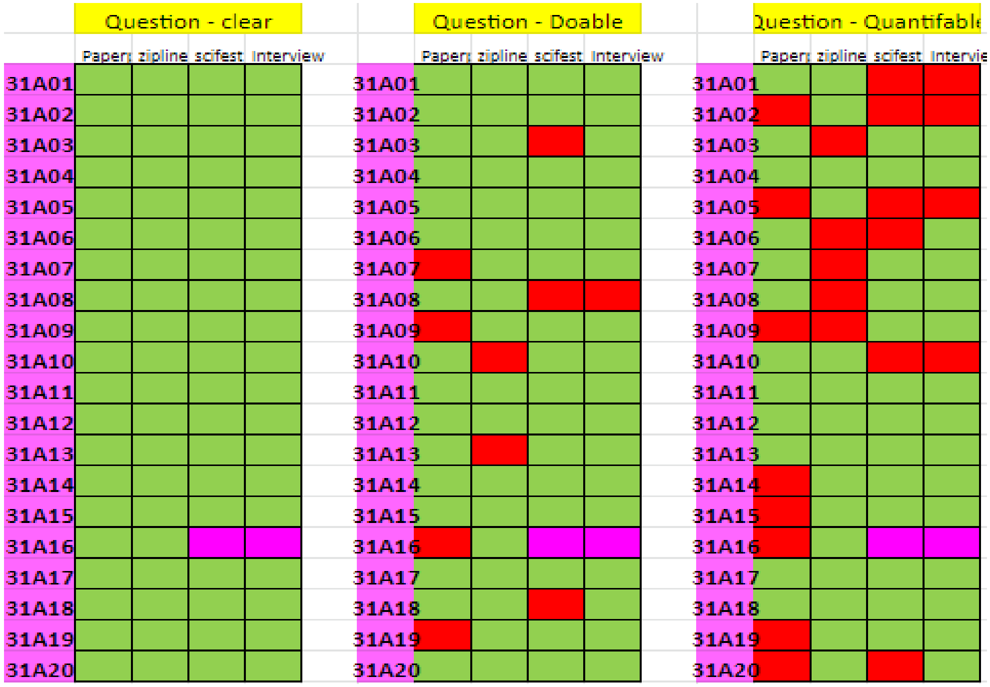


Figure 4.23: Students progression in the skills of forming a question overview:

Variables

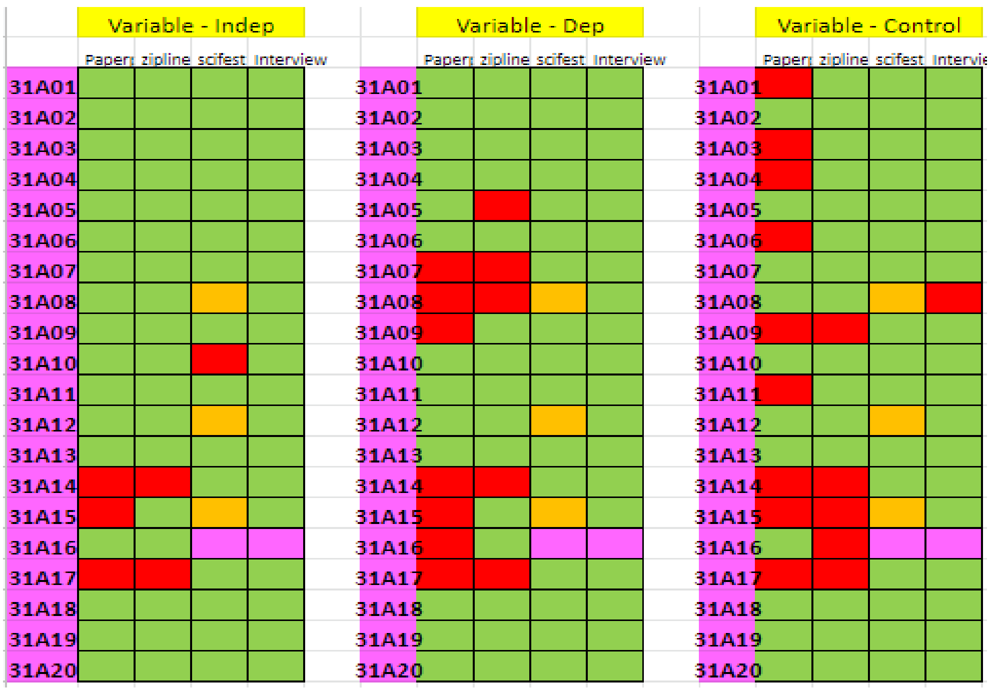


Figure 4.24: Students progression in the skills of identifying variables

Variables overview

By the end of the year 19 students had grasped the concept of variables. During the interview students were asked what variables you consider/measure. And how did you ensure your experiment was a fair test? All students were able to explain the variables they had in their experiment and used the terms, ‘we changed’, ‘we measured’ and ‘we kept the same’. When asked how you ensured it was a fair test 7 out of the 10 groups mentioned how they only changed one thing in their experiment, students also mentioned getting the average form their results.

4.3.4 Conclusion phase 3

Similar to the previous phase students improved on each subskill for the skills of COM and WWO. The sub-skills in which students improved most differed compare to phase 2 (Q3.1) .The additions of the new activities was positive and students found them very engaging and fun. They provided students with opportunities to develop and be monitored on their planning skills. We can see a slight improvement in some of the planning skills when compared to phase 2 (**Q3.2**).Looking at the peer and self-feedback sections we can see an improvement when compared to phase 2. Looking at peer feedback there is no missing or irrelevant feedback. Also, as the year progressed, although there is a decrease in the number of positive informative comments, there was an increase in the informative comments made by peers. This showed engagement by the students in providing feedback. We see similar result for the self-feedback section , as the year progressed the number of students receiving informed feedback increased and uninformed and missing feedback decreased. This may be due to the additional time devoted to completing the feedback section in class and greater monitoring by the teacher (**Q3.3**).

4.4 Key Findings

Looking at all the phases there was a significant difference between the agreed assessment and the Final assessment at the end of the year , this showed that in each phase the students improved on all aspects of the skills of communication and working with others. Therefore, the lessons and activity sequences supported students in their development of the skills of communication, working with others and scientific planning skills (phase 2 & 3). The skills that students improved most on differed for each phase, although the skill of eye contact and no messing were commonly the most improved in all phases. There appears to be a correlation between the skills that are emphasised by either the teacher or students and those most improved in the different phases. In all phases, there was a significant difference between SA1 and AA the subskills ‘No messing’. Male students ranked themselves higher for this element. Looking at all phases, male students are more likely to overestimate for behavioural elements such as ‘no messing’ and ‘no fighting /be friendly’ and females underestimate themselves on the elements ‘no fighting/be friendly’.

Students struggled in phase 1 and 2 with peer and self-feedback, although the support provided in the passport in phase 2 saw an increase in formative feedback, students were still leaving this section blank. Looking at reflections from both phase 1 and 2, time and teacher feedback seems to be a major factor. More time was devoted to filling in the feedback sections and monitoring from the teacher was increased, this resulted in a reduction in comments section which was left blank.

In phase 2 and 3 students struggled with the same inquiry elements, forming a hypothesis in which the justification was clear and a question that was quantifiable. Students in phase 2 also struggled with control variables which were not evident in phase 3. Although both struggled with the same element, students in phase 3 struggle with a lesser extent. This may be due to the additional inquiry activities during this phase, which result in more encounters with forming a hypothesis, writing a question and variables. What is evident from the data is that the sequence of lessons and the activities chosen to monitor and develop the skills of communication, working with others and the planning skills was effective and there is clear evidence that students can develop both simultaneously within the science classroom. The result of phase 3 will be discussed in more detail in chapter 6.

Chapter 5 Evaluation of implementation with second year group

5 Introduction

This chapter presents the results from the implementation of the programme with second year students. One class group of first years from Phase 2 (Group P1a) continued with the same teacher into 2nd year and the programme followed built on the COM, WWO and scientific planning skills developed in the first year – this group called P2a. At the end of the year, the 2nd year students all completed an investigative project – called EEI (Extended Experimental Investigation) – as set down in the Junior Cycle Specification. As there were three class groups completing the EEI projects at the end of the year, it allowed for comparison between the groups as group P2a had followed the skills programme (this research) over two years, F2b had followed the programme in 1st year only and had a different teacher in 2nd year, and group C2c had not been involved in the programme at all (see Chapter 3, Figure 3.1). It should be noted that all three groups followed the same scheme of work as agreed by the science teachers in the school and that none of these classes was taken by the researcher.

The main aim of this study with the 2nd year group was to determine if the skills as developed in 1st year (COM, WWO and Scientific Planning Skills) could be extended in 2nd year and monitored through the use of a skills passport and student work. Additionally, to determine if the students who followed the programme over two years could demonstrate their skills in their EEI projects. Specifically, the research questions posed are:

> Q1: What additional subskills of COM and WWO did students identify for 2nd year?
>
> Q2: Did students show development of these subskills throughout the year?
>
> Q3: In terms of the EEIs, was there a difference between different class groups, based on their prior experience of the skills programme?

This chapter will first introduce the skills identified, the general outline for the year and the lesson sequence for the class group involved in the main study i.e. class P2a (Section

5.1). The evaluation of the results from the skills passport is then presented (Section 5.2) followed by the evaluation of the planning skills for this group (Section 5.3). The final section examines the EEI projects and interviews for the P2a group and draws comparisons with the other two class groups, in terms of EEIs (Section 5.4). The methodology used in the analysis follows that as described in Chapter 3.

5.1 Skills and Lesson Sequence

At the beginning of the year (week 2), the students discussed subskills to focus on in terms of COM and WWO. The agreed subskills are shown in Table 5.1 and the general outline of the year in terms of monitoring activities is given in Figure 5.1.

***Table 5.1*: Subskills of communication and working with other for 2nd year**

Skills	Subskills
Communication	- Respond honestly & sensitively, - Speak with confidence, - Speak clearly - Ask questions - Respond constructively
Working with others	- Create a supportive atmosphere - Take on different roles - Help group achieve their goals, - Engage in group discussion, - Suggest solutions to problems

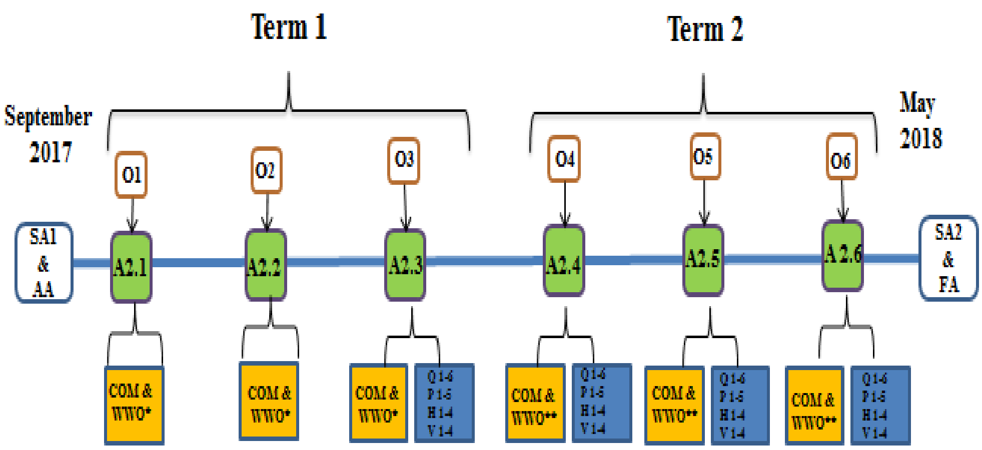


Figure 5.1: **General outline for 2nd Year programme**. (SA1 - Student assessment 1, AA - Agreed assessment, SA2 - Student assessment 2 , FA - Final assessment , A - Activity ,O – Observation, COM &WWO* *(Respond honestly & sensitively, Speak with confidence, speak clearly / Create a supportive atmosphere, Take on different roles)*, COM & WWO ** -(*Ask questions, respond constructively /Help group achieve their goals, Engage in group discussion, Suggest solutions to problems*), P – Procedure, H – Hypothesis, V – Variables, Q – Question.

As in previous phases, students completed a self-assessment at the start of the year in terms of the COM and WWO subskills; following discussion with the teacher, they arrived at the agreed assessment (AA). They also completed the self-assessment at the end of the year (SA2) and the final assessment (FA) was given by the teacher.

An overview of the content knowledge sequence is given in Table 5.2 with further details in Appendix J. While emphasis was placed on subskills throughout the year and also on development of inquiry skills, specific activities were used when monitoring these skills. In terms of COM and WWO, these were activities A2.1, A2.2, A2.3 in Term 1 and A2.4, 2.5 and 2.6 in Term2. For planning skills, A2.3 in Term 1 and A2.4 2.5 and A2.6 in Term 2. The EEI and interview were used in the final review.

During term 2, all students conducted an EEI over a three week period. The students were expected to generate an investigative question, formulate a scientific hypothesis, plan and conduct suitable experiments to test their hypothesis, generate and analyse primary data, and reflect on the process, with support/guidance from the teacher. Students were encouraged to collaborate with their classmates for their EEIs but had to submit individual reports at the end of the three weeks for assessment.

Table 5.2: **Lesson sequence for 2nd year science.**

Weeks	**Learning outcomes linked to the Junior cycle**	**Content knowledge**	**Activities where skills were monitored**	**Skills focus**	
				Key Skills	**Planning skills**
1	Wellbeing				
2-4	Human body -Effect of environmental factors (BW6)	Evaluate how human health is affected through the environment, inherited factors and microbial infections under the following headings: Obesity & diet, Smoking, Exercise, Bacterial Infections plus benefits of bacteria, Viral infections plus benefits of viruses, Antibiotics & Vaccines, Fungal infections plus benefits of fungi	**Activity**:2.1 Vaccines	**COM& WWO ***	Yes
5 -9	Bonding / The atom (CW3)	-Compare the charges, mass, location on electrons, neutrons & protons Define 'atomic number' and 'mass number' and find the atomic number and mass numbers of elements using the periodic table -Draw the Bohr model of an atom - -Properties of covalent and ionic bonding	**Activity 2.2:** History of the atom **Activity 2.3**: Fish	**COM& WWO ***	Yes
11-13 18-19	Patterns and relationships- Measuring physical observables (PW3)	-Understanding the terms independent variable, control variable, dependent variable -identifying the independent dependent and controlled variables in an experiment. -Identify relationships between variables. How to ensure fair testing. Changing the Independent variables and the impact on dependent variables -Give the formula for calculating density. Give two units for density--Use the formula to calculate the density/ mass/ volume of an object	**Activity 2.4** : Zip line **Activity 2.5:** Paper planes	**COM& WWO ****	Yes

		-Give the formula for calculating speed. Give the unit for speed -Use the formula to calculate the speed/ distance/ time of an object -Define force. Give the unit for force			
20-21	Measuring physical observables (PW3)	Hookes law (No researcher input)			
24-27	Sustainability	Illustrate how earth processes and human factors influence the earth's climate, -Discuss the overuse of fossil fuels and why they are non-renewable -Explain the pros and cons of nuclear power -Discuss climate change in terms of the greenhouse effect and global warming -Explain 2 initiatives that could be implemented to reduce the effects of climate change -Evaluate the extraction, use, disposal and recycling of materials and how this contributes to sustainability	**Activity2.6**: Recycling paper	**COM& WWO ****	Yes
	EEI	A student will, over a three week period, formulate a scientific hypothesis, plan and conduct an experimental investigation to test their hypothesis, generate and analyse primary data, and reflect on the process, with support/guidance from the Teacher.	**Activity**: EEI **Activity** : EEI Interview	**COM& WWO*** **COM& WWO ****	Yes

(COM & WWO * indicates the following skills -*Respond honestly & sensitively*, *Speak with confidence*, *speak clearly* / Create a supportive atmosphere, Take on different roles)(**COM & WWO **** indicates the following skills -Ask questions, respond constructively /Help group achieve their goals, Engage in group discussion, Suggest solutions to proble

5.2 Evaluation of results from Skills Passport (2nd Year)

This section will examine the data from the skills passport in terms of development of the COM and WWO subskills during the year (in Section 5.2.1) and the nature and quality of peer and self-feedback (in Section 5.2.2).

5.2.1 COM and WWO subskills (2nd year)

Looking at the change in ranking from the start of the year to the end of the year for this class group, it is clear from Figure 5.2 that students increased on the ranking scale for every subskill of COM and WWO.

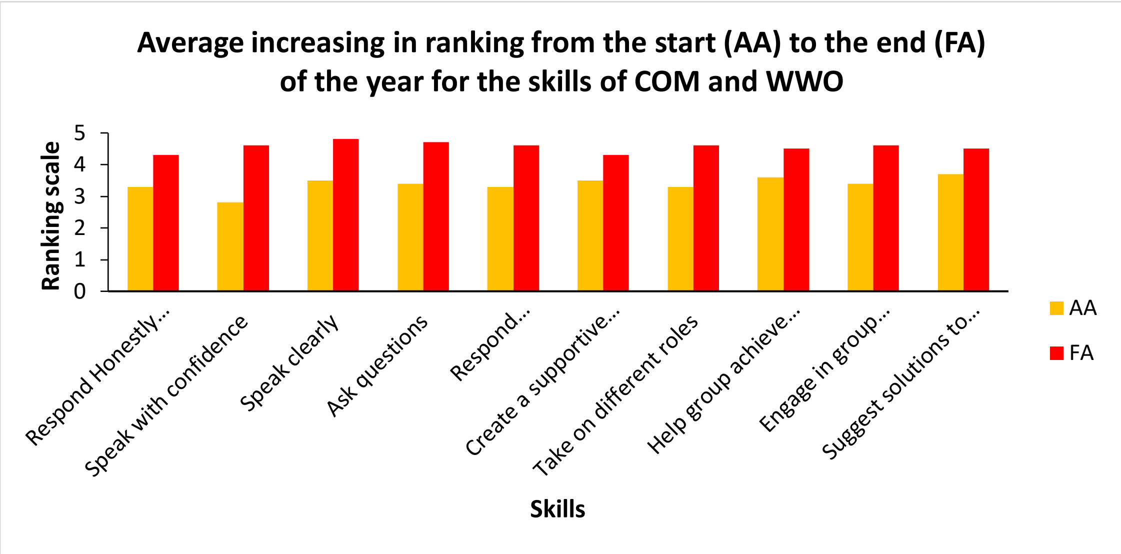


Figure 5.2: **Average ranking for the subskills of COM and WWO in 2nd year**

An independent t-test was used to check if there was a significant difference between the agreed assessment (AA) at the start of the year and the final assessment (FA) at the end of the year. The t-test showed there was a significant difference between the two, this shows that the students improved significantly on all the subskills of COM and WWO.

The magnitude of the change in ranking between the agreed assessment (AA) at the start of the year and the final assessment (FA) at the end of the year was determined for each of the subskills – COM subskills shown in Figure 5.3 and WWO subskills in Figure 5.4.

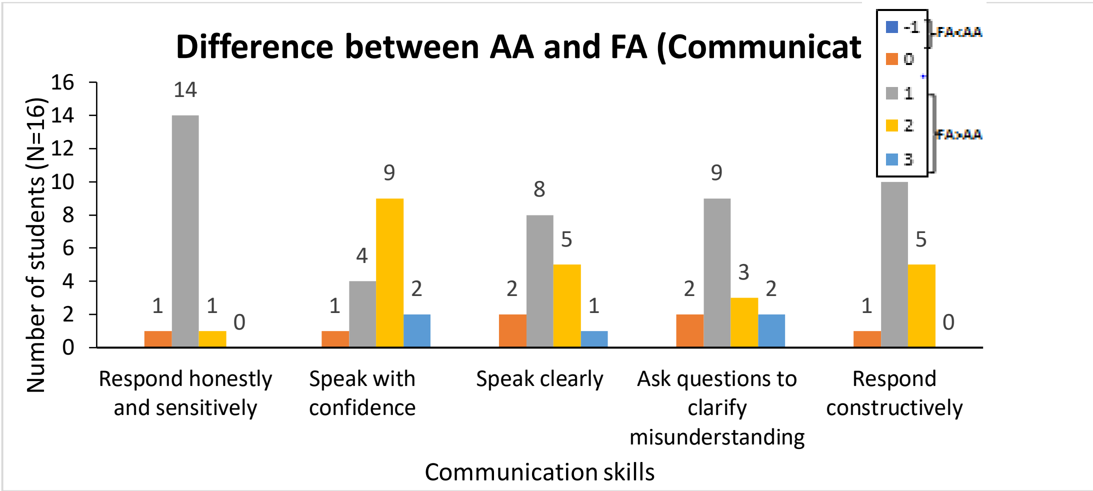


Figure 5.3: **Difference in ranking between the agreed assessment (AA) and the final assessment (FA) for the sub-skills of COM (2nd year).**

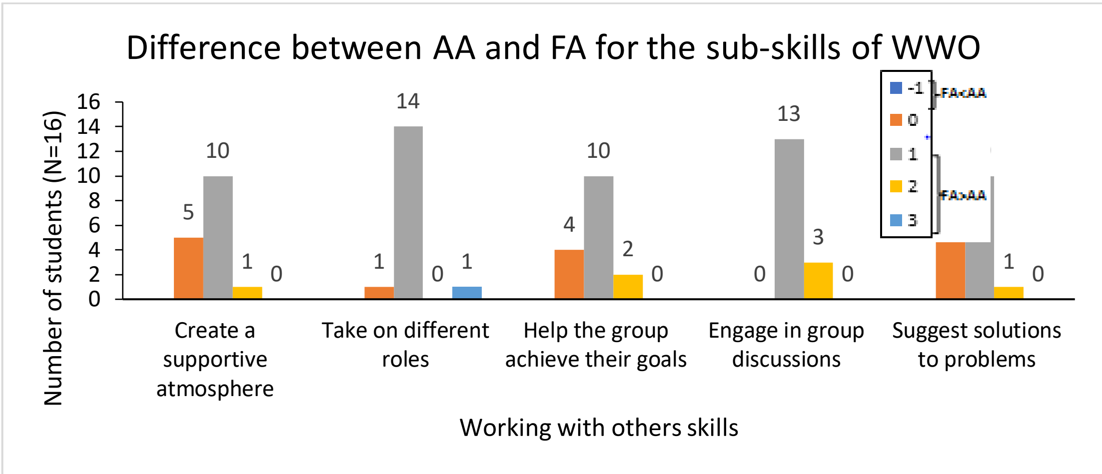


Figure 5.4: **Difference in ranking between the agreed assessment (AA) and the final assessment (FA) for sub-skills of WWO (2nd year)**

Initially it is noted in the teacher observation notes that students struggled to provide examples of good tips on how peers could improve or provide examples, in particular for the skill '*respond constructively'*; however both teachers P and K mentioned they would liaise with the SPHE department to integrate some of the communication skills into the SPHE classes.

> "*Although students grasped the idea of the new skills, they found it difficult to give concrete examples of some skills (respond constructively and create a supportive atmosphere) and to state their importance through discussions. I think I will liaise with SPHE teachers and see if they can focus on these skills from a wellbeing perspective*" (*O1, P2a, Vaccines*, P).

"*Students struggled with providing feedback examples for some of the skills such as 'respond constructively' and 'create a supportive atmosphere' and 'suggest solution to problems'. I will ask SPHE teachers to focus on some of these skills in class*" (*O1, P2a, Vaccines, K*).

Teacher K was able to liaise with the SPHE teachers as they frequently do group work projects and had been interested in introducing the skills passport. Although they were not using the skills passport, teacher K felt it was the most appropriate class to get students to practice in and time could be dedicated to providing concrete examples and feedback.

It is clear from Figures 5.3 and 5.4, that the majority of the students increased their rating in each subscale by one point. However, the sub skill, '*speaking with confidence*' had the greatest increase on the scale. We see evidence in the teachers' observations that the activities were supporting the communication skills, in particular the sub-skill of '*speaking with confidence*' and '*speaking clearly*'.

"*This activity was great at monitoring the skills of communication such as speaking with confidence, speaking clearly and asking questions to clarify. The previous activities have allowed students to get valuable practice with speaking in front of their peers" (O1, P2a,* Vaccines, P)

Further teacher observation notes highlight student comments heard showing the support and encouragement given by students to each other in terms of COM skills:

"*All the videos you post on Facebook have really made you confident when you speak"* (O2, P2a, History of atom, P).

"*You should present you are the on the debating team and have experience talking to groups*" (O2, P2a, History of the atom, P)

"*Say something positive we are supposed to be supporting each other*" (O3, P2a Fish, P)

The teacher reflections also gave good insight into how students engaged with the skills of WWO, with teacher P mentioning on numerous occasions that he overheard students giving oral feedback to their peers on some of the sub-skills of WWO, such as:

"I think student X should be the time keeper she is always on time for everything and never late" (O2, P2a, History of the atom, P),

"*Let student X be the scribe they never get to use that role"* and *" You are the best at scribing cause you have the neatest handwriting"* (O3, P2a, Fish, P)

A nice example of group discussion was noted in Observation 4, where students were heard saying:

"*Ok well everyone come up with a solution and we will see which one works*"

"I *think we should put blue tack at the end. Like the swing in the park their is rubber at the end but what do you all think?*" (O4, P2a, zip line, P).

Following their EEI projects, students were interviewed on the range of skills that they had used. During these interviews, the skills that were mentioned most frequently by students as useful or important when working in a group were '*responding honestly / sensitively*' and '*speaking clearly'*. When asked were there good communication skills used, one group responded:

"When sharing ideas we always spoke clearly and responded honestly if we didn't agree with the other person" (Students 21B15, 21B13).

*"Make sure you're clear and give proper instructions and make sure everyone knows their role. Make sure you're not speaking quietly and when something is brought up you give your opinion but respond nicely." (*Student 21B05, worked on his own but would have "*preferred to work in a group*").

Many groups also mentioned the communication skills they had been working on in 1st year such as '*making eye contact'*, '*no talking over anyone'* and '*active listening*', although these were not the focus of this year; students still mentioned them as important:

"*We didn't talk over each other and made sure everyone was listening to each other's ideas.It is important to speak clearly to each other and with confidence*" (Students 21B01, 21B06)

Although students did not explicitly mention the sub-skill '*create a supportive atmosphere'* it was implied by responses such as:

"*That you actually get along with the people in it (Group) and feel supported*" (Students 21B01, 21B06),

"*We encouraged each other*" (Students 21B15, 21B13)

> *"Didn't have any disagreements and supported each other*" (Students 21B04, 21B07).

The sub-skill '*take on different roles*' was mentioned explicitly in the interviews:

> "*Making sure everyone knows what they have to do by asking questions if unsure and assigning roles so the workload is fair*" (Student 21B05)
>
> "*We didn't argue over who wanted to do what as we had assigned different roles*" (Student 21B09, 21B03).

Students were able to articulate the benefit of assigning roles and how it had a positive effect on their group. The interview data seems to support the change in ranking seen in Figures 5.3 and 5.4 and indicate that students were able to put into practice the subskills identified in terms of COM and WWO. In the students interviews the most commented on sub-skill was 'respond honestly "and 'speak clearly' this was mentioned by 4 out of the 8 groups as important when communicating. No groups explicitly mentioned the sub-skill 'respond constructively' but many groups did mention using eye contact, active listening and providing feedback. "*It is important to meet in the middle if you have different opinions and listen to their ideas, give full attention, make eye contact and give good feedback*" (students 21B04, 21B07) and when asked what was important when working together this group responded with "we *used eye contact and didn't talk over each other, and we listened to each other's ideas and discussed the ideas and provided feedback on how to improve*" (students 21B09, 21B03). The skills that students focused on last year were mentioned by every group and also mentioned more often than the skills they were focusing on this year. The skills of 'Making eye contact', 'Active listening' and 'Don't talk over anyone' were mentioned by 5 groups as important when working as a group. When asked if good communication skills were used? Many of the students' responses were a combination of skills from 1st and 2nd year with a greater emphasis on the skills from 1st year " *we didn't talk over each other, we were listening and asking questions if we didn't understand something and we gave good eye contact.*" (Students 21B16, 21B11) and "*We used eye contact and took turns speaking and spoke clearly to each other and asked any questions to avoid any confusion or tension*" (Students 21B08, 21B12). This shows that students were able to transfer the skills from 1st year into 2nd year and that they may have seen the skills from 1st year as more important than the ones developed in 2nd year. It was clear from the EEI interviews at the end of the year that students valued working as a group and was able to elaborate on the benefits of working with others such as split workload and playing to different strengths:

"I*t's better than working alone, there is less of a responsibility because you're able to split up the work and make sure everyone had their strengths and weaknesses used*." (Students 21B01, 21B06)

"*Yeah it's easier because you can do half the workload and it's more efficien*t." (Students 21B04, 21B07)

One student who did the EEI project on his own spoke about his regret that he didn't do a group project "*I would've preferred to work in a group because it would've e made the workload easier and you could've focused on more stuff so you would have time to perfect it.*" (Student 21B05)

When asked in their EEI interview , what was important when working together ?, students mentioned dividing the workload "*we had different jobs* " (Students 21B16,21B11) , supporting each other "*we encourage each other and we didn't have any arguments, we were bending around each other's schedules*" (Students 21B15,21B13) and using skills such as "*eye contact and didn't talk over each other, speak clearly and with confidence*" (Students 21B16,21B11) and "*It is important to meet in the middle if you have different opinions and listen to their ideas , give full attention ,make eye contact and give good feedback*" (Students 21B04,21B07)

In Chapter 4, it was noted that there were some students who differed in their self-assessment of their skills level in comparison to that of the teacher, particularly so in the first assessment at the beginning of the year (SA1). Therefore, the data was compiled again for the 2nd year group to determine if any gender effects were evident in over or under self-estimation of each of the subskills in comparison to the agreed assessment (AA, and likewise at the end of the year, between SA2 and FA. Number of females / males under / over estimation in comparison to AA and FA are shown in Table 5.3.

It is clear from the Table 5.3 that there are more male students who overestimate their ranking particularly for the sub skills of COM at the start of the year, in comparison to female students. This is not as prevalent in female students; however 4 of female students did overestimate their ranking for the sub skill '*speak clearly'* and 3 females over estimated for the sub skill '*responds constructively*'. There are very few instances of underestimation in their rankings. At the end of the year, there is much more agreement between student and teacher ranking (SA2 and FA); however, still some of the male students overestimate their ranking.

It should be noted that numbers here are small and so results may be pointing to a trend only; this will be discussed further in Chapter 6.

Table 5.3: **Difference between assessments. Looking at over and under estimating between students (2nd yr.).**

Sub Skill	**Agreed***	**Female Under***	**Male Under***	**Female Over***	**Male Over***
Respond honestly & sensitively	11 (11)	0 (1)	0 (1)	1 (0)	**4 (3)**
Speak with confidence	8 (12)	1 (0)	1 (2)	2 (0)	**4 (2)**
Speak clearly	7 (12)	0 (0)	1 (2)	**4 (0)**	**4 (2)**
Ask questions	9 (13)	0 (0)	0(1)	0 (1)	**7 (1)**
Respond constructively	12 (12)	0 (0)	**1 (3)**	**3 (1)**	0 (0)
Create a supportive atmosphere	13 (14)	0 (0)	0 (1)	0 (0)	**3 (1)**
Take on different roles	13 (14)	0 (0)	1 (0)	0 (0)	2 (2)
Help group achieve their goals	15 (16)	0 (0)	0 (0)	0 (0)	1 (0)
Engage in group discussion	14 (16)	0 (0)	0 (0)	0 (0)	**2 (0)**
Suggest solutions to problems	15 (16)	0 (0)	1 (0)	0 (0)	0 (0)

*First number relates to difference between SA1 and AA at the start of the year. Number in brackets refers to the difference between SA2 and FA at the end of the year. Total number of students is 16, 5 female and 10 male

5.2.2 Nature and quality of feedback given in the skills passport (Class P2a)

Similar to 1st year study in Phases 2 and 3, students received feedback from their peers on how they were engaging with the particular skills and they also were asked to self-feedback throughout the year during different activities. Time was allocated in class to support students given feedback as results from previous phases, highlighted that students gave more informative feedback when time was dedicated to providing feedback. The feedback was analysed into 5 categories (as in Phase 2), i.e. positive informative, informative, uninformative, irrelevant, and missing). In this section, the peer feedback will be discussed first, followed by the self-feedback.

Peer Feedback

The peer feedback given on the skills passport for each of the 5 monitored activities was examined and categorised, depending on the nature of the written comments. Figure 5. 5 shows the nature of the comments for each activity (total number of students is 16).

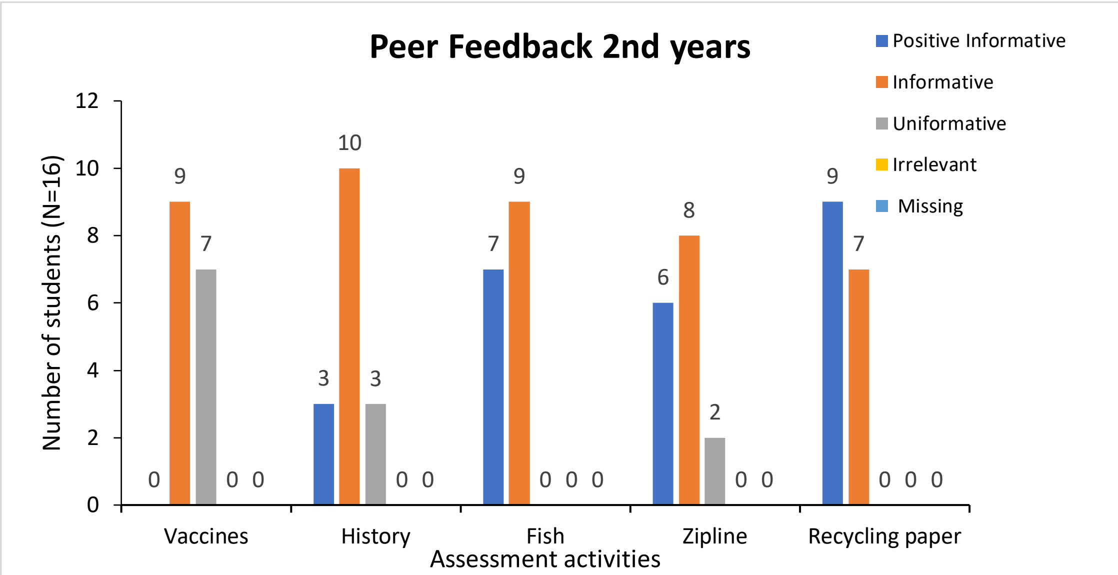


Figure 5.5: **Classification of peer feedback as recorded on the skills passport (2nd Year)**

It is clear from looking at the graph that as the year progressed the number of students receiving feedback that highlights what the students is doing well , what they need to improve and relevant tips on how they can improve (Positive Informative) increased and the number of uninformative feedback decreased. During the first assessment activity 'Vaccines' which was completed at the start of the year ,no students received positive informative feedback .During the second assessment activity 'History of the atom' there is a slight increase in the number of students receiving positive informative feedback and a decrease in uninformative feedback. This may be due to students covering these skills in their SPHE class.

We can see by assessment activity three 'fish' no student received feedback that was uninformative and again the number receiving positive informative feedback increased.

By the end of the year we saw that 56% of students were receiving feedback from their peers that was positive information and 34% were receiving feedback that was informative. No student received irrelevant feedback or had their peer assessment left blank for the whole year therefore the majority of students received written feedback from peers throughout the year that supported their development of the skills COM and WWO.

Self-Feedback

The self-feedback was categorised under the same headings as the peer feedback and is shown in Figure 5.6 for each of the activities. Similar to the results seen in Figure 5.4, the amount of students giving themselves positive informative feedback increased as the year progressed and by the end of the year the majority of students provided feedback for themselves that highlighted what they were doing well, what they needed to improve and relevant tips on how they could improve.

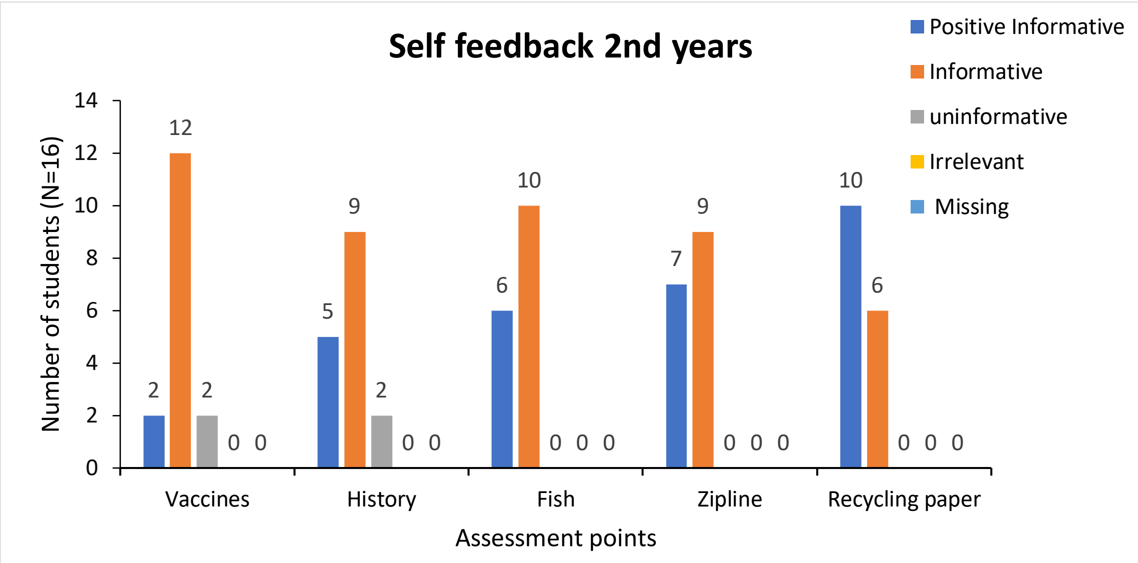


Figure 5.6: Classification of self-feedback as recorded on the skills passport (2nd Year)

From these results we can see that student's self-feedback was majority informative and all students fill out this section. This would indicate an increase in engagement with the process when compared to first year.

5.3 Scientific Planning skills (2nd year – Class group P2a)

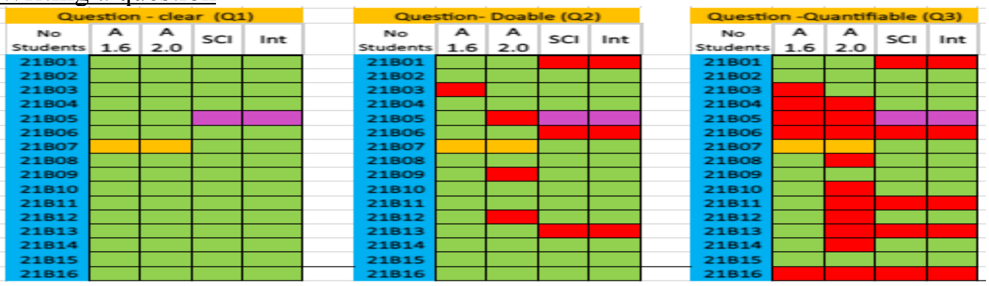
The scientific planning skills focussed on for the class group P2a were: devising a valid question for investigation, writing a hypothesis, writing a procedure for the investigation and identifying the variables. Each of these aspects was further broken down into sub – skills (as shown in Chapter 3). These aspects are summarised in Table 5.4.

Table 5.4: Summary of elements of scientific planning skills (2nd year)

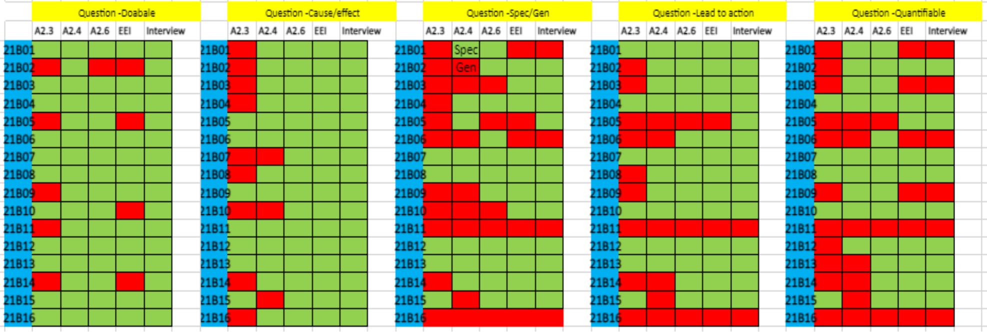
Planning Skill	**Elements**	
Question	Clear and understandable	Cause and Effect Relationship
	Doable and appropriate	Specific vs General
	Quantifiable	Lead to action
Hypothesis	Is a statement	Justification clear
	Justification given	Justification valid
Procedure	Clear and easy to follow	Provides detail
	Suitable equipment	Measurable amounts included
	Neat and clear presentation	
Variables	Independent identified	Explained in scientific language (rather than 'we are changing', 'we are measuring' and 'we are keeping the same' which were used in 1st year)
	Dependent identified	Are controlled variables appropriate and measurable
	Controlled identified	

While these skills were implemented in class throughout the year, specific activities were used to monitor the development of these skills in students' work – specifically A2.3 (Fish), A2.4 (Zip line) and A2.6. The EEI projects were also analysed for evidence of the particular skill and students were interviewed for clarification. As this class group of students had followed the skills programme in first year (as group P1a), the results of their planning skills are repeated here to allow for ease of comparison. Results for each element for class group P2a (along with their data from 1st year as P1a) are shown in Figures 5.7 – 5.10. In these figures, the colour codes are used to indicate if the particular element was evident, green indicating that it was evident, red showed not evident, yellow indicates that the element was not considered and pink indicates the students did not complete the activity. Each planning skill is now considered.

Writing a question



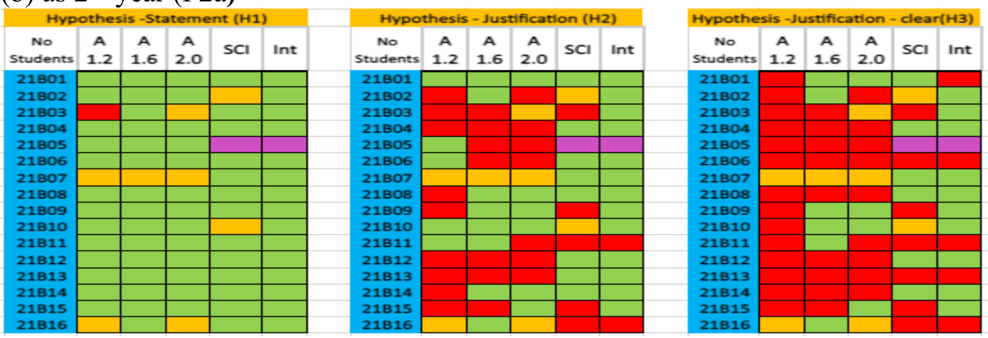
(a) Group P1a (1st year)



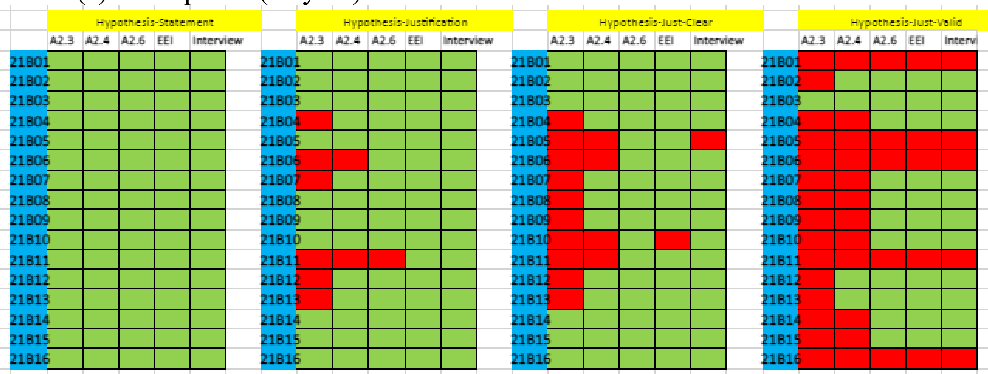
(b) Group P2a (2nd year)

Figure 5.7: **Scientific planning skill - QUESTION - evident in monitored activities.** (a) As 1st year P1a,

(b) as 2nd year (P2a)

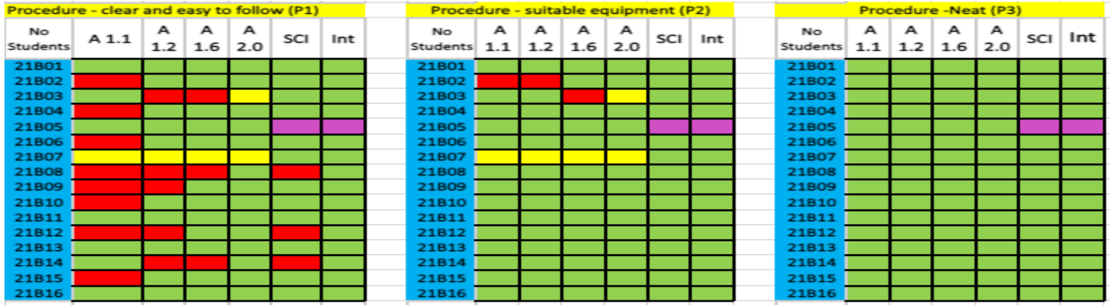


(a) Group P1a (1st year)

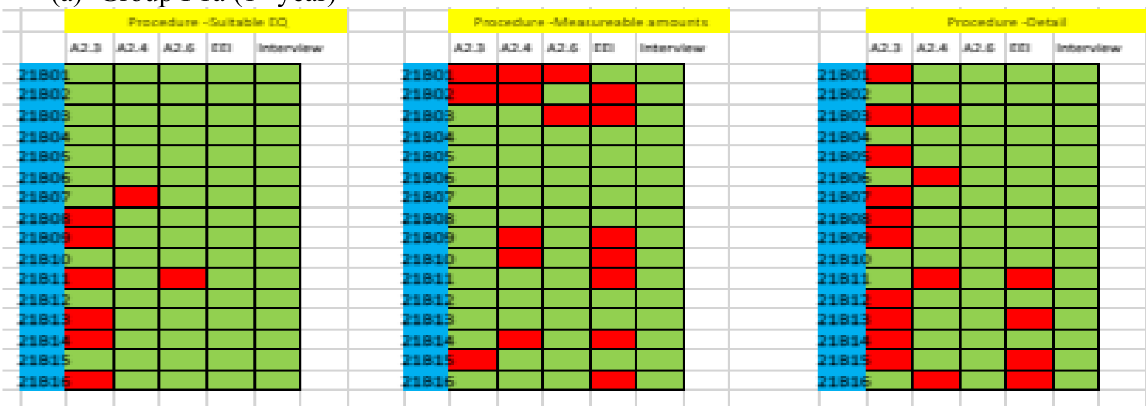


(b) Group P2a (2nd year)

Figure 5.8: **Scientific planning skill - HYPOTHESIS - evident in monitored activities.** (a) As 1st year P1a, (b) as 2nd year (P2a)

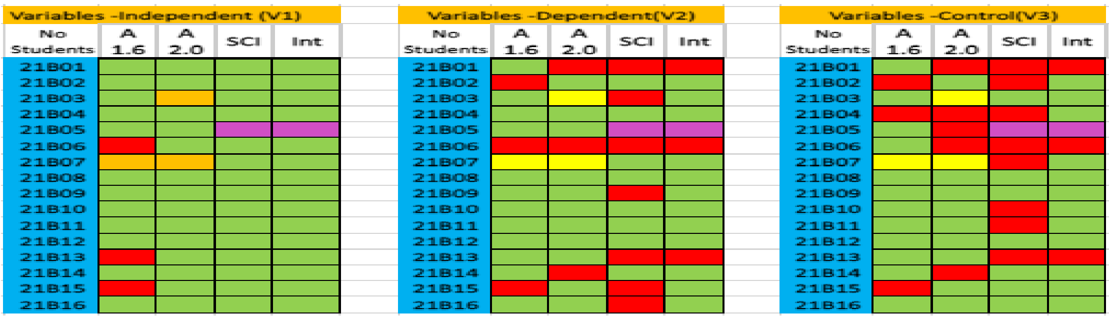


(a) Group P1a (1st year)

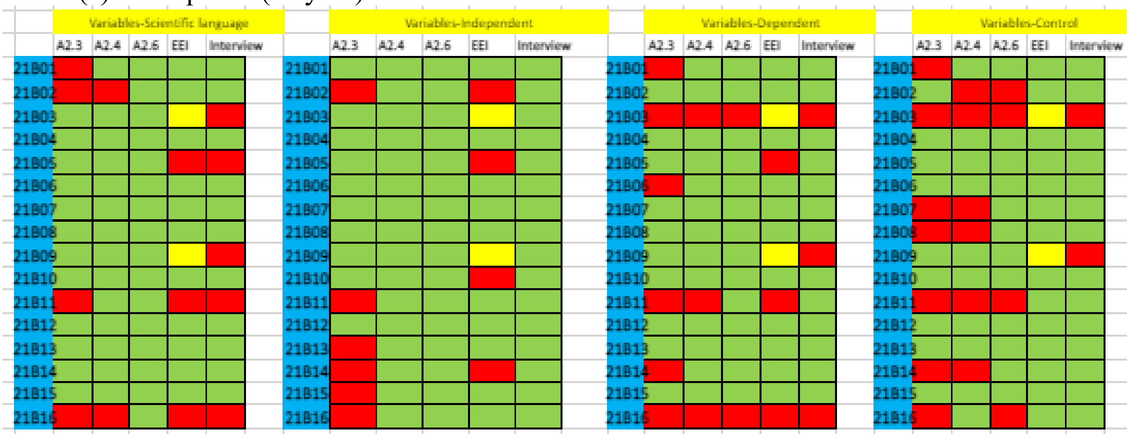


(b) Group P2a (2nd year)

Figure 5.9: **Scientific planning skill - PROCEDURE - evident in monitored activities.** (a) As 1st year P1a, (b) as 2nd year (P2a**)**



(a) Group P1a (1st year)



(b) Group P2a (2nd year)

Figure 5.10: **Scientific planning skill - VARIABLES - evident in monitored activities.** (a) As 1st year P1a, (b) as 2nd year (P2a**)**

Question

Figure 5.7 (a) shows the results of the scientific planning skill "write a question" for group P1a (1st year) and when they progressed into 2nd year (P2a) (Figure 5.6 (b). In 2nd year students were monitored on the skills from first year (clear question, Doable and write a question that was quantifiable). All students were able to write a clear question in 2nd year and these results were not included in figure 5.7(b). At the start of 2nd year, 5 students struggled initially with one of the 1st year skills; write a question that was "Doable". However , with practice the number of students not writing a question that was "Doable" reduced but 3 out of the 5 students who didn't write a question at the start of the year that was "Doable", did not write a "Doable" question for their EEI or interview. Similarly to first year, students struggled to write a question that was quantifiable i.e. allows for measurements to be taken. Of the 5 (21B01 , 21B06, 21B11,21B13, 21B16,) who did not achieve this element by the end of 1st year 4 of these students (21B01 , 21B06, 21B11, 21B16,) could still not write a question that was quantifiable by the end of 2nd year. The new elements for second year focused on writing a question that had a cause and effect relationship, was specific and led to action. Looking at the second year elements, all students had mastered the element of cause / effect by the assessment activity 2.6, this means their question showed that changing one thing affects something else. The majority of students had achieved the element "leads to action" by the EEI which is not the case for the element quantifiable. The element student most struggled with was the element of writing a question that was specific and not general. As the year progressed and students received feedback, the number of students achieving this element also increased. Students who didn't achieve this element in their EEI or interview (21B01, 21B06 (same group) & 21B11, 21B16 (same group)) also did not write a question that was quantifiable. Group which contained students 21B11 & 21B16 asked "*does chewing gum help you concentrate?"* This question was general and not quantifiable, it was also the same question they used for Scifest in 1st year, and they did not expand on it for their EEI. These two students were not successful in writing a question that was specific or quantified during 2nd year.

Hypothesis

Data from analysis of the particular activities for first year (P1a) and 2nd year (P2a) are shown in Figure 5.8. The entire group were able to write the hypothesis as a statement in 1st year and they continued to do so in 2nd year. All could also write a justification for their hypothesis, and all but one student could write a 'clear' justification by the end of

2nd year, i.e. a justification that was based on prior knowledge/scientific knowledge or an observation. This was the element where there were 5 students unsure at the end of 1st year; however, they could all show evidence of this in 2nd year in their EEI projects (one student showed evidence of this in the interview following EEI).

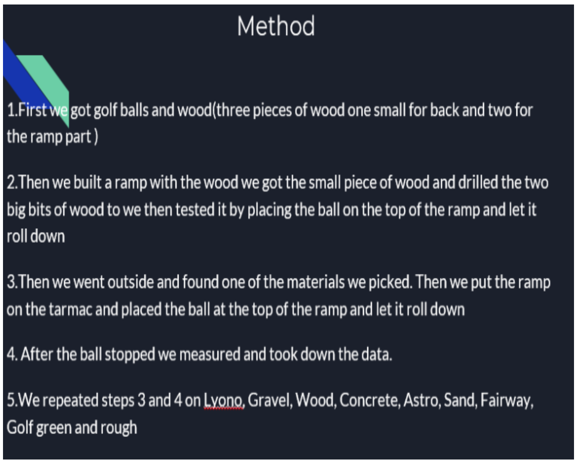
The new element for 2nd year focused on students writing a hypothesis that had a valid justification. While most of the group (13/16) showed evidence of element in the final monitored activity (A2.6)), this reduced to 10/16 when applied to their EEI projects. Also, in the follow up interviews, the six students were not able to expand on their ideas of a valid justification for their hypotheses. This may be due to lack of background knowledge in their chosen investigations or lack of appropriate research.

Procedure

Figure 5.9 shows the results for writing a procedure in 1st year (Figure 5.9a) and 2nd year (Figure 5.9b). Students continued to show continued evidence of these elements from first year into 2nd year. All students were able to write a procedure that was neat, clear and easy to follow at the end of first year and brought these skills into 2nd year. As there was no change in the results between 1st and 2nd year (i.e students had achived at them in 1st year and also in 2nd year)these results were not included in figure 5.9. Also, in first year, all the students could select and include all the equipment necessary for their investigation; following a reminder to the 2nd years after their first monitored activity, (initially 6 students did not list all the suitable equipment for the A2.3), the majority of students achieved this element for the rest of the year with the exception of one student in activity 2.4 and one students in activity 2.6.

The new elements for the second year (detailed procedure and inclusion of all measurable amounts) focus on including sufficient details to allow someone else to repeat the procedure exactly. Students struggled somewhat in generating procedures with sufficient detail initially; however all showed evidence of this in the final monitored activity (A2.6). Some took longer to master but all students had mastered these new elements at the end of the year. In the EEI projects, 4 (of the 16) students did not provide sufficient detail in their procedure and 7 (of the 16) failed to include measurable amounts; however, in all of these cases, when the students were interviewed, they could successfully provide and discuss the missing details.

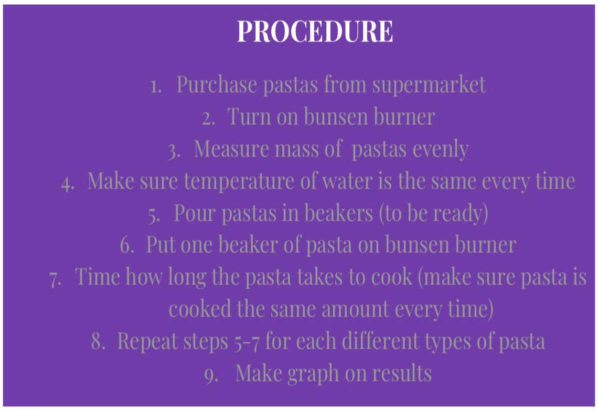
An example of the difference between the written procedure and the detail provided in the interview is shown in Figure 5.11. The vague detail of the presentation is expanded on very clearly in the interview.



"*We made a ramp out of wood about 45 degree angle and length 30 cm and we chose a random golf ball and placed the golf ball at the top of the ramp and let it roll down and we saw how far it rolled and waited for it to stop. Then we got a measuring tape to see what the measurements were from the end of the ramp to where it stopped and we made sure we didn't roll it ourselves because the pace would change if you roll it too hard one time, that's why we used the ramp. We repeated 3 times using different material such as lino, wood, gravel, concrete, actor, sand and done it on a golf course*"

Figure 5.11: **Screenshot of the (a) written procedure (b) interview procedure for student's 21B15 & 21B13 EEI project.**

A further example relating to 'measurable amounts' is shown in Figure 5.12, again showing the lack of detail in the written procedure for the EEI but clarified in detail during the interview. The students left out the measurable amount which would have resulted in the procedure not been able to be repeated, however we can see from the transcript of their interview, that they knew this information and had include the measurable amount and units when interviewed which allowed the procedure to be repeated.



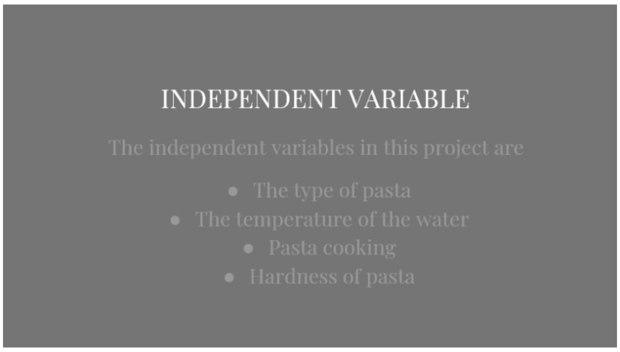
"We just got all of the equipment and made sure there was the same amount of boiling water 100ml. Then we put the 20g of the different pasta - white and whole wheat - into two different beakers and put them on the hot plate. We set a timer for 10 minutes and when the timer was done we checked which was softer."

Figure 5.12: **Screenshot of the (a) written procedure (b) interview procedure for student's 21B02, 21B10 & 21B14 EEI project.**

Clearly, some students struggle with writing or do not like writing, and so writing detailed procedures are difficult for them. However, it is clear from the interviews that students do know the details.

<u>Variables</u>

Looking at figure 5. 10 we can see that there was one new element for variables in 2nd year beyond what they had covered in 1st year and that was in the use of the correct terminology for variables (i.e. independent, dependent and control) rather than 'we are changing', 'we are measuring' and 'we are keeping the same' which was used in 1st year. Also, 2nd year students had to list all the controlled variables, whereas in 1st year students had to include a minimum of 2 control variables only. These elements were the most difficult to show evidence for and many did not show one or more of the elements in their EEI projects. . Five students did not achieve the element using scientific language in their EEI projects and did not use this language in the interviews either. Comparing the answers given in the EEI report versus the interview in relation to the 'independent variable', many students who didn't achieve an element in the EEI were able to achieve it in the interview; e.g. Figure 5.13 shows the independent variable given by one group in their EEI project and the corrected version, given in the interview. It is clear from the interview that students understood the term independent variable, however if using just the EEI project it would appear that students didn't understand this concept.



"Independent variable was the type of pasta"

Figure 5.13: **Screenshot of the (a) written procedure (b) interview procedure for student's 21B02, 21B10 & 21B14 EEI project.**

5.3 Comparison of EEI Projects between Class groups

This section we will present the scientific planning skills evident in the EEIs and the collaborative skills used when carrying out the EEI for the classes F2b and C2c. These class groups had different teachers in 2nd year, they did not follow the skills programme; however, group F2b had followed the skills programme in their first year. The only data gathered on this group was their individual EEI projects and their EEI interview. The interview was used for two purposes; firstly to seek clarification on any of the planning skills and secondly to determine how they worked as groups while doing their EEIs. Note that while the students worked in small groups while doing their projects, they had to write up individual reports.

5.3.1 Scientific Planning skills (Groups F2b and C2c)

The scientific planning skills of forming a question, writing a justified hypothesis, clear procedure with variables identified were examined in the EEI final project submissions for class group F2b and C2c. Results are shown in Figures 5.14 – 5. 16. Results from class P2a which were discussed in section 5.3 are included as a comparison(Figure 5.14).Note that in group F2b, students 21A01 and 21A18 had left the school at the end of 1st years and therefore did not complete the EEI and student 21A09 was absent from the EEI interview. Also, due to a school trip, many students in C2c (21C01, 21C06-21C11 & 21C16) were absent from the interview.

<u>Question</u>

The questions posed for the EEI were analysed under the 5 headings as already done for P2a group in Section 5.2.

In class group F2b, 5 groups did not include their question in their EEI write up, this may be due to the lack of teacher involvement as teacher F had “ varied input” or an oversight on the student’s part , but most of them were able to speak about their research question that was clear and doable during the interview. These were the elements which were introduced in first year and it seemed that the majority were able to write a good question to investigate, but did not think it was important to include in their EEI write up.

Many of the elements of a good question were not considered by F2b group. Of the 8 groups, many of them struggled in their interview to show their research question as ‘specific’ (N=4), ‘quantifiable’ (N= 3), ‘lead to action’ (N= 4) and had a cause and effect relationship’ (N= 2).

In contrast, the majority of the 8 groups in C2c were able to write a question that was ‘doable’ (N=6), had cause and effect’ (N=8) and the ‘question led to action’ (N=7). However, the students struggled with the elements, writing a specific question (5 groups achieved) and a question that was quantifiable (4 groups achieved). Unfortunately, these aspects were not possible to probe at interview; however, for the groups that were interviewed, the students were not able to clarify these elements.

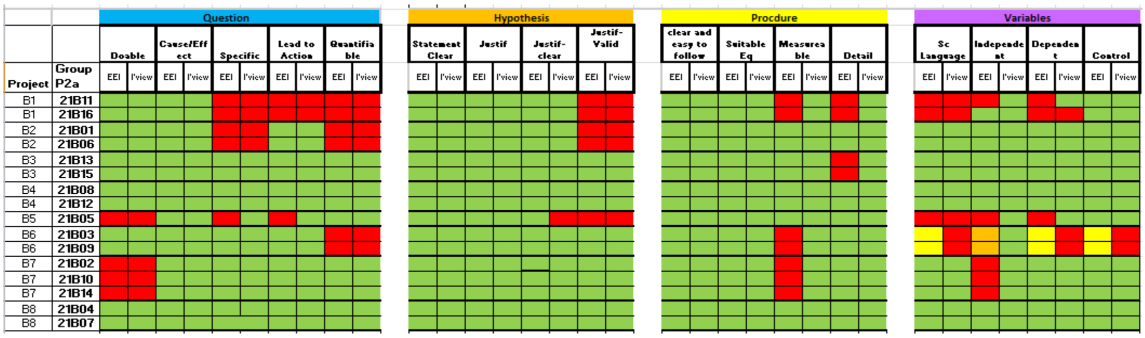


Figure 5.14: **Scientific planning skill evident in EE1 and interview for class group P2a.**

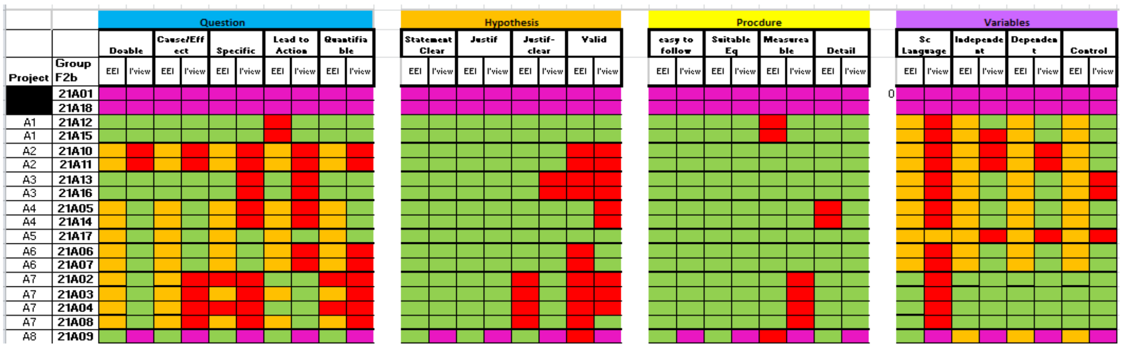


Figure 5.15: **Scientific planning skill evident in EE1 and interview for class group F2b (Note student 21A01 & 21A18 left the school and didn't complete the EEI).**

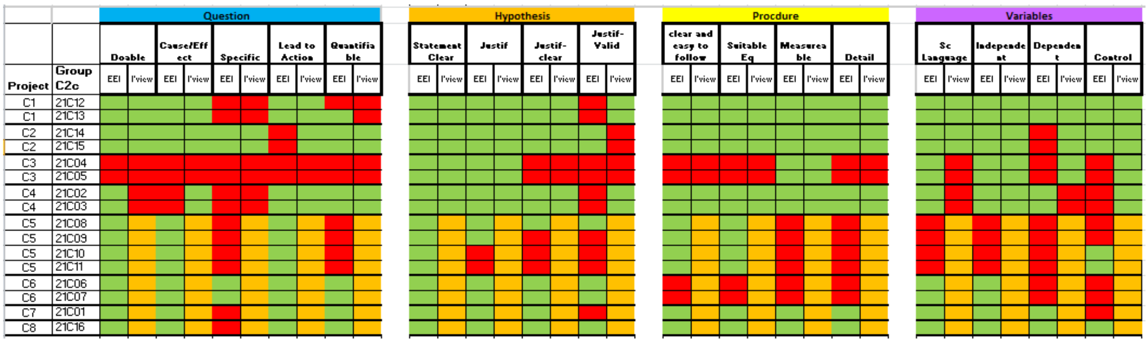


Figure 5.16: **Scientific planning skill evident in EE1 and interview for class group C2c.**

<u>Hypothesis</u>

Looking at the results of analysis of the hypothesis by students in classes F2b and C2c, in total, 2 groups in class F2b and 1 group was able to write a hypothesis statement with a clear and valid justification for their EEI.

Students in group A7 who did not write a clear justification for their hypothesis in their EEI reports were able to give a clear justification in their interview (Figure 5. 17a and Figure 5.17b).

"I *think tap water will have the most bacteria because it is not filtered*"

"*We thought tap water would be the worst because of the taste and filtered would be the best (have the least bacteria). Taste*

***Figure5.17a*: Written hypothesis** ***Figure 5.17b*: EEI Interview response**

Giving a justification that was valid is the difficult element for both groups of students. Interestingly students in group A6 wrote a justified hypothesis that was not valid in their EEI but then gave a different hypothesis which had a valid justification in their interview (see Figure 5.18a and 5.18b).

I think that the reusable insulated mug will keep the heat in for the most time out of all the cups because it is metal and metal is a conductor of heat"

"We thought the mug would be the best because it was a thick material and therefore would lose heat the slowest as it would take the heat longer to

***Figure 5.18*a: Written hypothesis** ***Figure 5.18b*: EEI interview response**

Likewise, four students in group C2c were able to extend their hypothesis justification during the interview to include valid elements.

However, those students who had a valid justification in their report 2 of them who were interviewed could not give a valid justification when questioned about their hypothesis and just responded with "*Our hypothesis was correct*" "(Students 21C14 & 21C15,group C2, EEI Interview).

<u>Procedure</u>

Students in class F2b were successful in writing a procedure that was clear and easy to follow, contained suitable equipment and was doable in their EEIs (Figure 5.16 (a)). Only 2 projects (A1 & A8) in this group did not include measurable amounts and one group (A4) failed to give sufficient details; however, these were clarified during the interview. Again highlighting the benefit of an assessment that includes both a write up and interview.

In class C2c, 3 groups were able to write a procedure that contained all the elements i.e. they were able to write a procedure that was clear and easy to follow, contained suitable equipment, measurable amounts and enough detail to be repeated (see Figure 5.16(b)).

Variables

Looking at the result from figure 5.15 and5.16 for groups F2b and C2c we can see that only 1 group in F2b (A7) included variables in their write up and were able to use the correct terminology and state their independent, dependent and control variables. When talking about variables in the interview, however, they used the terms 'we changed', 'we measured', 'we controlled' to describe the variables. Figure 5.19a and 5.19b shows the variables as presented in EEI project and the detail as presented in the interview for the group A7.

Variables :

Independent variables
I am changing the different types of water I use

Department variables
I am measuring the amount of bacteria in the different waters

Constant variables
I am keeping the amount of water used and the method for each water the same

"*We changed the different types of waters, we measured the amount of bacteria in the water and the only thing that didn't change was the way we made the agar and we added the same amount of water*"

***Figure 5.19*a: Written variables** ***Figure 5.19b*: EEI interview response**

The group F2b were introduced to variables when in 1st year, using the terms 'I changed', 'I measured', and 'I controlled', rather than independent, dependent and controlled. However, the majority of students (13/16) did not include the variables for the investigation in their EEI reports. Most of them could nevertheless state in the interview what they were 'changing, measuring and keeping the same'. We can see an example of some of the responses when asked what variables they considered:

> "*We controlled how much water we added, how long we kept it in for, the cups and how long we checked the temperature. We changed what the tea was in and measured the temperature*" (Students 21A06&21A07, Group A6,EEI interview)

> "*We changed the location of where we bought the can from, we measured how much bacteria and we kept the brand of the drink and the method the same. And we put them in the same place and gave them the same time.*" (Students 21A15&21A12, Group A1, EEI interview)

This indicates that students had a good knowledge of variables but decided not to include them in the report. The importance of a dual assessment of report and interview is highlighted here as many of these students would have lost marks in their EEI for not including variables; however, it is clear from the interview transcripts that students had a good understanding.

In group C2c, only 1 group (C1) successfully dealt with the concept of variables, in report and interview. We can see with the exception of group C5 the rest of the group were able to use the appropriate language and identify the independent variable in both their EEI and during the interview. Some did use the terms ‘we changed’, ‘we measured’ and ‘we controlled’ in the interviews. Noting and identifying the dependent and control variables was not done by 10 students in each case in their reports but those that were interviewed could identify them; e.g. in a particular project report, the control variable was recorded as ‘*the time*’, but in the interview noted “*we kept the time we measured the heart rate the same, the foods each received, the type of food and amount the same and the method”* (21C02 & 21C03 EEI, group C4 projects and interview).

5.3.2 Skills of COM AND WWO (Classes F2b and C2c)

During the EEI interviews, students were asked 4 questions about working as a group, namely:

- How did your group work together?
- What was important when working as a group?
- Why did you like working as a group?
- Was it useful working as a group?

Examining comments made by F2b group:

When asked how did your group work together, students mentioned some of the skills they had been working on in first year such as, no fighting , take turns talking , listen to each other and the importance of dividing the work load. Student’s attitude towards working as a group was very positive.

> “*We worked together well because we listened to each other well and took turns talking*” (Students 21A13 & 21A16)
>
> “*We worked well, we communicated and talked well and did everything as a group, we all did our fair share and the work was evenly divided.*” (Students 21A06 & 21A07)

One of the students who did the EEI project on his own mentioned that having to rely on someone else was the reason for doing the project on his own:

"I did it on my own because I thought it'd be easier if I did it alone, say someone had to go out and I had something the next day we wouldn't be able to do it so I could just do it when I had the chance to do it" (Student 21A17, EEI Interview)

When asked what is important when working as a group, students again mentioned the skills they had focused on in first year, namely: active listening, eye contact, no fighting, contribute ideas, no messing, back up opinions and contribute ideas. Groups also mentioned equal work, help if a member is struggling, and respect.

"*It's important that you listen to the other person, use eye contact, keep it serious and have equal amounts of work*" (Students 21A15 & 21A12, EEI Interview)

"*That we listened to each other's ideas because that would make the experiment better, no fighting and we can back our own points up without it being aggressive*" (Students 21A13 & 21A16, EEI Interview)

"*That we told each other what we were doing and our opinions on things and if we had new solutions we would tell each other*" (Students 21A02, 21A03& 21A04, EEI Interview)

When asked why they liked working as a group, the responses were positive and mentioned mainly the opportunity to work with friends, more fun and more people to contribute ideas.

"*It's fun and if you're working in a group you can evenly divide out the work but in a group you can share out everything and it will work well*" (Students 21A10 & 21A11, EEI Interview)

"*I knew that we would have got along and we are comfortable with each other to bring up things we weren't happy about and we would meet each other halfway with our roles*." (Students 21A02, 21A03 & 21A04, EEI Interview)

When asked about the benefits of working as a group again student's responses were very positive and mentioned many benefits such as less pressure, support, more ideas and completed faster.

"*A group is better because you get more opinions and it will make the project better*" (Students 21A02, 21A03, 21A04, EEI Interview)

"Y*es it was useful because you can dish out the workload and there's less pressure and if I don't know something they might "*(Students 21A15 &21A12, EEI Interview)

However, the students that completed his EEI individual could see both the advantages and disadvantages of working in a group

*"I think it was useful and easier on my own because you don't need to run everything by the rest of the team but being in a group would give you an extra opinion" (*Student 21A17, EEI Interview)

Limited interviews were conducted with C2c group; however, skills of communication and working with others were evident. When asked how they did work together students all said they worked well together and this was because they are friends, they evenly divided the work, everyone contributed and they all had different roles which helped them to complete the project.

"*We worked well because we're friends and get along well*" (Students 21C12 &21C13, EEI Interview)

"*Good, when 21C05 was timing it and noting down the results I was cutting the food we had a flow to it and we all had different roles*". (Students 21C04 &21C05, EEI Interview)

When asked what was important, students in this class felt that everyone contributing to the project, sharing the workload, communicating with each other and knowing what others in the group are doing were important when working on a group project.

"*That we all knew what we were doing and telling each other what we have to do and keeping the others notified*" (Students 21C02 &21C03, EEI Interview)

"*Sharing out the work and listening to everybody and agreeing on the same things*" (Students 21C14 &21C15, EEI Interview)

Students highlighted the personal benefits of working in a group such as less stress, less pressure, easier with more people, less nervous and that you have more opinions.

"*It seemed easier and took the stress off of you because it was more teamwork*" (Students 21C04 &21C05, EEI Interview)

"*I get nervous by myself so at least you have other people do give your idea*" (Student 21C02 &21C03, EEI Interview)

When discussing if it was useful to work as a group all groups said they were glad they had chosen to do it as a group and felt doing it as a group made it more enjoyable, reduced the pressure and workload, felt they benefited from the others group member opinions and the workload was divided.

> "*It was better as a group because then you don't have as much pressure on you and you can listen to different opinions.*" (Students 21C14 &21C15, EEI Interview)

> "I*t's more enjoyable when you can do it with other people*" (Students 21C12 &21C13, EEI Interview).

5.4 Key findings

What is evident from the data collected from the second year students is that group P2a appeared to have benefited from the extra year of skills developed and students felt it benefited them when carrying out their EEI project and although they struggled to grasp some of the inquiry skills similar to the to the other two groups they did better in some of the other elements.

Looking at the Inquiry planning skills for the three groups we can see at the end of the year in the EEI write ups that the three groups had difficulty achieving similar elements. All three groups struggled to achieve the elements of writing a question that was specific and quantifiable and writing a hypothesis that had a valid justification. Groups F2b and C2c also struggled to achieve other inquiry elements. Students in group F2b did not include writing a question or variables in their EEI write up. When interviewed on their question they weren't able to give a question that was specific, quantifiable but also lead to action. When asked about variables they weren't able to use the correct language to describe the variables (Independent, dependent and control), instead using the prompts they had learnt in first year, 'I changed, measured and keep the same''. Students in F2b achieved many of the elements they had focused on in 1st year but struggled with some of the elements that were focused on in the 2nd year of the programme. As well as struggling with the elements writing a question that was specific and quantifiable and a hypothesis that had a valid justification group C2c struggled to write a procedure that contained enough detail to be repeated and also include 2 or more control variables in their write up. The results also highlight the importance of the interview to support the student's written project work.

Looking at the communication skills we can see that the group P2a improved on every sub skill but there were still many incidents of students under or over estimating their initial ranking. The majority of students who over or underestimated were male students. The EEI interview at the end of the year highlighted that students felt the skills they had focused on in 2nd year were important when completing their EEI project, they also felt the skills they had focused on in first year were equally if not more important when working collaboratively in a group. Every student also improved on each sub skill for the skill WWO. There were less incidences of over and under estimating and any incident that occurred involved male students only. Students initially struggled to provide feedback to peers on the sub skills of working with others but an intervention in SPHE class allowed students to develop a better understanding of the sub skills ‘respond constructively’ , ‘create a supportive atmosphere’ and ‘ suggest solutions to problems without compromising the time spent on scientific content. The level of peer and self-feedback improved in 2nd year and more students were able to provide feedback that was positive informative or informative and no students feedback from peers was left blank or irrelevant comments left. This was an improvement on 1 set year.

When interviewed on how they worked together or what's important when working or communication in a group , group F2b mentioned many of the skills they had focused on in 1st year and also mentioned skills such as dividing the workload and respecting each other. Class C2c responses focused on sharing the workload, they mentioned communicating as a general statement and did not provide any details, the importance of friendship and divided roles. All three groups spoke positively about working in a group and were aware of the benefits such as less pressure, more fun and reduced workload .Although all three groups results were looked at together it should be noted that due to different teacher’s approaches and ability levels of students it is difficult to make a clear comparison between the three groups.

Chapter 6 Discussion and future implications

6. Introduction

This body of research aims to answer the overarching research question “To what extent are students' key skills of communication and working with others developed alongside scientific planning skills in a junior cycle science classroom?. It is clear from the results form chapter 4 and 5 that the key skills of communication and working with others can be successfully developed alongside scientific planning skills in the science classroom and that the skills passport that was designed for this project plus the activities chosen are an effective way to develop these skills. The next sections summarises the main findings from chapters 4 and 5 and discusses these findings in the context of the research question of this thesis, presented in chapter 1. Section 6.1 presents the outcomes for chapter 4 and Section 6.2 presents the outcomes for chapter 5 and the final section 6.3 discusses implications for further studies

6.1 1st year’s overview

This section of the study aimed to address the research question, can the skills of communication, working with others and scientific planning skills be supported in a 1st year science class. We will first discuss the key skills of communication and working with others and if the skills passport was an effective way to monitor their development and secondly discuss the development of the scientific skills in a first year classroom. To see if there was an improvement on each subskill a t-test was carried out to see if there was a significant difference between the agreed assessment (AA) at the start of the year and the final assessment (FA) at the end of the year for the sub skills of communication and working with others. Looking at the result from all three phases we can see that there was a significant difference (p value less than 0.05) between the AA ranking and the FA ranking indicating that students did improve on every sub -skill. A more in depth analysis of the AA and FA was carried out.

At the start of the year the students ranked themselves and then an agreed assessment point was decided with the teacher, the difference between the two show gender differences in the student’s self-assessment practices. Female students demonstrated higher incidents of underestimating their rankings whereas male students demonstrated higher incidents of overestimating their rankings. Male students rate themselves as more self-efficacious. Females underestimate themselves in the sub skills 'making eye contact' , ' be friendly/no fighting and ' No messing' and male students over estimated themselves in the sub-skills 'Eye contact' , 'Active listening', 'Back up opinions' , 'No messing', 'No messing' and 'contribute ideas' and males under estimated their ranking for the sub-skill 'Take turns talking'. However, the it is also possible that the teacher overestimated the female students and underestimated the male student's attainment of certain skills.

The gender differences found might be as a result of stereotypical beliefs that girls are expected to behave in a certain way in an academic setting. Females are expected to be well behaved in a learning environment when compared to males. This hypothesis echoes the arguments made by researchers that gender differences in "academic variables may be a function of stereotypic beliefs about gender that students hold, rather than of gender itself" (Pajaras & Valiante, 2002, p.216).Research shows that teachers implicitly convey their stereotyping through their classroom instruction (Keller 2001) and this may impact students beliefs about how they should behave in a classroom setting. A substantial body of literature suggests that male students tend to overestimate their performance, whilst female students tend to underestimate their performance, despite female students actually being equal or outperforming male students (Bryan et al., 2005; Lind et al., 2002; Rees, 2003; Rees & Shepherd, 2005). Female students generally perform better or equally to males and therefore it is not clear why gender differences in perception occur during self-assessment(Masson et al., 2004, Richardson & Woodley, 2003).Various theories propose that gender differences are innate (Myers & McCaulley, 1985), or due to early socialization and this can influence students' performance .Many studies have also shown that realistic self-assessment appears to be very difficult to accomplish, due to human nature (Dunning, Heath, & Suls, 2004) and therefore it is important to have the consistency of agreed assessment and the Final assessment done by the teacher at the start and end of the year as student self-assessment on its own is regarded as less reliable indicator of student performance than other assessments such as teacher assessment (Kuncel, Crede,& Thomas,2005).

To help with the monitoring and development of skills, activities were chosen that allowed students to demonstrate the skills and were facilitated so as to support both peer and self-feedback. The analysis of the quality of feedback received from peers highlighted that once scaffolding was provided by the teacher this resulted in peer feedback that was positive informative, but once the scaffolding was reduced the majority of peer feedback was informative, this resulted in students not receiving tips on how to improve. The findings also highlighted that students found it difficult to give tips on how to improve on the behavioural elements of the skills, especially if a student did not need to improve.

Phase 2 highlighted the need for time to be embedded into classroom planning to allow for effective feedback and indicated this may result in less feedback that was missing or irrelevant. The embedding of time to give feedback into the classroom planning was successful in reducing the amount of missing or irrelevant feedback during phase 3. The significant difference between AA and TA indicates that the chosen activities were successful in providing opportunities for the skills to be practiced and monitored. However, some students struggled to give feedback that was positive informative, but the number of incidents of students receiving informative feedback did increase as the year progressed. The analysis of the self-feedback section for phase 2 also highlighted that students are able to highlight what they did well , what they need to improve on but unable to give tips on how they can achieve this and many students not filling out the self-reflection section. Although it was highlighted that students had reduced time to complete this section and the same emphasis was not placed on filling it out compared to the peer feedback sections. The increased in time an emphasis during phase 3 resulted in a decrease in uninformative, irrelevant and missing self-feedback with the majority of students given themselves formative feedback.

Literature indicates that the skill of peer assessment takes time and practice and students must be given the opportunity to gain confidence in the process in order to become competent at it (Falchikov, 2007). The absence of self-regulatory feedback which Hattie and Timperley (2007) describe as ‘where am I going next’ in both peer and self-feedback aligns with Gan’s (2011) findings that self-regulation feedback was extremely rare, even in upper secondary school students’ peer-assessment comments, despite the training provided. Literature provides multiple potential hypotheses explaining the scarcity of self-regulatory feedback. Harris, Harnett, & Brown (2013) highlighted that teachers seldom provide this kind of feedback in their written comments and students tend to mimic their teachers' feedback and therefore they are unlikely to create self-regulation comments. As students are relative novices they may have difficulty constructing feedback that provides tips on where to go. Harris (2014) believes it is unrealistic to expect peers to be able to create self-regulation level comments, a role that teachers themselves find difficult. He believes asking students to provide strategies that the learner can employ to improve his or her own work may be a set of skills beyond the scope of most students in compulsory schooling. Andrade, 2010 believes that peer or self-feedback is unlike to “accurately reflect everything students think about the quality of their own or their peers’ work” and that although students may have self-regulatory feedback in mind they do not see the need to “write these kinds of observations down as they already have access to their own thoughts”. Another reason for the lack of self-regulatory feedback in both peer and self-feedback is that students may view this type of feedback as private (Cowie ,2009) or they may feel the need to provide feedback that they feel provides the type of comments teachers want (Harris & Brown ,2013).

Through a series of chosen activities, 1st year students were able to develop adequate scientific planning skills by the end of 1st year, although the development patterns for each skill varied. The chosen activities allowed evidence to be gathered for the students as they developed science planning skills, but also gather evidence of what elements students struggled to achieve by the end of first year. While students made significant progress in writing a procedure, writing a hypothesis that was justified, identifying independent and dependent variables, and writing a clear and doable question in phase 2 showed slight improvement in writing a clear justified hypothesis, identifying more than two control variables and writing a question that was quantifiable. Although in phase three students also struggled to write a hypothesis that was clearly justified, we see more evidence of students being able to write a question that was quantifiable and also identify two or more control variables. Students in phase 3 encountered forming a question and control variables more often due to additional inquiry activities.

Given the limited understanding about scientific concepts in a 1st year science class, constructing a clear justification that is backed up by prior knowledge/ scientific knowledge or observation could be hard for a 1st year student .Students’ difficulties in constructing explanations are well documented. Many students generate incoherent explanations from personal ideas (Driver et al., 1985, 1996) and are not able to make logical relationships between evidence and explanations (Kuhn et al., 1988).

6.2 2nd years overview

This section looks at the development of the skills of COM, WWO and planning skills in a second year science class and the benefits if any on completing the CBA (EEI) at the end of second year. An independent t-test showed that students did improve on every sub-skill for COM and WWO for class P2a. During the interview the teacher of class P2a highlighted the benefits he felt the skills of COM and WWO brought to his students:

> "*The most important one though is the key skills we were focusing on right from the start using the skills passport so my students are excellent communicators, they are excellent collaborators, presenters and no matter what project they do I can see them becoming more scientists*"(Teacher P interview)

Although the increases were not as modest as first year they did increase on the ranking scale. Unlike 1st year, students struggled to initially provide good examples of each sub-skills and this may be due to the fact that the skills were much broader and could be interrupted in different ways compared to the more specific skills in year 1.When students picked the skills to be focused on the teacher tried to include as many of the students suggestions as possible and put them under broad headings. In the future these sub-skills should be broken down into simpler more manageable sub skills. As a result an intervention was prepared with the SPHE department to help breakdown the skills and provide students with a better understanding. This intervention however did highlight that the skills could be easily transferred to other subjects and not confined to just the science classroom. The activities chosen really supported the skills in 2nd year as they were more focused on students presenting their work to peers and carrying out research combined with practical work. Whereas these activities would not have suited the skills that were focused on in first year which were heavily focused on practical work. Focusing on the skills of COM both male and females over estimated their rankings initially but by the end of the year there was less evidence of the students over or underestimating. This may be due initially to students not understanding the sub-skills as they were too broad. When interviewed on the skills in 2nd year after their EEI more students mentioned the skills they had focused on in 1st year and less mentioned the skills from 2nd year. This shows that the skills are transferable and retained by students and students felt they were more important than the ones focused on in 2nd year. This was also evident when the group F2b were interviewed; they also mentioned many of the skills they have focused on and developed in 1st year. Class F2b did not focus on any skills of COM or WWO in 2nd year and during the teacher interviews teacher F mentioned that the after carrying out EEI they can see how they are important and should be focused on and is something they will do next year:

> "*The key skills are not something I focused on before but having gone through this process now this year and going through the course I see why you need to focus on them in class*" (Teacher F interview)

Whereas group C2c responses when asked about the skills were much more broad and not very specific. Looking at their teachers interview, although when asked what skills are important, T4 mentioned *"Communication, working with others and safety*" when asked if they had integrated them into their planning or monitored them teacher C replied "*no*". They did highlight in the interview that they felt their students would have benefited from these skills when conducting the EEI:

> "*Their group work was grand but if there was any strong character they would make everyone stand back and just do what they're told and that was shown in their write up because they weren't too sure on what their role was, I would give them tips on how to communicate with each other and sharing the workload next time.*" (Teacher C interview)

When the interviewer asked T4 what they would do differently again they mentioned focusing on the skill of WWO:

> "*Possibly teach them how to work properly with others and share information*" (Teacher Interview)

The skills in 2nd year were less practical compared to the skills in 1st year such as 'use eye contact' , 'active listening', 'use a quiet voice etc and more focused on the emotional side to the skills such as ' create a supportive atmosphere', 'respond honestly and sensitively' and ' respond constructively' and students many not at this stage have the emotional intelligence to be able to fully engage with these skills **.**Emotional Intelligence(EI) in teens covers their ability to use emotions effectively and productively in an adaptive way (Sekhri, 2017).Although the skills focused on in 1st year support the development of EI in teens if students are lacking EI they may lack the ability to understand how others might feel and why, this is due to a prefrontal cortex that is not fully developed.

Focusing on class P2a first we can see that any planning skills that they mastered in 1st year although initially they seemed to struggle after the summer holidays they quickly mastered them again in 2nd year. The majority of the new elements which were the focus in 2nd year students were able to master by the end of the year and this was evident in the EEI and the EEI interview.

Looking at the three classes, we can see that they all struggled with similar planning skills elements regardless of the teaching approach that they experienced. Class F2b left many of the planning elements out of their EEI write up, their Teacher F mentioned in their interview that this could be due to finding it difficult to "*strike a balance between the the amount of guidance which should be given* " (Teacher F, Interview) and not given enough support about what to include at the right time:

> *" I gave them to help with a list of sections of things they needed to include like hypothesis and data etc and there was a thing that I would give that to them after their experiments and in retrospect I would do that from the beginning so they really knew what to look at and think about."*(Teacher F ,Interview).

Looking at the planning skills for the EEI each of the three classes received different levels of support. Class P2a had minimal guidance from the teacher when carrying out the EEI :

> " *The students picked their own topic and my role was just to guide them and assist them in gathering materials and just being there to help them reach conclusions at the end of the project. Once they had that and they chose their question for the EEI almost every group was able to go off with themselves and report back to me with minimal input from myself as their teacher.* " (Teacher P, interview) .

Class F2b had varied guidance from the teacher depending on their ability " *My input varied, I didn't give anyone a topic as such but some did need some guidance on the approach for theirs like how they're going to measure something or whatever*" (Teacher F , Interview) .

Whereas, class C2c appeared to have the most guidance from their teacher, she mentioned her input in relation to the element forming a question " *I went through with them and helped them come up with a better question if they were too simple or too hard*" (Teacher C , Interview) . All three groups did well in developing the planning elements , however the data from chapter 6 shows that group P2b displayed a better understanding of the elements in their EEI write up and interview when compared to the other two classes.

6.3 Implications for further studies

The outcomes of this study indicate that the key skills of communication and working with others can be developed and supported alongside scientific planning skills in the junior cycle science classroom. Due to time constraints it was not possible to follow students for the 3 years of the junior cycle science programme, however future work could focus on the monitoring the development of skills and students interaction with the skills over three years and any implications on the students second CBA in third year. Future research could also focus on the breaking down of the skills of communication and working with others in second year into less broad sub skills as this was highlighted as an issue for this study as students struggled to develop a good understanding of the broader skills in second year compared to the more defined skills in first year. More detailed research could also be carried out on the effects of variables such as age, gender and grade level and their impact on student's ability to engage in the self/peer assessment process as this project highlighted these factors as possible areas that needed to be addressed and investigated.

The skills passport and activities chosen for this project proved to be an effective way to develop both the communication and working with others skills as well as the scientific planning skills. However, it should be noted that activities used to monitor the development should be adapted to reflect the subskills the teachers are focusing on, as the activities chosen for this project were suitable for the sub skills focused on in first and second year, however if a teacher implementing this approach focus on other subskills the activities in this project may not be suitable. The small sample size of both implementations means that the results from this project are not generalizable. Only one class was monitored for two years of the programme. These students showed clear development in the skills over this time and the benefits of engaging in the project were evident in the interviews at the end of year 1 and 2.

Possible extensions to this work would be to conduct the research with a larger sample size and the possibility of looking at the use of the skills passport in other subject areas to investigate the transferability of the passport and the development of the skills of communication, working with others and planning skills.

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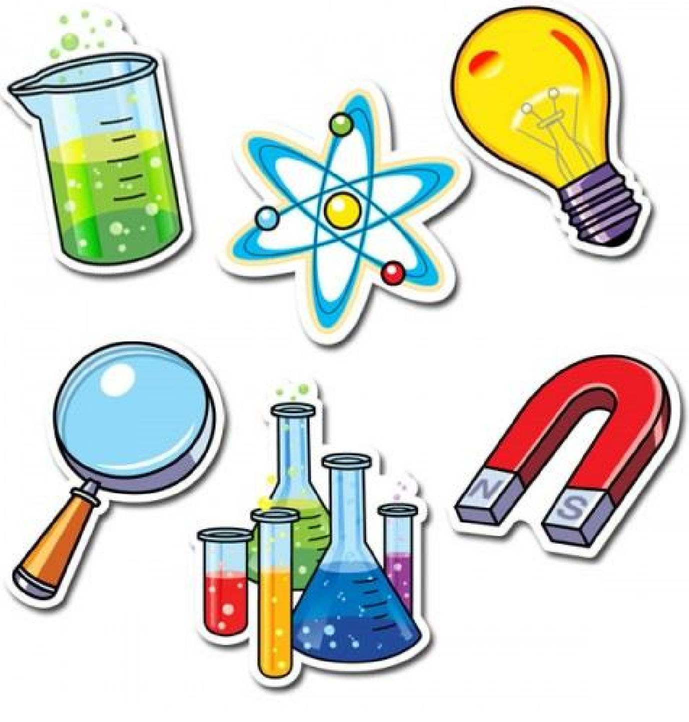
Appendices

Appendix A Skills passport for 1st years

Skills passport



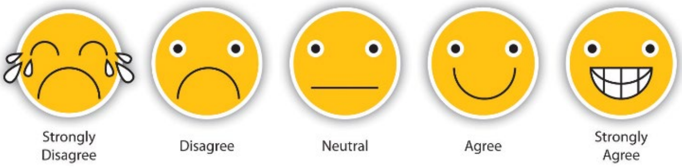
Name: ___________________________

Class : ___________________________

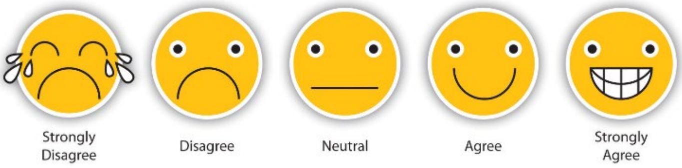
Communication

Circle the answer that best describes your response:

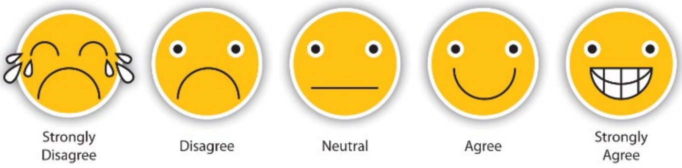
When I talk to someone I always maintain eye contact?



When someone is talking I always give them my full attention? (Using body language?)

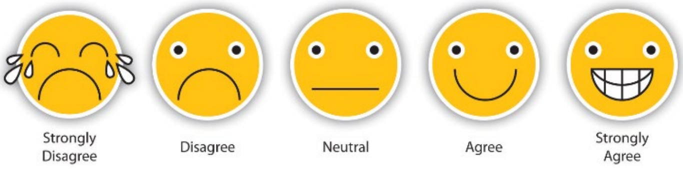


I never talk when someone else is talking?

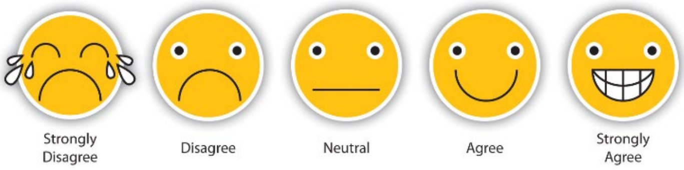


Working with others

When working in a group I always take turns talking?



When working in a group I always contribute ideas?



Skill: Communication & Working with others

Success Criteria:

Communication:

- Make eye contact
- Don't Talk over anyone
- Active listening

Peer feedback

What he/she is doing well:

What he/she needed to improve on next time

Tips on how they could improve on any aspect of the skill:

Self-feedback

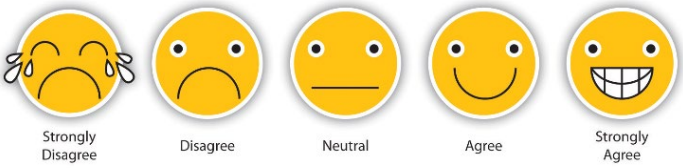
Do you agree with the feedback?

How could you improve for the next time? (Mention what you did well, what you need to improve and how you could improve)

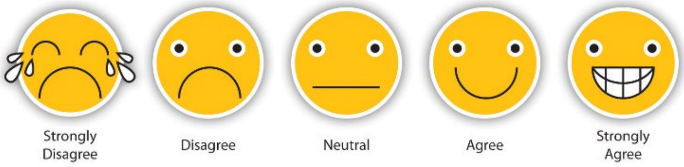
Communication

Circle the answer that best describes your response:

When talking to someone I use a quiet voice?

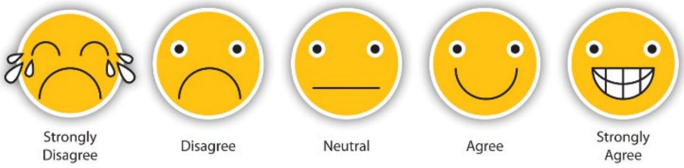


When discussing ideas, I always back up my opinions?

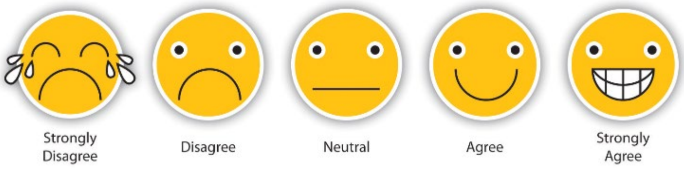


Working with others

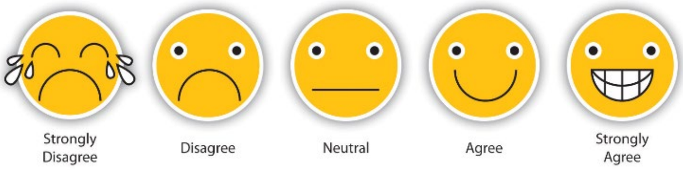
When working in a group I never mess?



When working in a group I always get on well with everyone?



When working in a group I always stay with my group, I don't walk around and talk to other groups?



Skill: Communication & Working with others

Success Criteria:

Communication:

- Make eye contact
- Don't Talk over anyone
- Active listening

Peer feedback

What he/she is doing well:

What he/she needed to improve on next time

Tips on how they could improve on any aspect of the skill:

Self-feedback

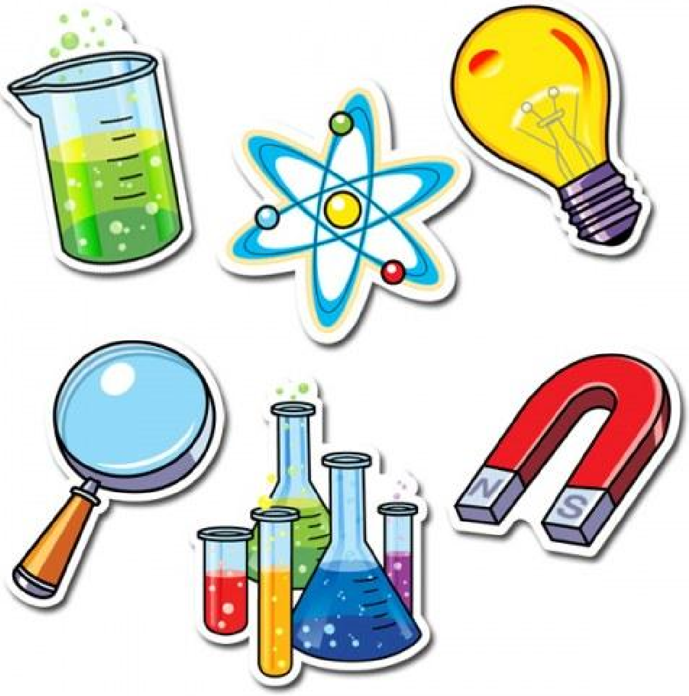
Do you agree with the feedback?

How could you improve for the next time? (Mention what you did well, what you need to improve and how you could improve)

Appendix B Skills passport for 2nd years

Skills passport

2nd yr



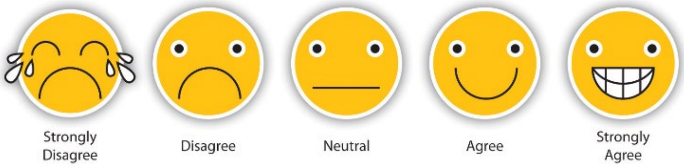
Name: ___________________________

Class : __________________________

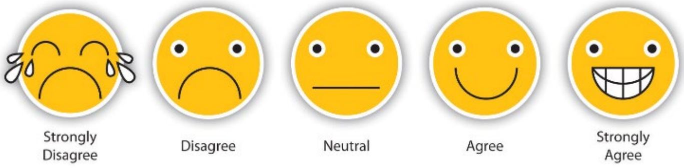
Communication

Circle the answer that best describes your response:

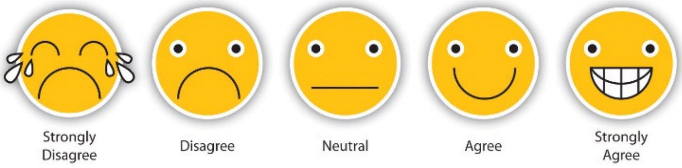
I am always honest and sensitive in your response to a question?



I speak with confidence in group discussions

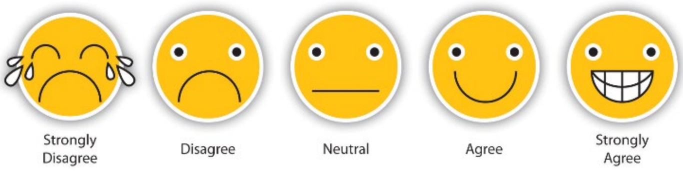


When expressing my opinion, I am clearly and use appropriate language

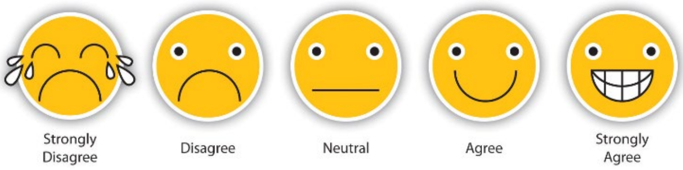


Working with others

I always ensure the atmosphere in the group is supportive and positive



When working in a group I try to take on different role



Skill: Communication & Working with others

<u>Success Criteria:</u>

Communication:

- Respond honestly & sensitively
- Speak with confidence
- Speak clearly & use appropriate language

Working with others:

Create a support & positive atmosphere

Take on different roles

<u>Peer feedback</u>

<u>What he/she is doing well:</u>

<u>What he/she needed to improve on next time</u>

<u>Tips on how they could improve on any aspect of the skill:</u>

<u>Self-feedback</u>

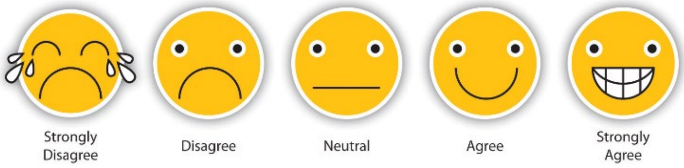
<u>Do you agree with the feedback?</u>

<u>How could you improve for the next time? (Mention what you did well, what you need to improve and how you could improve</u>

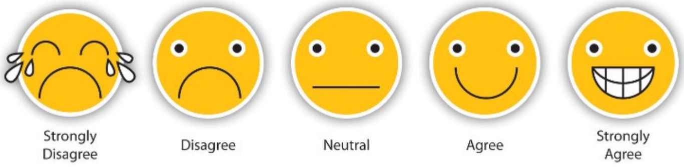
Communication

Circle the answer that best describes your response:

If I don't understand something I always ask questions to clarify what I don't understand

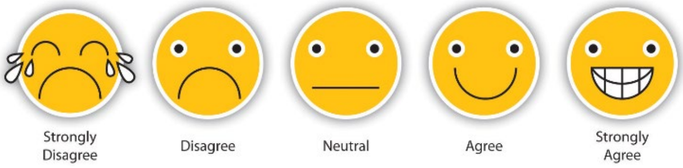


I always respond to opposite arguments constructively

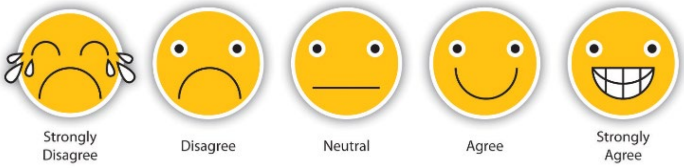


Working with others

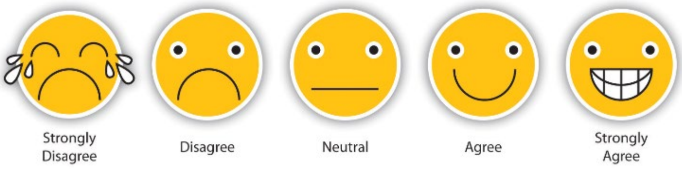
I always help the group to achieve their goals



I always engage in group discussions



If the group encounters a problem, I always Suggest solutions to problem



Skill: Communication & Working with others

Success Criteria:

Communication:

- Ask questions to clarify misunderstandings
- Respond constructively

Peer feedback

What he/she is doing well:

What he/she needed to improve on next time

Tips on how they could improve on any aspect of the skill:

Self-feedback

Do you agree with the feedback?

How could you improve for the next time? (Mention what you did well, what you need to improve and how you could improve)

Appendix C Student interview questions

Student Semi Structured Interviews for EEI/Scifest

<u>Participants</u>

Group 1: Two years of skills development and scientific planning skills programme
Group 2: One years of skills development and scientific planning skills programme
Group 3 : Didn't partake in the skills and scientific planning skills programme

Determine if students have used different approaches to EEI /Scifest investigation and particularly if the groups who have took part in the skills development and scientific planning skills programme have approached it differently in relation to content and what they feel is important.

Think about your experience of carrying on the EEI/Scifest as a whole from the introduction to the research to the report-writing stage. The following questions ask you to talk about your own experiences and how you felt the EEI/Scifest project went for you. This includes the scientific planning skills and key skill you feel you personally developed through carrying out the Assignment.

1. What was your experience of carrying out your EEI/Scifest?
   i. list the top 3 things you learnt? - knowledge or skills or something else.
   ii. What went particularly well for you?
   iii. What was particularly challenging for you?
2. What do think is important when carrying out a scientific investigation
   i. How did you carry out the investigation?
   ii. What were your key findings?
   iii. What did you predict at the start and how were your results different from what you predicted at the start? (Explain)
3. What was your research Q and did you come up with a research question?
4. When carrying out your investigation:
   a. What variables did you consider/measure?
   b. How did you ensure your experiment was a fair test?
   c. What safety issues did you consider and how did you deal with them.
5. How did your group work together?
   a. What was important when you were working together?
   b. Why do you like working in a group?
   c. Was it useful working as a group or would you prefer to do an individual project?
   d. Were there good communication skills used between group members?
6. Did you feel you showed off all of your work well?3
   a. was there anything missing from the poster? Explain
7. If you were to do your EEI/Scifest again what would you change? Would you approach it differently?

Appendix D Teacher interview questions

Teacher questions

The following questions will be asked to teachers as the researcher feels it is important to get an insight into the methods and approaches used by teachers when trying to reach the same outcome. These questions will allow the teacher to describe how they have implemented the new course and will give the researcher an insight into barriers they encountered when trying to implement / assess soft skills and scientific planning skills. These question will also allow the teachers to explain in detail (using examples) how they planned for the EEI and how they integrated soft skills and scientific skills into their classroom planning.

1. In general, what key skills are important to develop in science?
   a. During class time do you integrate key skills development?
   b. Did you and how did you integrate skills development such as communication and working with others? Please provide examples
   c. Did you asses key skills development during class time? Please provide examples
2. What **scientific planning skills** are important to develop in science?
   a. During class time did you use an investigative approach? Please provide examples
   b. Did you asses **scientific planning skills** during class time? Please provide examples
3. Describe for me how you approached the EEI investigation with your class this year under the following aspects?
   a. Learning intentions
   b. Teaching approach
   c. Resources
   d. Timing
   e. Preparation 1st and 2nd year
4. What do you think your students learnt from carrying out the EEI
   a. this may be skills, knowledge or something else?
   b. What do you think your students found particularly rewarding/challenging?
5. As part of the Assignment, do you think your students had the opportunity to developed the following skills: rank 1 to 10 with 1 been most important.

Skills	Rank 1-10
Communication Skills	
Working with others skill	
pose testable questions	
pose testable hypothesis	
Fair testing	
identify safety issues	
identify variables	
consider suitable equipment	
produce and analyse data	
Presenting their findings	

6. Comment on how you prepared students to develop these skills?
7. Did you encounter any problems/barriers with the new JC Science course/EEI this year? Explain/ give examples. What would you do differently next year?

Appendix E Activities phase 1

Details of the activities used in phase 1

Activity 1.1 - Cookie mining inquiry activity

Prior to students carrying out the cookie mining activity, a class discussion occurred about why it's important for scientists to communicate effectively and work as a team and the ramifications if scientists are lacking in these skills. The discussion included how miscommunication can occur and how it can be avoided. Students were then asked in pairs to write down what they thought would help a scientist be successful at communicating or working with others. The answers were compiled by the teacher on the whiteboard and the most frequently recorded answers became the sub skills for the skills of communication and working with others. These sub skills became the focus for the year. The sub skills were displayed on the skills noticeboard in the lab and recorded in the skills passport. The teacher and students discussed and acted out good and bad examples of each sub skill so that students were aware of how to successfully engage with the skill.

The cookie mining was an inquiry activity where students could engage with the success criteria of the key skills. Inquiry science is underpinned by cooperative learning where students work together to investigate a problem. This inquiry activity was novel for the students, hands–on, and didn't require any previous science knowledge. The activity also allowed students to be introduced to the skills of planning an investigation and allowed the teacher to gauge any experience students may have had with planning investigation from primary school. This was important as it was the first-time students were working with peers in groups in a science environment.

Students were put into groups of three and assigned a the following task : Design the best way to remove the chocolate chips from the cookie using equipment in the lab. As a group, students must design an experiment under the following headings: equipment needed method and diagram. Students had 10/15 minutes to plan an investigation, this was done individually and then the three plans combined to make a group plan. Once the students had a group plan written up they had 20 minutes to carry out the task. The students had to remove the chocolate chips and place them in a petri dish. The aim was to have the cleanest chocolate chips (i.e. no cookie attached). Once complete the students presented their petri dishes to the class and they voted which one was the best. They then discussed their different approaches and what was different about the approach of the groups who won.

After the end of the activity students filled out a group reflection sheet as a group, this was a practice run for using the skills passport and its aim was to get students thinking about how they had engaged with the skills of COM and WWO. Students first indicated on a traffic light (red, orange, green) how they felt they used the skills to complete the task. Students noted down what parts of the skills they did well and which skills they struggled. Students then got the opportunity to self-assess (SA1) themselves on each subskill in their skills passport. Each subskill was presented as a statement and students had to rank themselves from 1-5 (1-strongly disagreed with the statement and 5 if they strongly agreed). The teacher had also ranked the students from 1-5 on these skills and both rankings were compared. If any differences occurred between the student and teacher ranking, a discussion took place and each gave an explanation to why they had picked the rankings, they then picked an agreed rating (AA) between them.

Activity 1.2 -Paper Planes

In this activity, students used their knowledge of units, measurement apparatus and calculating area to answer the question: Does the area of the paper used to make a paper airplane affect the distance it can travel? The focus of this activity was to practice the subskills of communication. Activity 1.2 is an inquiry activity and was chosen as it allowed students to work in groups through cooperative learning, answer a scientific question, practice the skills of planning an investigation and engage students of all levels. At the start students were reminded of the skills they would be focusing on and a discussion was had about why they were important and how they could demonstrate them. Students gave good examples of each; this helped the teacher determine if students understood how to successfully engage with the skill. During the activity, the teacher walked around and pointed out to students good and bad practices of the skill of communication, Verbal feedback was also given.

As a group of 3, the students were asked to design their experiment under the following headings: equipment needed method, data and results. Students were given a worksheet which outlined how to build a paper airplane that prevented students from designing their own paper plane and ensured they were only dealing with one variable.

Emphasis was placed on the skills of communication and how it could be used to help students complete the task successfully. Students had about 30 minutes to carry out the task. Students needed to pick an appropriate instrument and unit for measuring the distance travelled. At the end of the activity the students reflected in groups on how they had used the skill of communication to complete the task. They noted on mini whiteboards two examples of how they had successfully used the skill to help them complete the task. These were shared with the class and discussed.

Activity 1.3: What Varies?

The activity 1.3 “What varies” was chosen as it’s an effective activity to introduce a difficult topic ‘Variables’. The lesson and activities break down the concept of variables into manageable chunks which are easy to understand. The cognitive conflict pillar of the activities provided an opportunity for students to really engage with the skills of communication as they needed to work as a group and communicate effectively in order to complete the task. Therefore, this provided an excellent opportunity to both practice the skills but also be used to monitor the development of each student the skills passport.

Students were introduced to the idea of connections between different variables and how changing one variable can impact another. An everyday example was given to concrete their learning and then students got the opportunity to work in groups and work together to determine the variables of other groups of items. Once students could determine the variables, they then had to look for relationships between them. A demonstration was carried out using different weighted bottles and in groups students had to figure out the variables and if there was a relationship between them. Students learnt that sometimes there is no relationship between them. Students then in groups completed a worksheet from CASE. At the end of the activity students within the group gave peer feedback in their skills passports .Before filling the passport in in the teacher explained the importance of feedback and that the peer feedback and self-feedback should mainly focus on what the student is doing well and also include tips for improving. Visual examples of good and bad feedback were shown to students.

Activity 1.4: Fair testing

Activity 1.4 was chosen to follow on from the lesson on variables as it helps students to grasp the idea that during an investigation only the variable you are testing changes and this is what makes it a fair test. Fair tests are an essential concept in science, but it can be a difficult concept to grasp. This activity allows students to experience the idea of fair testing through the use of hands on activity. At the start of the lesson the teacher highlighted the skills of communication that were the focus that day. The teacher gave practical examples of how to achieve the sub skills such as “when someone is talking put down your iPad and look at them” ,“ when you are talking, sit up straight, lift your head, don't be looking at the desk, make eye contact”, “ if you want to add to the conversation, wait until the person has stop talking” , “if you have an opinion that is different than the rest of the group, use the phrase ..’I think because.’”.

The activity is to investigate the effects of variables on the note produced, using tubes of different length (long/medium/short), width (wide/medium/narrow) and material (plastic tubing, acrylic & PVC, straws, copper). . Students were shown how to get a note by blowing across one of the tubes. The teachers demonstrated notes with three different tubes. Students were encouraged to describe the thinking they have already engaged in regarding variables each group got the opportunity to experiment freely with the tubes, starting with the three different ones for a few minutes. They were then asked what are the different variables involved, and what their values are. Elicit material (plastic tubing acrylic & PVC, straws, copper); length (long/ medium/short); and width). Each group picked a pair of tubes which they think is useful to help them solve the problem, what variables such impact the note produced by the pipes The teacher's role was to talk around the class questioning students on the activity (What were you thinking when you chose that pair? Can you compare the note produced by each? Do you think this pair is useful?) While also providing feedback on how they were engaging with the skill of communication. The teacher gave out the worksheets and emphasised that they could try the tubes in pairs, comparing the note produced by each. . The students filled out the worksheet and at the end of the activity swapped passports in order to provide peer feedback. The teacher emphasised again the importance of feedback and that the peer feedback should mainly focus on what the student is doing well and also include tips for improving

Activity 1.5: Classification of living things

Activity 1.5 was chosen to help students develop an understanding of the characteristics of living things. The activity was carried out after the teacher had spent some time on the characteristics of living things and students had taken down notes on the characteristics in their hardbacks. In this activity, students in their groups were given a list of items such as stone, cloud etc. and using what they had learnt in the previous class on the characteristics of living things, they had to classify the list of items as living or non-living and justify their answer. Some of the items were difficult to classify such as the cloud and this created cognitive conflict. This cognitive conflict element resulted in students forming opinions and contributing ideas by communicating in their group through making eye contact, active listening, using a quiet voice and not talking over each other. Students had to work together and communicate effectively and agree on a final answer. When students were working on classifying the items the teacher walked around and provided verbal feedback on how students were engaging with the skill of communication and reminded students of the good and bad examples. A class discussion then occurred to bring all the ideas together. Before the individual skills passport were swapped in the group, the teacher explained how to give good peer feedback and the importance of giving examples of how they could improve for both peer and self-feedback

Activity 1.6: Inquiry: Woodlice

Activity 1.6 was used when teaching about ecology and habitats. Through looking at the preferred conditions woodlice like to live and using choice chambers, students were encouraged to review ideas about their possible combinations, notions of 'fair' test and probabilities. They are led to consider the need for large sample numbers and replication. This is particularly important in biology where variables cannot always be controlled. Living things often behave unpredictably due to factors including free will. A whole class discussion took place facilitated by the teacher. (Where do the woodlice prefer to be? How can we tell? -Where are the woodlice happier, in the dark or in the damp? How can we tell? -From the results of our investigation, can we say for certain that all woodlice like to live in dark and damp environments? -Why do you think there were some woodlice in other sections?). This activity allowed for free play with the experiment setup and design of different choice chambers. This free play allowed the group to communicate effectively and collectively decide on one choice chamber they would investigate. Students got the opportunity to collect their own woodlice and this allowed students to feel involved in the process and resulted in all students engaging with the activity. Students designed their own choice chambers looking at different combinations of preferred living conditions. Once set up students added the woodlice and left for 24hours. After the 24hours they then came to the conclusion based on their results.

Activity 1.7: Scaling pictures

The scaling pictures activity 1.7 was a suitable short activity when teaching cells and the microscope as it helped students apply what they had learnt about magnification in class to everyday life. It was chosen due to its relevance to the topic that was covered and its suitability to allow for the skills of working with others to be introduced, practiced and monitored in the skills passport. At the start of the lesson the subskills of WWO were introduced to students (as they had not been discussed since activity 1.1 as the focus of activity 1.2 to 1.6 was on the skills of COM) and a discussion was had about what the group dynamic would look like if the group didn't use the skills of working with others correctly and what impact it would have? Good and bad examples were discussed.Then the students were put into groups of three and instructed to complete a worksheet that look at scaling items and students had to work out the scale of the pictures using a ruler. Students also had to use their pervious knowledge of working out magnification on the microscope to solve the problems on the worksheet.

Activity 1.8: States of matter

Activity 1.8 helped students understand what happens to the particles as we change states. It also allows students to use the processes of observing, describing, and especially explaining. First the teacher Demonstrate warming stearic acid in a boiling tube to depth of about 3 cm gently until it melts, then heating until it starts to boil. Using the words solid, liquid, melt, boil and condense. Next Students heat ice, or wax, using the correct words when recording. As each group finishes one substance, give them the next one in a test tube (sulphur and lead). Students are warned not to smell the fumes, and not to heat it so strongly that fumes come out of the tube. Once they have completed the exercised with all the substances they must explain what they observed on a worksheet. This activity is a nice visual way of explaining states of matter, students carry out the activity, but the 'explanation' part is the whole point of the exercise. Once they have completed the task in groups, they must come up with an explanation for what they have seen. This creates cognitive conflict and the group most work together to come up with an explanation for their observations. This provides ample opportunity to practice and be monitored on the skills of working with others in particular the skills of contributing ideas and taking turns talking. While students were working on their explanation, the teacher's role is to circle the class, question students on the models they are forming and provide feedback on how they are engaging with the skill. After the activity, read all the 'explanations', and note common or interesting ones which you can use to start the next activity. If there are some good drawings, it is effective to make a display so that students can look at each other's ideas

Activity 1.9: Floating and sinking

For this activity students are presented with little bags of materials (Styrofoam, wood, steel, play dough, thumbtack, pasta shell etc.) And were asked to predict whether they would float or sink in water. Students were asked to construct and record explanations as to why they think Styrofoam will float, steel will sink or vice versa. Students were invited to test their predictions. Students were asked why they think certain things float and others sink and encouraged to make suggestions that can easily be investigated.

Students were shown a collection of bottles (excluding X and Y). Starting with the series that are all the same volume (A-E), students got to help weigh each bottle in turn, and to test it in the water to see whether it floats or sinks. Students were instructed to write the weight of each bottle onto their worksheet. Students also wrote F or S on the picture of each bottle on their Worksheet to show whether it floats or sinks. The teacher asked questions: What conclusion can be drawn? Students should notice that the heavier the bottle, the more likely it is to sink. Next the second set of bottles (1-6) was shown. The bottles were Weighed and tested if they float/sink as before and students filled the information in on their worksheet.

Bottle X was produced. The teacher asked the class questions, which bottle is it the same size as? (Does bottle 4 float or sink? Weigh the bottle and ask which bottle is it the same mass as? Does bottle C float or sink? Students are then asked to make a prediction whether bottle X will float or sink (Questions 1 and 2 on the Worksheet). Take a vote and when all have answered ('don't know' is a respectable answer), demonstrate: it sinks.

Through experimentation, students realise that the combination of these two factors is important (i.e. density). Again, this activity fitted in perfectly with the curriculum and the topic on density. Density is usually a topic students find difficult, but this activity broke the complex idea of density into manageable chunks. Students find this activity fun and again the two pillars (Cognitive conflict and social constructivism) result in students working together to try and figure out the problem collectively and hence using the skills they have learnt.

Appendix F Lesson detail for 1st years phase 2

Details of lessons used with class P1a and P1b (1st year)

Phase 2 – week 1

The focus of the first three lessons was to introduce students to safe practices in the lab, how to use a Bunsen burner (BB) safely, and basic lab equipment and to introduce the skills of COM and WWO. Safety procedures were introduced to students using a PowerPoint and pictures such as where to store your bag, always tie your hair up during lab work, no eating or drinking in the lab, wearing a lab coat and goggles during lab work etc. In groups of 3 students were given a worksheet that has many common hazards, e.g. Students running in the lab, eating in the lab or not wearing lab coats. In small groups, students were asked to identify the hazard and discuss with their groups what they could have done differently**.** This activity introduces students to working in groups and how to be safe in the lab. Students were made familiar with the fire exit route out of the lab, the location of the sharps bucket, the eye wash station and where to wash their hands. Lab rules were discussed and why they are important. The Bunsen burner was introduced, and students watched a video which shows how to use one safely and turn onto a safe flame. How to correctly use it is then demonstrated to the class and the different types of flames and how to identify them was explained. Students drew a labelled diagram of the BB and got a chance to practice lighting the Bunsen burner and putting safety flame on and off. Students were tested on their safe use of the BB, the teacher demonstrated how to safely light the BB, take it off the safety flame, put it back on safety flame and turn off the BB. Then each student got an opportunity to try and once successful got a BB licence which allows them to light their own BB. Students then get an opportunity to use the Bunsen burner by carrying out the flame test in small groups of 3 students and this group activity allowed students to get familiar with working as a group. The science behind the flame test is explained and linked to fireworks at Halloween. Next, Lab equipment is laid out for students to see, where they are stored is shown to students. In groups students are given a selection of lab equipment and get a chance to use the equipment and decide what it is used for and important features (Conical has the long neck to allow for mixing etc.).A class discussion took place about the use of each item. In their hardbacks, students noted down the correct name, function and draw a diagram

At this stage of the week, students have had three opportunities to work in groups. The skills of COM and WWO are now introduced. It is explained why as a scientist these skills are very important. A discussion is had about miscommunication and its implications on a group. In groups students are asked to note down on mini whiteboards what elements of these skills they think are important and why and encouraged to reflect on any benefits they experienced working in groups over the last week. Class discussion is had, and students' answers noted on the board. We then agreed on which elements we would focus on for term 1 and term 2. However, students will be practicing all the skills throughout the year and receiving verbal feedback from the teacher but will be only monitored in their skills passport on certain elements in term 1 and 2.

The elements they will be focusing on where then displayed in the lab.
Good and bad examples of each are acted out by teachers/students so that students could understand the meaning of each skill and its importance.

Phase 2 -Week 2

The focus of this week was on planning investigation using guided inquiry. A task was posed to students "Mr X in the science department doesn't like chocolate chips in his cookies and needs the students' help to design an investigation to have them removed". . Minimal guidance was given by the teacher. This allowed the teacher to evaluate students' level of knowledge of planning skills.

Students used the content they learnt last week (Lab safety/equipment) to plan an investigation and act like scientists. At the start of the lesson, students were introduced to the skills passport. Students were asked to rate themselves (SA1) for each sub skill for the skills of COM and WWO. This acted as a baseline to determine a starting point for each student with the aim for each individual student to close the gap over the year. The teacher/researcher would also rank students on each skill, and both would be compared, a discussion would be had with the student and an agreed starting point (AA) would be determined. Again, the importance of each skill was discussed, and the student's attention drawn to the skills board. The teacher introduced the idea of peer and self-assessment and why it was important and how to provide effective feedback. (Feedback should mainly focus on what the student is doing well and include tips for improving.) Prompts are provided in the passport to support students. How to provide good feedback was also placed on the skills wall as a visual reminder. In groups of three, students planned out how they would complete the task safely in the lab and what equipment they would use, they also wrote up their plans individually. The teacher walked around and facilitated discussions and questioned students on their approach and asked how and why questions. Before carrying out the investigation students combined their plans together. When carrying out the activity Verbal feedback based on observations was given to students on how they engaged with the skills of COMM, WWO and planning and students were reminded of how they could successfully achieve the criteria for that skill. At the end of the class students had to present the chocolate chips and explain to the class how they carried out the task. A winner was picked by the class and a discussion was had about that group's procedure and how other groups could improve on their procedure. At the end students swapped their skills passports with group members and peer assessment and self-assessment took place, again the teacher went through verbal examples of good and bad feedback. Once this was completed, students handed up their individual work and the student's procedure was corrected and assessed using the rubric for planning scientific skills (appendix X) and written feedback on how they could improve was given.

Phase 2 – weeks 3-5

The focus of these 3 weeks was to introduce the topics of living things , cells and cell organelles , the microscope and for students to practice and be monitored on their development of the skills of communication and working with others The content was taught using Chalk/Talk, videos, worksheets and slides as some of the sections were text heavy sections. Group activities on living things and magnification–(See section XY, Activity XY for more detail) allowed students to practice their skills of communication and working with others.

Living things was first introduced. A discussion was carried out in the class about how we know if something is a living thing. All answers were noted on the board. Photo of a baby and a rock was put up on the slide and students had to in groups discuss why one was living and the other wasn't. Answers were then discussed as a class group. Students in small groups carried out the activity classifying living things. Some of the items were difficult to classify such as the cloud and this created cognitive conflict. This cognitive conflict created a space for students to work collaboratively As a result it provided students with an opportunity to use the skills such as contribute ideas, talk turns talking, not talking over anyone etc. Students had to work together, communicate effectively and agree on a final answer. At the end of the activity classifying living things students were given an opportunity to assess each other and self-assess their skills development. The teacher's role was to walk around and facilitate group discussions and challenge students' answers. At the end of this activity students were given an opportunity to assess each other on skills development. Verbal feedback was given by the teacher as she went around each group. From homework students had to pick something that was living and do a project on it, describe the characteristics it had that made it a living thing.

The topic of cells was introduced over the next three lessons. Students first using mini white boards wrote down everything they knew about cells and a class discussion was had. Due to the text heavy nature of the topic the plant and animal cells were taught using pictures, slides with notes, videos showing the different structures and talk and chalk. The microscope was introduced using a story about its history, how it was invented and linking it to a telescope and the telescope in Birr. Students were given an opportunity to use the microscope and afterwards had to note down on a blank diagram what they thought the function of each part was. They then used their iPad to research the function of each part of the microscope

Next working out total magnification was introduced and an activity on magnification was used to concrete students learning on magnification. It provided students the opportunity to put into practice what they had learnt about magnification to everyday scenarios. Students carried out the activity in groups. Students were shown how to prepare a slide which was demonstrated by the teacher and then given an opportunity to prepare one themselves. They were given Onion (Cheek cells. Once all students had successfully prepared the slides they were then asked to identify if it was an animal or plant using their knowledge of cells and using the microscope. Students had to sketch what they could see at each magnification. Class discussion was had about which was a plant cell and which was an animal cell. Students were given prepared slides**)** and using their knowledge of plants and animals' cells had to identify if the slide was animal or plant. Students worked in groups of 3 and using mini whiteboards had to contribute ideas, take turns and actively listen to their partner while also maintaining eye contact. Students had to pick one cell and do a 2-slide presentation on it for homework

Phase 2 - Week 6-8

The topic of the next three weeks was measurement. This content allowed for hands on approach to be used and plenty of group work. This allowed students to practice their skills of communication and working with others. Students had to design investigations, and this allowed them to develop their planning skills of writing a procedure, selecting suitable equipment and forming a hypothesis. The sub-skills of COM and WWO were monitored during the paper planes activity and this activity was also used to assess students in the planning skills of writing a procedure and forming a hypothesis.

First the equipment used to take measurement was first introduced. All measuring equipment (Trundle wheel, metre stick, measuring tape, opisometer, graduated cylinder, mass balance, and thermometer) was displayed and students were given the opportunity in groups to discuss what they knew about each device. This group activity allowed them to practice their subskills of COM and WWO .Students discussed what each piece of equipment was used for and the units were then explained to students. Students were given different scenarios and had to decide which measuring instrument they should use and why. They then had to take measurements. (Example: Group member's height, length of the lab, distance to the staff room, mass of their journal, temperature of the tap water, length of a river on a map etc.). Correct units had to be used. The concept of volume was introduced to student's next using, definitions and talk and chalk. They were assigned a task of designing an experiment to determine the volume of a stone selected from the local beach, and were given the story of Archimedes to help them. Students were asked to focus on writing the procedure and guidelines were given (clear and easy to follow, include suitable equipment and neat) in groups students put their ideas together and as a group put forward a combined plan. As they were carrying out the investigation the teacher walked around to each group and gave feedback on their procedure, hypothesis and skills. Students wrote up their combined plan once feedback was received and carried out the investigation. Once completed the groups got a chance to display their approach to the rest of the class. A class discussion of each approach was had, students got the opportunity to give oral feedback and the best approach voted by students won a prize.

Topic of measurement was continued, specifically examining area. A step by step approach was used and mainly talks and chalk was used to introduce the formula for working out the area. Once students had grasped the equations, hands on activities were used for example: find the area of the basketball court etc.) These hands-on activities allowed students to apply what they had learnt in class to familiar contexts which helped solidify the learning.
The focus moved to taking measurements to calculate area and procedure writing and forming a hypothesis. The teacher started the week off with a question that needed to be researched and investigated "Does the area of the paper used to make a paper airplane

affect the distance it can travel?" A discussion was had about the question and if students considered it a good question and what makes a good question and the idea of forming a hypothesis was introduced. A good hypothesis was explained to students (Must be a statement, justified and the justification must be clear). The idea of variables was also introduced but no terms were used. A discussion was had about the importance of changing just one thing and if we changed two things, we wouldn't know which would impact the distance. Students were reintroduced to the success criteria for writing a procedure. Students were then asked to design the experiment and write a procedure and before testing it gave it to the group beside them to see if they could carry it out based on the group's procedure. Oral peer feedback was given from the groups. An opportunity was given to rewrite the procedure. The activity was carried out and students recorded their procedure, hypothesis and equipment needed. At the end of class this was handed up and assessed using the planning skills rubric and written feedback was given to students about how they could improve .The paper planes activity provided an excellent opportunity for students to start thinking about forming a good question that can be investigated. The familiarity of the activity (making paper planes) also allowed students to be introduced to the idea of forming a hypothesis. At the end of the activity, students swapped skills passports for peer feedback and then self-feedback was recorded in the skills passport.

Phase 2 - Week 9 (2 classes)

The concept of scientific variables was expanded on this week using the phrases 'what did they change', 'what did they measure' and 'what stayed the same'. . As this is a difficult topic a hands-on approach was used to introduce the topic of variables. An adapted activity from the CASE methodology 'what varies' was chosen as it allowed from a difficult and complex topic to be broken down into manageable unit while also encouraging students to engage with the sub-skills of COM and WWO.. The activity was adapted, and more examples of variables and working out the variables were added to help students develop a better understanding of the concept of variables.

At the start of the class the sub- skills which were focused on were discussed and good and bad examples of each were given. Students were also reminded about how to give good peer feedback. The Teacher spent a few minutes explaining the importance of feedback and that the peer feedback should mainly focus on what the student is doing well and include tips for improving. The activity 'What varies' from phase 1 was introduced and The idea of connections between different things in experiments and those things can change. An everyday example was given to concrete their learning and then students got the opportunity to work in groups and work together to determine the variables of other groups of items. This was a visual and tangible activity. Once students could determine the variables, they then had to look for relationships between them. A demo was carried out using different weighted bottles and in groups of 3 students had to figure out the variables and if they had a relationship between them. Students learnt that sometimes there is no relationship between them.
A worksheet was given to students in which they had to identify variables and if there was a relationship between them. At the end of the activity students within the group

swapped passports in order to carry out the peer feedback. Throughout the lesson if the teacher observed any student not demonstrating the skills criteria effectively, it was highlighted by the teacher and verbal feedback given.

Week 10 (2 classes)

A hands-on activity ‘fair test’ was used to teach a difficult concept of variables and forming a hypothesis. Students carried out an activity in groups of three which involved them investigating what affects the note produced by a pipe- length, width or material? The activity ‘The Fair test’ helped introduce an essential concept in science, fair testing and the idea that only one variable you are testing should be changed at a time and embed the learning from the previous week. The terms independent, dependent and control variables were not used but replaced with the phrases ‘what did they change’, ‘what did they measure’ and ‘what stayed the same’.

The skills of COM and WWO they were focusing on for term 2 were recorded on the board and students copied them into their skills passport. As a class they demonstrated good and bad examples of each skill. Before the activity the students were encouraged to describe the thinking they have already engaged in regarding variables. Students were then shown pipes of different length, width and material and asked to find out what affects the notes they produce. In groups of 3/4 students were given a range of pipes and had to examine the pipes and as a group come up with a procedure to investigate the question and come up with a hypothesis. The teacher reminded the students of the success criteria for the procedure, variables and forming a hypothesis. The teacher then walked around the classroom and provided verbal feedback on the student’s procedure and hypothesis. Free experimenting was allowed for a few minutes. The task is to find out which, if any, of these input variables affects the note and design a procedure to investigate the question. Groups asked to pick a pair of tubes which they think is useful to help them solve the problem. While working in groups the teacher asks each group to pick a pair of tubes which they think is useful to help them solve the problem.

- Which pair did you pick?
- What were you thinking when you chose that pair?
- Can you compare the note produced by each?
- Do you think this pair is useful?

The teacher also provided verbal feedback on the skills of communication and working with others as she walked around the groups. Highlighting how the students could improve. At the end of the class students swapped passports and received peer feedback and also self-feedback in their skills passports.

Week 11-13

The main focus of these two weeks was to introduce the topics of habitat, competitions in habitats, food webs, interdependence, adaptation and carry out a habitat study.
A hands on activity ‘Behaviour of woodlice’ was carried out which allowed students to work on the planning skills of writing a question, forming a hypothesis, writing a

procedure, selecting suitable equipment, variables and fair testing and also work on the COM and WWO.

First in groups of 3 students carried out a research project looking at different types of habitats in the local area. The aim was to find out information about which animals leave there, what they eat, how they survive and how they have adapted to their environment. This activity was used to practice their skills with a focus on making eye contact and don’t talk over anyone.
Then students focused on studying a habitat. It was taught using PowerPoint videos and talk and chalk the main emphasis was on the equipment to be used to when conducting a habitat study. The teacher showed students the equipment and how to use it correctly. In groups students then got an opportunity to; practice how to use the equipment needed to conduct a field study such as the pooter, quadrant etc. How to carry out field study was covered with the students and information regarding collecting data and using equipment was also covered.¬-Students got an opportunity to go outside and carry out a field study in the local grassland area this was a hands-on activity and allowed students to practice the theory they had learnt in the classroom.

Next the activity ‘Behaviour of woodlice ‘was used to monitor the sub skills in the skills passport and the assessment of planning skills with a focus on forming a question, hypothesis, planning an investigation and variables. First, in groups of 3, students are given a worksheet and asked to think about where you would find woodlice, their habitat and preferred living conditions. Through looking at the behaviour of woodlice in choice chambers, pupils are encouraged to review ideas about their possible combinations, notions of ‘fair’ test and probabilities. They are led to consider the need for large sample numbers and replication. This is particularly important in biology where variables cannot always be controlled. Living things often behave unpredictably due to factors including free will.
Students are asked to design an experiment to investigate the preferred living conditions of woodlice. . In groups students came up with the question they wanted to investigate. A discussion was also held about the design of the experiment, how to make it fair and what variables to be considered and what combinations of variables they should consider. Students were asked to highlight what they were changing, measuring and controlling. In groups students had the opportunity to trial different experiment setups and design different choice chambers. At the end of the activity student assed each other and themselves on the subskills of COM and WWO in their skills passport

Week 17-22

The circulatory , breathing and respiratory systems were the focus of these weeks with emphasis placed on practicing and monitoring the sub skills of COM , WWO and the scientific planning skills. The circulatory system was introduced first. Discussion was had to determine any previous knowledge on the topic. Real heart was passed around class to stimulate a conversation and interest. Models of the circulatory system were used to teach the theory as well as photos from the body's expo which displayed real specimens. Using models and real photos helped link what the students were learning to everyday life. Circulatory system, blood vessels and the heart theory were taught using PowerPoint, pictures and videos. At the end of the week students brought in their own hearts and showed how to dissect them. After a safety talk student got an opportunity to dissect their own heart and identified the structures that they had been introduced to during the week.

The focus of the next two week was on the digestive system and practicing their COM,WWO and planning skills Again due to the heavy content and vocab of the topics being covered the main approach was talk and chalk, models, questions and answers, PowerPoint with notes and pictures and videos showing the digestive system. Once the content was covered, students were assigned a 'hands on' task and applied what they had learnt. The task was a group activity which provided students with a chance to practice their skills The task involved , a group of 3/4s students making a 5 minute video physically showing digestion using household materials/apparatus from the lab. They had to record all the stages of digestion and then condense into a 5 minute video which would be presented to the class. During the planning stage of the task students were able to practice their skills; verbal feedback was provided to students as the teacher circled the groups. Next the respiratory system was introduced using PowerPoint, videos and photographs. At the end of the week we looked at how all the systems were linked together. In groups students drew the outline of a member in their group, and added in the three systems the circulatory, the respiratory and the digestive system. On this diagram students had to include how the three systems were linked. Students had to research how they were linked add it to the poster and then present to the class.

Diet, excise and other lifestyle choices was the focus of the final two weeks. During these two weeks students got the opportunity to be assessed on their planning skills and COM and WWO skills Students got the opportunity to reflect on how their own diet and exercise could be impacting their body and its effect on their circulatory system, breathing system and digestive system. We then looked at what lifestyle choices can have a negative effect on these systems in relation to exercise and diet and what can have a positive impact on these systems. We looked at case studies of different People and their lifestyles and in groups students had to discuss how this lifestyle choice would impact their body and their systems. Students learnt how to correctly take a pulse. They got an opportunity to measure their own pulse, a group member's pulse and a pulse at resting and after exercise. A discussion was hard about why their pulses would be different after we exercise and what might be causing this. Students then got the opportunity to use blood pressure monitors and stethoscopes. At the end of the week in groups students got an opportunity to plan their own investigation. The task was to design an experiment to investigate if exercise influences our pulse rate. The headings to be used to write the report were mentioned to students but not directly given to the students. Students had to pick their own question, formed a hypothesis, designed a procedure and had to state the variables and how it was a fair test. At the end of the group activity students swapped their skills passport and carried out peer and self-assessments .Individual student reports were given to the teacher and the scientific planning skills were assessed by the teacher.

Appendix G additional activities for first years phase 3

Additional activities used with class K1a (1st year)

Activity 1 :Zip line

The following task was put to students:

Dona bate/Portrayed is getting a zip line!!!!The designers have asked us to design a zip line that transports people to the end in 4 seconds and is safe for riders of different weights.

Some criteria for the zip line:

- Should be able to transport passenger's safety
- Should be able to hold people of different weights
- Should be able to be used multiple times
- Construction and operation should have little impact on the environment

When designing zip lines, engineers must consider speed, the difference in height between starting and ending points, and the safety needs of a rider. Making zip-lining safe is of critical importance. Students were put into groups and reminded of the skills of communication and working with others they should be focusing on. First, the teacher gave students some research questions to discuss and research in the group.

- What can you do to make your zip line go faster?
- Which materials can help your zip line slide quickly?
- What forces are involved in an object moving down a zip line?
- What could we measure?
- Where is the best location in Donabate/Portrane and why?

After researching the question, students had to research the following key words and note them in their hardback *(Acceleration, Force, Gravity, and Mass, Speed, Weight, Slope and friction*). Once that was done students set about designing their zip line in groups. Students had to draw out a labelled diagram including the materials to be used, the height, and angle of descent, length of the zip line and safety issue. While planning the teacher walked around and questioned students on their design and asked probing questions. Verbal feedback was also given on the skills they were practicing. Once designed, one member forms each group and presents their design to the class and feedback is given. Students got the opportunity to improve their design for homework. Students had to bring any material they needed for the next class to create their zip line.

Once the zip line was created, students had to decide which physical observable they were measuring. They had to come up with a research question, hypothesis, variables and a suitable procedure. The success criteria for each of these were recapped by the teacher. Once recapped, students were given a double class to design their investigation, carry it out and write up a lab report. The lab report was assessed using the planning rubric and used as an assessment marker. All the theory behind the observable measurable was put up on Edmodo and discussed in the next lesson.

Activity 2 :Parachute

Similar approach to the zip line activity. Students were given a range of material and asked to design and plan an experiment to investigate the effect of a physical observable on the parachute. Students spent time in groups researching the impact of different forces on the parachute, how to increase or decrease the speed, impact of the weight of a flyer etc. Once they had carried out research the group had to pick one physical observable and carry out an investigation and at the end test their theory. Students had to first write out a plan of how they were going to investigate their chosen physical observable and come up with a hypothesis. They had to decide as a group what material and equipment they would need and draw out a detailed diagram. Once this was complete students then built the parachute and then tested it out. Before students started the teacher went over the skills, they would be focusing on how to give constructive peer feedback, and also the success criteria for the planning skills. The teacher's role after that was just to walk around and observe students engaging with the sills and provide feedback. The teacher was very much hands off for this activity. This activity was chosen as it was relatable and appealing to all levels in the class. It also provides a great opportunity for students to work together and work on their skills. Students gave peer feedback on the skills development in their peer's passports. At the end each group presented their investigation and findings to the class and peer feedback was given and the teacher graded the individual reports.

Appendix H Lesson Detail for 2nd year group phase 3

Weekly Lesson plan detail for Class P2a (2nd year)

Year 2: Week 2-4

The focus of these three weeks was to introduce students to the topic of human health and how it is impacted by our environment. The new set of sub skills for communication and working with others were also decided by students and compiled in the same way as first year to give the sub-skills that would be focused on this year. Similar to first year by the end of week 4 the students got the opportunity to rank themselves on the new sub-skills (SA1) and the teacher also ranked the students and an agreed starting point was decided (AA) between the teacher and students. As this topic is content heavy the teaching pedagogy focused on Self-directed learning and group research. This allowed for a students led and research focused approach that shifted the focus away from the teacher and focused the control back to the student.

Firstly, students were reminded of the skills they had focused on last year. A class discussion was had about the importance of these skills in science and how they were beneficial to scientists and to them in first year. In groups of 3 students were then asked to reflect on the skills they used last year and as a class group discussed what was missing or how the skills in first year could be expanded, what could be included and how they could build on what they had learnt last year. Students noted down their responses on the mini whiteboards individually and then in groups discussed and compiled group responses. Group responses were compiled into a list of ideas on the board by a nominated student under the headings of communication and working with others. As a class student had to decide what they would focus on this year. Some of the skills from last year were mentioned such as 'make eye contact' and 'active listening' to build on these skills the teacher add skill C10 which was 'Respond constructively' which integrated these skills from last year and similar response were grouped together and given an overall sub skill such as WWO6 'Create a supportive and positive atmosphere'. A discussion was had about what it would look like to successfully achieve these skills or unsuccessful achieve them, examples were given. The skills were put on the skills notice board and students also reminded them about how to give feedback and the prompts used last year were put back up on the skills board.

This week's topic was researched focused and self-directed learning was the approached used. Students were put into groups of three. Students were asked to spend this week carrying out a research project on the impacts of diet, smoking and exercise on human health. Students were given headings for which they had to carry out research (Impact of the environment and inherited factors, Health statistics, what we can do to help etc.). Students had two and a half classes to complete this task and present their findings using PowerPoint or video and give a 3-minute group presentation. Before the students started the research they were reminded of the skills they were focusing on. A discussion was had about how they could incorporate these skills into their group work. The group had to give everyone a role and decided what the role involved. The teacher role was to facilitate discussion within the group and provide feedback to students on both their project and their skills. This activity provided ample opportunity for students to practice their skills of communication and working with others. As the activity was student led, this allowed the teacher time to provide oral feedback on how they were engaging with the skills.

Next the theory behind bacteria, fungus and virus was introduced using PowerPoint and videos. Students were shown videos that focused on both positive and negative sides to bacteria and viruses. Everyday examples were given to students such as bacteria used to produce food, decomposer, and virus used for research etc. . . . During the double class, similar to the previous week students engage in research projects which focus on the benefits of bacteria, viruses and fungi. Students worked in groups and again students were assigned different roles (Time keeper, scribe, researcher, presenter etc.), students presented their projected on PowerPoint and at the end of the activity gave a 2 minute presentation to the class. While students were working on the projects the teacher walked around the class room and questioned students on their skills (How are you creating a supportive atmosphere? How could you respond sensitively if you didn't agree with someone's idea ?etc.).

Finally, the debating topic was put up on a PowerPoint "Vaccines beneficial or harmful". The aim was to research both side of the argument and come up with 3 points for each side. This was done in groups of 3. Again the students had to focus on their skills, assign roles within the group, ensure the atmosphere was supportive, and speak clearly and with confidence to the group members. The teacher walked around the groups and again gave feedback to students on their engagement with the skills. As a class, pick a side and compile all the information they had gathered and nominate 7 people to debate against another class. After the debate and after observing students engaging with the skills and providing verbal feedback the teacher ranked the students on each subskill. The students were also asked to rank themselves on the skills in their passport (SA1).The teacher compared their ranking to the ranking the students gave themselves and an agreed ranking (AA) was decided. This would be the starting point for the student .Students then got an opportunity to give peer/self-feedback in the skills passport. The teacher went over how to give good feedback; she explained it should highlight what they are doing well, what they need to improve on and how they can improve

Year 2 : Week 5-9

The focus of the next few weeks was to introduce students to the atom and bonding. The approach was mainly group research led and an inquiry activity was used at the end to allow students to put into practice the new content they had been introduced to.

Students were first introduced to the basic theory of atoms. At the start of this topic, new vocab and definitions were introduced (Atom, electrons, proton, neutrons, atomic mass, atomic number and the periodic table). As this is text heavy the best approach was via PowerPoint and talk and chalk. To help students develop a better understanding of this new content, videos and animations were shown. Students were taught how to draw Bohr diagrams and how to determine the number of protons, neutrons and electrons using atomic and mass numbers. Students then got the opportunity to draw their own Bohr diagrams and the week was finished off with Bohr diagram/definitions Kahoot.

Next students' skills of COM and WWO were monitored. They had to carry out a group research into the history of the atom and the periodic table. In groups Students had to design a PowerPoint presentation on what they had learnt. The teacher didn't give any headings and it was up to the groups to pick the direction of the presentation. Before the research started students were reminded on the skills they would be focusing on. A discussion was had about how to create a supportive environment in a group, what this would look like and the importance of including all. Students were reminded of our school's wellbeing policy and why this was important. (This was also taught to students in SPHE as the school's wellbeing anchor I was able to liaise with SPHE teachers to ensure this was focused on during SPHE in more detail). Good and bad examples of each were given and a video was shown that spoke about how to be a confident speaker. Verbal feedback was also given by the teacher which highlighted what the students were doing well, how they could improve and tips on how to improve Students were also asked to assign roles to group members and decide what the role involved. As students were carrying out the task the teacher walked around and gave verbal feedback on how they were engaging with the skills and ways to improve. Once the activity was finished students assessed each other using the skills passport in the group and provided feedback and students also got the opportunity to provide self-feedback.

Next bonding was then introduced using online animations and Bohr diagrams on the board. The terms ionic and covalent were introduced and examples of each were drawn on the board. The properties of each type of bonding were discussed. The students then got the opportunity to practice a few examples using the mini whiteboards and then copied into their copies once corrected by the teacher. In pairs students used play dough to make bonding diagrams in class. The students made a video which was edited, and they voiced over. This was a visual representation of bonding and used for revision. Again, students were reminded of the skills they were focusing on and verbal feedback was provided by the teacher as she was walking around.

Students then got an opportunity to pick their "favourite” atom and carry out a research project. Students had to do 3 slides on the atom under the following headings (Number of electrons, protons & neutrons, who discovered it, when, how, modern day uses, Bohr drawing).Students also had to bring in range of household items and use them to build a 3D build a model of their chosen atom using household products .Students had to present these to the class. Before the presentation 10 minutes was spent on how to talk with confidence and videos were shown to students that contained good and bad examples. Students picked a famous person who they thought was confident and then we discussed why this person came across as a confident speaker. Attributes such as, spoke slowly and calmly, made eye contact , was humorous , changed the tone of their voice , stood tall and used their hands were mentioned by the students. After the students presented verbal feedback was given by the teacher based on these attributes.

Students put theory to practice during the last two weeks and applied what they had learnt about bonding and applied to an investigation on covalent and ionic bonding and their properties. This investigation would allow both the skills of COM, WWO and planning skills to be monitored. A problem was put to the students which they had to solve using their knowledge of the properties of ionic and covalent bonding and atoms. In your garden you have two fish ponds both contain fish. Your little brother accidently adds salt (Ionic) to one pond and sugar (Covalent) to the other. That night there is thunder and lighting. What would happen if the lighting hit both ponds? Would the fish survive? This class was used to remind students of the skills of planning and what was expected (Question, hypothesis, procedure and variables). Good examples from last year's student work were shown to current students. It was then explained how we would need to expand on each section. Starting with forming a question students were reminded of what was needed and the success criteria of forming a question had to specific not general, had to lead to action and must be quantifiable. Using a PowerPoint, examples from last year were put up that meet last year's criteria and we had a class discussion about how we could change the question to make it more specific, lead to an action and would result in quantifiable results. A class discussion was had about how to achieve all the criteria, the same was done for forming a hypothesis (New criteria - justification must be valid), procedure (New criteria- more detail, include measure bale amounts), Variables (Using scientific language to describe what you change (IV) what you measure (DV) and what stays the same (CV). Students had to come up with their own research question, develop a hypothesis, and record the procedure and variables using the new success criteria which students were reminded of. A worksheet was given out to students with these headings to highlight to students what was expected. Students then had to Design an experiment to investigate if the ionic (Salt) or covalent (Sugar) substances have the ability to conduct the electricity from the lightning. This was done in groups of three and each group received oral feedback from the teacher on their approach before they started. Students handed up an individual write up for assessment. Students carried out the investigation and got the opportunity assess each other on their skills of COM and WWO. Before students started planning the investigation they were reminded of the skills they were focusing on and again good and bad examples of each given. The teacher walked around the classroom as the planning was taking place and verbal feedback was given when needed. At the end of the class students got the opportunity to self and peer assesses each other. They also handed up an individual plan to be used for the assessment of planning skills.

Year 2: Week 11-13 /18-19

First density is introduced using the story of Archimedes'. Students are given a printy out of the story which they read and discussed how it could be used to determine the density of an object. Questions were put up on the board and in groups students had to discuss. Using Archimedes' principle of water displacement can we determine the density of these cubes? And if we can, which cube do you think will have the largest density? In groups and using mini whiteboards students develop predictions regarding the density of the cubes. Which ones will have a larger density and displace the water more? Students then rank the cubes. A question was posed to the student's which cube has the greatest density? Students must then develop a hypothesis. Emphasis was placed on writing a hypothesis that has a clear and valid justification as students had struggled with the element of a clear justification in 1st year. Oral feedback was given by the teacher on each student's hypothesis and how it could be improved. In pairs students then carried out an investigation to determine the volume and mass of the cubes. Students had to write a testable question, procedure and identify any variables. As the investigation was being carried out the teacher walked around and gave feedback. Students noted down the figures for each cube. Once a figure for mass and volume of each cube was obtained the formula for density was introduced, the technique to calculate density was explaining. Students then calculated the density of the different cubes and other examples were given to allow students to practice. Students completed their investigation write up and received both oral and written feedback from the teacher highlighting how they can improve and what they did well.

Next the concept of speed was introduced to the students. First students were asked to form a mind map with the word speed in the middle. This allowed the teacher to judge a student's previous knowledge of the topic. Students are then asked to make measurements to find out: How long does it take you to walk 5 metres, walking slowly, and then walking quickly? How far can you walk in 5 seconds, walking slowly, and then walking quickly? In groups students develop a plan for investigating these questions. Students were reminded of the skills of communication and working with others and asked to use them to complete the task. The focus of this investigation was on writing a procedure and variables. Students were asked to explain the terms independent, dependant and control variable and how it applied to this investigation. Once students had written down their variables a class discussion was had about control variables as these were the ones students struggled with in first year. Students shared their control variables with the class and the teacher noted them on the board. We then checked if all control variables were covered. Students then swapped procedures with other groups who gave constructive feedback and suggested any improvements' teacher walked around and gave feedback on both the planning skills and communication and working with others skills. Skills focused on were asking peers questions to clarify misunderstandings, respond constructively, help others achieve their goal, engage in group discussion and suggest solutions to problems. Students then carried out their plan and obtained results. Once they had obtained results, they are asked to interpret them: How can the time and the distance measurements are related to one another? What can you work out from the measurements? Using google maps students are asked to make a measurement of the length of their journey from home to school .Using their results from the previous activity students then can work out, how long does your journey take? What can you calculate from these measurements? Students are then asked to consider how changing mode of transport for the journey from home to school would affect their answers: "If you get to school in a car or in a bus, how long would it have taken you to walk..." at a comfortable speed, and at your fastest speed A similar question can be asked for those who come by bicycle, whilst those who walk can be asked to estimate how long it might take by car. Students are then asked to represent the journey on a graph of speed vs time.

The focus of the next was on the planning skills and how to achieve them successfully. Exemplars of past students work was shown to students. As a class they look at each planning element in the exemplars. Starting with writing a question, the class discussed if the question was clear and understandable, doable, and cause/effect, specific vs general, lead to action and quantifiable. They were then shown examples of poor questions an again asked to apply the success criteria. As a class a discussion was had about how the poor question could be turned into an exemplar question. This was done for all the planning elements, forming a hypothesis, writing a procedure and variables. This was a very valuable exercise as it allowed students to see the difference between a good and bad planning report.

The skills of communication and working with others students would be focusing on for term 2 were recorded on the board and students copied them into their skills passport.. A discussion was had about how these could be integrated in to group work, the benefits they would bring and how would you know if a group was not using these skills correctly, A reminder of the importance of these skills in working in groups was also given by the teacher and students discussed as a class how these skills have already benefited their group work. This week students applied what they had learnt on previous weeks to a fictional problem. (The lesson sequence was the same as phase 3 week 21-27 for 1st years noted in chapter 5.)Students were asked to design a zip line ride that would transport 4 riders from one end of the village to another. Students first had to research how it works and how it stops safely, taken into consideration the impact of weight, speed and friction. Students had to then design an investigation to determine the impact of a number of Physical Observables and design an experiment for each one. Students had to pick their own question, hypothesis, identify variables, do a procedure and graph result. This was a very hands-on activity and students had to first make their zip line. It was a complicated task which allowed for some great discussions and disagreements and provided students with the opportunity to focus on the following skill ‘Help the group to achieve their goal’, ‘engage in group discussions’, ‘Suggest solution to problems’, and ‘ask questions to clarify misunderstanding’ and ‘respond constructively’. In order to complete the task students really had to engage in group discussions and all contribute ideas and come up with solutions. At the end of the task students were assessed in their skills passport. Very little guidance was given to students during the planning stages. The teacher’s role was to walk around and provide feedback to students on both the planning skills and the COM and WWO skills. At the end, students handed up their plans to be corrected and feedback was given on each of the planning skills.

Year 2:Week 20-21 (No input)

The topic of force and Hooke’s law done using a combination of notes and PowerPoint. Once students had done the calculation for force and the definitions, they carried out the experiment to investigate Hooke’s law. Students followed the procedure form their books and recorded and graphed their results. There was no input from the researcher during these weeks.

Year 2:Week 24-27

These three week focused on sustainability and the environment. The approach used for this topic was very students centred. The emphasis was put back on the student by encouraging them to do group research and present findings to their peers and green school committee. The group work allowed students to practice their skills of communication and working with others, while the hands-on activity designing an investigation to make their own paper allowed them to work on their scientific planning skills. Huge links were made to their everyday life and this sparked students’ interest and kept them engaged when carrying out their own research.

Students are shown a variety of stimulus’ (pictures, words, and phrases in a fast PowerPoint flash cards format) that relate to our problem of increased energy consumption. Using mini whiteboards students wrote down words and phrases that come to mind when they see the pictures (pollution, smog in china, deforestation etc.). The term sustainability is introduced, and students brainstorm the meaning and why it is important.

A class discussion is had about human factors that impact the earth's climate and a mind map is created. In groups students must pick an initiative introduced in Ireland that was introduced to address those effects and they must make a PowerPoint presentation and present to the class (Examples: Bike scheme, electric cars, increase in carbon tax, and ban on straws). Before students began working on the project 10 minutes was spent on the skills of communication and what successful completion of the skill looks like. Students were reminded to all contribute to completing the goal, to engage in group discussions and suggest solutions to any problems. Students were also encouraged to write down any questions during their peers' presentation if they needed clarity on anything and to ask at the end. When the group work was carried out the teacher walked around and gave feedback when needed. Once the presentations were completed groups were paired up and asked to give constructive feedback.

Next Fossil fuels are introduced using a video to explain how they are formed. Using PowerPoint the terms renewable and non-renewable are introduced using chalk and talk and pictures. Students are split into groups of 3 max and research a form of energy/product production e.g. wind, solar, coal, nuclear. Students investigate the positives and negatives of their given energy/production source and record their information on the mini whiteboards. While working in groups students are asked to work on their skills of communication and working with others and to provide oral feedback to students at the end of the class, the oral feedback must include what they did well and what they can improve on and how. Each group presents their findings to the class. Students design posters for the green schools committee to help promote ways to reduce global warming.

In groups students must research and present initiatives which the school can implement to reduce climate change in our school. They must pitch their ideas to the school's green school committee. Ideas such as eliminating single use plastics and promoting reusable bottles, having one class a week where no electricity is used, walk to school Wednesdays etc. Again this activity allowed for the students to working on their skills and also receives oral feedback from group member son how they are engaging with the skills. Students then learnt about the 3Rs of recycling. Using a PowerPoint presentation, the teacher demonstrated a basic journey map to the students of an everyday item e.g. bottle, food packet. The presentation showed how a product begins, where it goes in its lifecycle and where it ends. In groups students were asked to pick a product from their lunch box and asked to consider whether their product is environmentally friendly and what materials are required to make it. Students mapped out the journey of the product. Students were then asked to design an Investigation to see if paper could be made in the lab using recycled materials. In groups students had to think of a question, hypothesis, variables and also design and evaluate their approach. At the end of the investigation they handed up their report to be assessed by the teacher and also peer and self-assessment took place in the skills passport

EEI

The extended experimental Investigation is a classroom-Based Assessment it is completed at the end of 2nd year and over a three week period students, formulate a scientific hypothesis, plan and conduct an experimental investigation to test their hypothesis, generate and analyse primary data, and reflect on the process, with support/guidance from the teacher. It is encouraged, but not required, that students collaborate with classmates. For the purpose of this research the students EEI will be used as a point of reference for their development of the scientific planning skills. Students will also be interviewed on their EEI project and how they worked with group members and communicated within their group.