Is fearr DEIS chun chainnte: An initiative to support teaching for robust understanding in post-primary mathematics classrooms.

Emma Owens, Diarmaid Hyland & Aoibhinn Ni Shuilleabhain

University College Dublin

This paper outlines a research project which aims to support the pedagogical practices of Mathematics teachers in socioeconomically underprivileged post-primary schools. In Ireland, the socioeconomic background of a student continues to determine how likely they are to experience high-quality post-primary education and make the transition to further or higher education. This is particularly relevant in mathematics, which remains a gateway subject in accessing third-level education. This research aims to address such inequity by supporting teachers to incorporate student-centred practices in their mathematics pedagogy. The project is undertaken in two phases: First, case studies of high-quality mathematics teaching and learning will be conducted in four schools. The findings from the case studies will inform the design of an intervention, which will involve 10 pilot schools across Ireland in the 2023-24 academic year. The research team (and research Mathematicians) will collaborate with the schools and support the teachers to reflect on and reform their teaching by engaging in school-based Lesson Study. This paper provides an outline of the project and initial findings which will contribute to research on the teaching and learning of mathematics in Ireland.

Introduction

The socioeconomic status (SES) of young people impacts their educational achievement and is a predictor of their achievement in mathematics (OECD, 2016). A young person's mathematical achievement is, in turn, a predictor of earnings and employability (Rose & Betts, 2004) and so a cycle of inequality continues. While there has been a marked increase in the numbers completing and continuing on from post-primary education in Ireland recently, this has not impacted students equally. A student's SES continues to shape how likely they are to experience high-quality post-primary education and make the transition to further or higher education (Byrne & McCoy, 2017). This is particularly evident in the case of mathematics, which has become a gateway subject in accessing third-level education (McCoy et al., 2019), further impacting the diversity of those who enter the Science, Technology, Engineering, and Mathematics (STEM) fields and STEM teaching, again perpetuating the cycle of educational disadvantage. In this paper, we provide an outline of a two-year study intended to positively impact the teaching and learning of mathematics in schools designated as socioeconomically disadvantaged and, thereby, attempt to address some of the inequities of achievement and experience for learners in post-primary schools.

Mathematics in the Irish post-primary classroom

Mathematics classrooms in Ireland have tended to follow a traditional, exposition approach, where a teacher demonstrates a method and students repeat that same method for a number of exercises (Byrne & Prendergast, 2020). While there is merit in mastering mathematical procedures, teaching mathematics exclusively in this way restricts students' development of conceptual understanding (Rittle-Johnson et al., 2001). Furthermore,

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experiencing mathematics in this way communicates the subject as a rigid, predictable subject that, often, students do not enjoy (Marchis, 2011). Learning mathematics in a classroom which emphasises one 'correct' procedure and which focuses on achieving the 'right' answer (as opposed to discussing how an answer was achieved) is also an issue that exacerbates the mathematical anxiety of students, particularly young women (Maloney et al., 2013). Such experiences are often lamented by mathematicians, who feel that students miss out on engaging and interesting mathematical insights that could benefit their understanding of the world around them, including the numeracy skills necessary for today's society. These 'traditional' experiences contrast with reform-oriented teaching, where students are encouraged to communicate their mathematical thinking as problem solvers and where the teacher acts as a deliberate and careful facilitator of students' learning (Takahashi, 2021). The most recent mathematics post-primary curriculum reform in Ireland has attempted to encourage the incorporation of such classroom practices, but research suggests that little change has occurred in how students experience the subject (Byrne & Prendergast, 2020). Such findings are particularly relevant in schools which are designated as socioeconomically disadvantaged, where students are more likely than their counterparts in other schools to experience mathematics in a procedural way, which emphasises rote-learning at the expense of understanding (Perkins & Shiel, 2016).

International studies have demonstrated that students with lower SES tend to experience lower self-efficacy and higher mathematical anxiety than their less-disadvantaged counterparts (OECD, 2016). In an attempt to prevent social and economic disadvantage from depriving students' access to and achievement in education, the Irish government launched the Delivering Equality of Opportunity in our Schools (DEIS) programme in 2005. The programme allocates additional resources to schools that cater for students with low SES. Research suggests, however, that not only are these resources inadequate, but that elements of the funding process perpetuates educational disadvantage (Fleming & Harford, 2021). Students in DEIS schools continue to, on average, have lower quality and less engaging classroom experiences and, in tandem, experience less success in high-stakes and other assessments (Perkins & Shiel, 2016). These students also possess higher anxiety, lower self-efficacy and self-concept in their mathematics learning (Perkins & Shiel, 2016). This has a detrimental effect on these young people's educational potential and Smyth et al., (2015) found that students in DEIS schools are 40% less likely than students in non-DEIS schools to study Mathematics at a higher level during Junior Cycle. With regards to the incentivisation scheme of 25 additional 'bonus points' given to all students who pass Mathematics at higher level in the final post-primary high stakes Leaving Certificate exam, this has resulted in further educational inequity between students in DEIS and non-DEIS schools (McCoy et al., 2019). This is particularly relevant when not all DEIS schools offer higher-level Mathematics and when students can be discouraged from considering such an option, even when expressing an interest in pursuing the subject at higher level (Ni Shuilleabhain et al., 2020).

Addressing Socioeconomic Inequity in Mathematics in Ireland

Dietrichson et al., (2017) suggest that targeted interventions have the potential to improve the educational achievement of students from low socioeconomic backgrounds. Their systematic review of the literature demonstrated that tutoring, feedback and progress monitoring, and cooperative learning have large and robust average affect sizes on student achievement. We consider two such examples in the Irish context.

Firstly, Project SUMS is an initiative which seeks to increase students' potential to positive academic achievements through the provision of extra supports and guidance to students. These services are provided free of charge and are designed to develop a positive attitude towards maths learning in students by instilling confidence in students' abilities. Project SUMS involves a multitude of resources based on students' preferred approaches and incorporates a combination of group and individual work. Secondly, the Maths Sparks engagement programme aimed to support post-primary students from DEIS schools with weekly out-of-school, extra-curricular workshops that were designed and delivered by undergraduate mathematics students. The activities consisted of a mixture of mathematical games, problems, and puzzles with the aim of providing students with the experience of non-traditional exercises. A focus of workshops was to develop mathematical thinking and an appreciation for not being able to immediately find a solution. The programme was designed with the aim of encouraging participating senior post-primary pupils from DEIS schools to continue their studies of mathematics at a higher level and to consider pursuing mathematics or STEM-based courses in higher education. Participating in the programme was found to positively impact students' attitudes towards, enjoyment of, and self-confidence in mathematics, and encouraged students to consider continuing in their Mathematics and STEM education (Ni Shuilleabhain et al., 2020).

While student-based interventions have the potential to improve students' mathematical achievement, Dietrichson et al., (2017) also suggest that interventions focusing on strengthening teachers' knowledge and practices are impactful. Indeed, Gersten et al. (2009) found that providing teachers with an opportunity to reflect on and receive feedback on their teaching had significant effects on mathematics outcomes. The current study builds on this work and that of Lewis et al. (2022) by focusing on school-wide interventions to impact student achievement successfully and positively.

Potential Challenges and Solutions in Educational Reform

The difficulty in addressing and scaling up educational improvements is one of the greatest challenges in research around teaching and learning (Fullan, 2001). Initiating top-down reforms, often through in-service forms of professional development, can fail to capture the buy-in of teachers, thereby losing necessary knowledge, leadership, and motivation to cultivate change (Ni Shuilleabhain & Seery, 2019). Lesson study, an approach to teacher professional development which originated in Japan, offers one potential way to combine pedagogical research with teachers' expertise and builds the theory-practice divide so often noted in reviews of traditional, expository ways of teaching and learning (Lewis & Perry,

2017). Research from Lewis et al., (2022) based in historically underserved populations, including students from low-income families, suggests that Lesson Study can be embedded in schools as a sustained and effective form of teacher learning.

Teachers, their knowledge, skills, and interests, are core to Lesson Study, which provides groups of teachers with opportunity to research their own practice with a view to improving student learning (Lewis & Perry, 2017). Lesson Study consists of a cycle of four phases in which a group of teachers engage in careful discussions around planning, conducting and reflecting on a research lesson. Discussions within the cycle specifically focus on student learning, with reference to specific tasks, actions, and communication which may arise within the lesson (Takahashi & McDougal, 2016). Teacher knowledge is a key factor in influencing students' mathematical achievement (Baumert et al., 2010) and Lesson Study has been demonstrated as a way of improving teachers' content and pedagogical content knowledge (Lewis & Perry, 2017). Furthermore, research has also demonstrated that teachers' participation in Lesson Study can lead to improvements in students' mathematical knowledge (Lewis & Perry, 2017). Most importantly for this project, Lesson Study provides teachers with a vehicle within which they can trial new classroom practices with the support of their colleagues (Ni Shuilleabhain & Seery, 2019). As an additional gain, Lesson Study has been demonstrated to develop teacher community beyond their participation in the model (Lewanowski-Breen et al., 2020), a key feature of educational reform.

In introducing professional development to a school, it is important to explicitly acknowledge the situated context of the learning (Lave 1988). This has been highlighted in various success and failure stories of Lesson Study (Bjuland & Mosvold, 2015). In this project, we look to learn from Mathematics teachers in DEIS schools who might act as positive examples of teaching and learning and from which we might learn and share findings specifically relevant to DEIS schools. The design of the research is therefore outlined below.

Research Design

The overarching aim of the project is to support the pedagogical practices of Mathematics teachers in post-primary DEIS schools. To achieve this, a two-stage project was devised which would investigate best practice in post-primary mathematics education through comprehensive case studies in four DEIS schools. The outcomes of this will inform the design of an intervention, which is intended to support an additional cohort of 10 DEIS schools across a school year to improve their practice in a sustainable way. This structure allows for many of the traits of successful mathematics initiatives mentioned in the previous section to be incorporated. It also allows for clear and concise research questions which align with the research aim to be posed. The research questions (RQs) are as follows:

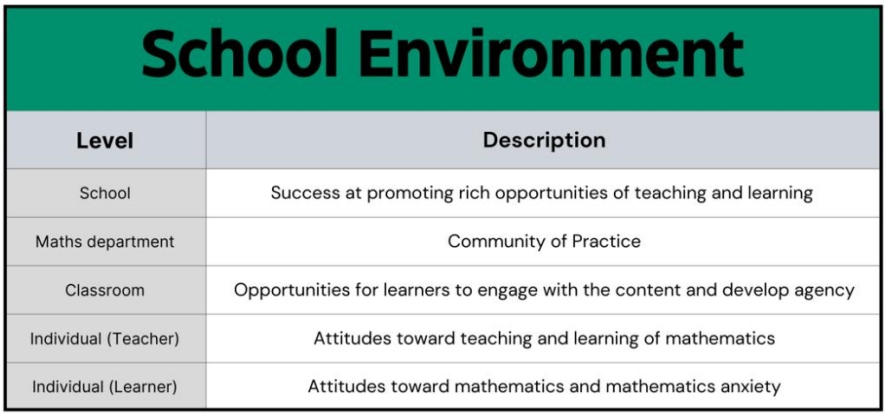
1. How are positive mathematical learning experiences cultivated and supported in post-primary DEIS schools?
2. How effectively can Mathematicians inform the teaching and learning of post-primary mathematics through Lesson Study?
3. How are the mathematical knowledge and attitudes of teachers and students impacted by participation in school-based Lesson Study?

4. How can Lesson Study be sustainably incorporated in post-primary DEIS schools?

As written, RQ1 aligns with the initial phase of the project, and RQ2-4 relate to the second phase. For the purposes of this paper, we will focus on RQ1 by detailing the recruitment and collaboration with the four case study schools. In attempting to investigate the mathematics classrooms and cultures which exist in our case study schools, a multi-layered description of the post-primary school environment was developed (see Fig. 1).

Figure 1

Description of the school environment



The importance of multiple stakeholder groups, and their interrelations, are a significant feature of the description, which translated directly to the participants that were recruited and the methods of data collection utilised. Data was gathered pertaining to each of these aspects through a combination of classroom observations (video, audio, and written field notes), student focus groups and surveys, teacher interviews, and interviews with school leadership. When the instruments and protocols were developed, ethical approval from UCD was sought and obtained, and a call for participants began.

Case Study Schools

The project was advertised to post-primary DEIS schools through email lists, attendance at teacher events, collaboration with relevant professional bodies, and via a targeted social media campaign. This resulted in seven expressions of interest which were shortlisted after satisfying various thresholds for participation (minimum of three teachers and one member of management were required to participate). The case study schools (detailed in Table 1 in a non-identifiable manner), were then selected from the shortlist based on the contents of the application and with an effort to attain a diversity of representation across school sector, enrolment (sex and number of students), and location. The case studies were conducted between January and March 2023, with each site visit lasting one week.

Table 1

Case study schools and data collection

	Enrolment		Location	Observations	Surveys	Focus Groups	Interviews
	Gender	Number					
1	Co-Ed	200-250	East Coast	3	53	3	4
2	Girls	800-1000	Dublin	8	136	7	9
3	Co-Ed	800-1000	Midlands	3	51	3	4
4	Co-Ed	600-700	Midwest	3	39	3	4

Data Analysis

A large quantity of qualitative and quantitative data was gathered during each site visit (see Table 1), and multiple independent paths of analysis are currently underway to inform the understanding of school and classroom practices, mathematical anxiety, and the opinions of students, teachers, and school leadership across all four schools. The data in Table 1 amounts to 14 hours of classroom observations, three hours of focus groups, and 10 hours of interviews. Given the range of data sources and subject matters, a multitude of theoretical frameworks will be leveraged across the various sources as appropriate to the data source. Though the analysis is only beginning, we include some initial takeaways in the final section.

Phase 2 Outline

The case studies inform the intervention, which will involve collaboration with 10 post-primary DEIS schools. In addition to the learnings from Phase 1, a significant component of the intervention will be introducing the schools to Lesson Study which they will practice across the academic year. A key aspect in the planned use of Lesson Study will be the inclusion of research Mathematicians as the 'knowledgeable other' to provide support for the teachers in the area of Mathematical Content Knowledge (MCK). MCK has been found to hinder the development of mathematically rich lessons (Lewis & Perry, 2017), and the preliminary analysis suggests it may be an issue in this study.

The pilot schools will participate in interviews and student surveying in a similar manner to the case study schools so that comparable data can be gathered across both phases of the project. This data will be gathered across the entirety of Phase 2, and will inform RQ2-4 which, in turn, will describe the success of the intervention.

Initial Findings and Discussion

Though much of the formal analysis is still underway, some of the data has yielded preliminary findings and potential lines of enquiry, which we include below.

- Mathematics anxiety is prevalent in post-primary schools to varying degrees. Sources and mitigators are being identified and targeted by schools with reasonable levels of success, but much more remains to be done. Of note was the success that schools are having with co-curricular activities and targeting the disposition of parents.
- Myriad external factors seem to adversely impact pedagogical approach. Time pressures are used to justify streaming (and even banding) after first year. Schools with 1-hour lessons seemed to reference time pressure less, though this is subject to further exploration.

- There is a variance of board use and technology being utilised in classrooms. There was very little use of IT beyond simple screen mirroring, however, several teachers made excellent use of IT to improve the accessibility and engagement of their lessons.

We reiterate that these findings are emerging as the data analysis is ongoing, however, they are supported by subsets of data across all four case study schools. We anticipate being able to describe a more complete picture as the analysis progresses, in addition to distinct findings relating to attitudes toward mathematics.

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References

Bjuland, R., & Mosvold, R. (2015). Lesson study in teacher education: Learning from a challenging case. Teaching and Teacher Education, 52, 83-90. doi:http://dx.doi.org/10.1016/j.tate.2015.09.005

Byrne, C., & Prendergast, M. (2020). Investigating the concerns of secondary school teachers towards curriculum reform. Journal of Curriculum Studies, 52(2), 286-306. doi:10.1080/00220272.2019.1643924

Byrne, D., & McCoy, S. (2017). Effectively Maintained Inequality in Educational Transitions in the Republic of Ireland. American Behavioral Scientist, 61(1), 49-73. doi:doi:10.1177/0002764216682991

Dietrichson, J., Bøg, M., Filges, T., & Jørgensen, A.-M. K. (2017). Academic Interventions for Elementary and Middle School Students With Low Socioeconomic Status. Review of Educational Research, 87(2), 243-282. doi:doi:10.3102/0034654316687036

Fleming, B., & Harford, J. (2021). The DEIS programme as a policy aimed at combating educational disadvantage: fit for purpose? Irish Educational Studies, 1-19. doi:10.1080/03323315.2021.1964568

Fullan, M. (2001). Leading in a culture of change. San Franciso: Jossey-Bass.

Gersten, R., Chard, D. J., Jayanthi, M., Baker, S. K., Morphy, P., & Flojo, J. (2009). Mathematics Instruction for Students With Learning Disabilities: A Meta-Analysis of Instructional Components. Review of Educational Research, 79(3), 1202-1242. doi:10.3102/0034654309334431

Lave, J. (1988) Cognition in Practice: Mind, Mathematics, and Culture in Everyday Life. Cambridge: Cambridge University Press.

Lewanowski-Breen, E., Ni Shuilleabhain, A., & Meehan, M. (2021). Lesson study and the long-term impact on teacher professional community development. *International Journal for Lesson & Learning Studies*, *10*(1), 89-101.

Lewis, C., & Perry, R. (2017). Lesson Study to Scale Up Research-Based Knowledge: A Randomized, Controlled Trial of Fractions Learning. Journal for Research in

Mathematics Education, 48(3), 261-299. doi:https://doi.org/10.5951/jresematheduc.48.3.0261

Lewis, C., Takahashi, A., Friedman, M., Liebert, S., & Houseman, N. (2022). Sustained, Effective School-wide Lesson Study: How Do We Get There? Vietnam Journal of Education, 6, 45-57. doi:https://doi.org/10.52296/vje.2022.178

Maloney, E. A., Schaeffer, M. W., & Beilock, S. L. (2013). Mathematics anxiety and stereotype threat: shared mechanisms, negative consequences and promising interventions. Research in Mathematics Education, 15(2), 115-128. doi:10.1080/14794802.2013.797744

Marchis, I. (2011). Factors that influence secondary school students' attitude to mathematics. Procedia - Social and Behavioral Sciences, 29, 786-793. doi:https://doi.org/10.1016/j.sbspro.2011.11.306

McCoy, S., Byrne, D., O'Sullivan, J., & Smyth, E. (2019). The Early Impact of the Revised Leaving Certificate Grading Scheme on Student Perceptions and Behaviour. doi:https://doi.org/10.26504/rd85

Ni Shuilleabhain, A., Cronin, A., & Prendergast, M. (2020). Maths Sparks engagement programme: investigating the impact on under-privileged pupils' attitudes towards mathematics. Teaching Mathematics and its Applications: An International Journal of the IMA, 40(2), 133-153. doi:10.1093/teamat/hraa009

Ni Shuilleabhain, A., & Seery, A. (2018). Enacting curriculum reform through lesson study: a case study of mathematics teacher learning. *Professional development in education*, *44*(2), 222-236.

OECD. (2016). Equations and Inequalities: Making Mathematics Accessible to All. Paris: PISA.

Perkins, R., & Shiel, G. (2016). PISA in classrooms: Implications for the teaching and learning of mathematics in Ireland. Retrieved from Dublin: https://www.erc.ie/wp-content/uploads/2016/10/PISA-in-ClassroomsWeb.pdf

Rittle-Johnson, B., Siegler, R. S., & Alibali, M. W. (2001). Developing conceptual understanding and procedural skill in mathematics: An iterative process. Journal of Educational Psychology, 93(2), 346-362. doi:https://psycnet.apa.org/doi/10.1037/0022-0663.93.2.346

Rose, H., & Betts, J. (2004). The Effect of High School Courses on Earnings. The Review of Economics and Statistics, 86(2), 497-513.

Smyth, E., McCoy, S., & Kingston, G. (2015). Learning from the Evaluation of DEIS. Retrieved from Dublin: https://www.esri.ie/publications/learning-from-the-evaluation-of-deis

Takahashi, A. (2021). Teaching Mathematics Through Problem-Solving: A Pedagogical Approach from Japan. New York: Routledge.

Takahashi, A., & McDougal, T. (2016). Collaborative lesson research: maximizing the impact of lesson study. ZDM, 48(4), 513-526. doi:https://doi.org/10.1007/s11858-015-0752-x

Thurston, W. P. (1994). On Proof and Progress in Mathematics. American Mathematical Society, 30(2), 161-177. doi:https://doi.org/10.48550/arXiv.math/9404236