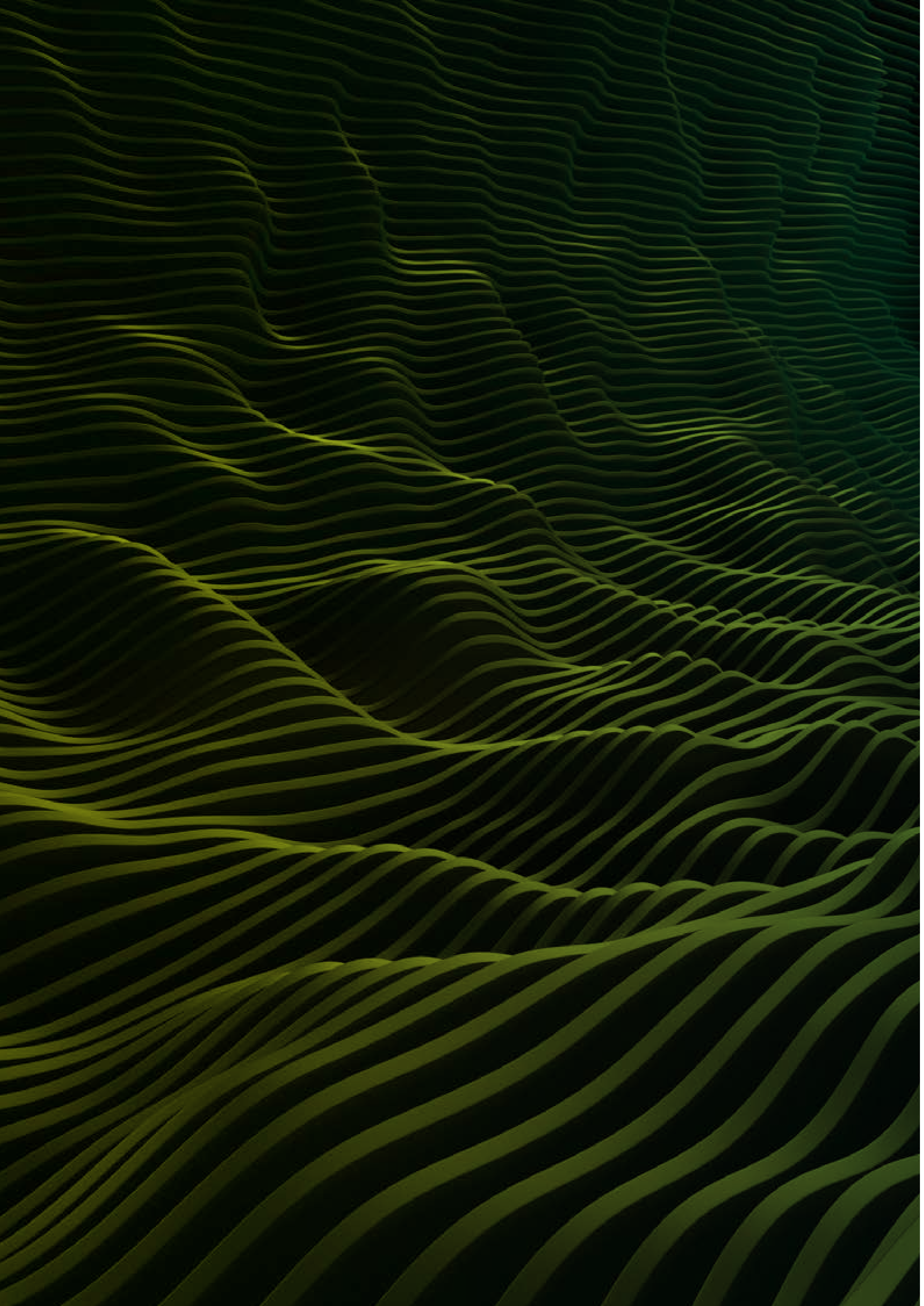
EPI·STEM

National Centre for STEM Education

MAKING THE TRANSITION:

Students’ Mathematical Journey from Primary to Post-Primary School in Ireland

Veronica Ryan, Olivia Fitzmaurice and John O’Donoghue.



PREFACE

The importance of early positive experiences in learning mathematics cannot be underestimated. There is a vast literature in mathematics education revealing the importance of self-efficacy and self-confidence in relation to student performance and achievement in mathematics.

This positive experience takes on a whole new meaning when children and young people start to navigate the transition from primary school to post-primary school in Ireland. For pupils, parents/guardians, teachers, and school communities this is an exciting time and at the same time, a stressful time. How will the students settle into their new learning environment? Will they feel cared for, recognised, included and with a fair chance to develop and to thrive, or will they feel lost and become anxious?

We know from education theory and research that learning not only involves paying attention to knowledge – theoretical knowledge and subject matter knowledge. At the same time, it involves an experiential journey of human emancipation, of identity and consciousness.

In Irish we often use the expression 'Tús maith leath na hoibre' [a good beginning is half the work] when starting something new. In this report, Making the Transition; Students' Mathematical Journey from Primary to Post-Primary School in Ireland, we are presented with research findings pointing to new substantive ways to make this transition in the mathematical journey of young people a productive one. The findings are of key national policy importance and suggest it is timely to designate this transition a boundary-crossing process of significance, requiring an authentic partnership in learning mathematics among all concerned.

The transition from primary school to post-primary school is already a perfect storm: the child is moving from the familiarity of the primary school to the new post-primary school; at the same time, this signals a transition from childhood to becoming a young adolescent. How best might we describe this transition in relation to curriculum and pedagogy, given that curriculum is understood as a selection from Irish culture? Is it from holistic child-centred pedagogies to exam-oriented pedagogies, or is it toward learning environments of inclusion and adaptive expertise?

Whatever the case, what is clear is that this transition is filled with hidden obstacles as well as with lots of new beginnings and possibilities. That is before we ever consider what is involved in making the transition successful in terms of mathematics performance and content knowledge.

This is exactly what the empirical study in this report seeks to do. It is an original study that investigates the transition of young people from primary to post-primary schools in Ireland in relation to mathematics achievement. It addresses the concern behind this crucial transition, taking the knowledge and identity questions into account – what it calls the academic question (the self-confidence, competence and skill with mathematics) and the affective question (joy of learning, student engagement, motivation, aesthetics).

The report draws from the doctoral study of Veronica Ryan (2018), a mathematics teacher of young people for more than a decade. The study is published in three peer-reviewed international journals with Veronica's supervisors, Dr Olivia Fitzmaurice, a Senior Lecturer in Mathematics Education at the School of Education, and Professor Emeritus John O'Donoghue, a mathematics educator and researcher and a key founder of EPI•STEM National Centre for STEM Education at the University of Limerick.

The findings from the study merit serious consideration in relation to STEM education policy in Ireland. We want all our young people to have a positive experience of learning mathematics, to enjoy a sense of pedagogical well-being, to thrive, to handle mathematics with ease and criticality in their lives, and in relation to the greater good of humanity and the planet. I now invite you to read the report in its entirety.

Professor Geraldine Mooney Simmie
Director EPI•STEM National Centre for STEM Education
Professor of Education (STEM Education), School of Education, University of Limerick

FOREWORD

Our lives are full of transitions. As young children we leave the familiar surroundings of the home to go to school; then as adolescents and adults we move through further education and training, employment, and eventually retirement from working life. How we navigate the boundaries between these life stages can have either positive or negative impacts on our educational development and personal well-being. This report is about one of the most important transitional milestones we will ever experience – from primary to secondary education.

I am sure that readers of this report will agree that Veronica Ryan, Olivia Fitzmaurice, and John O'Donoghue have produced a landmark study of the primary–secondary transition in mathematics education in Ireland. Their meticulously conducted research should arouse serious concerns about how this transition is handled by education authorities and experienced by students, but also promote genuine hope for how improvements can be made. The concerns come from the compelling evidence they present of a substantial decline in mathematics achievement between the last year of primary and the first year of post-primary school, across all strands of mathematics content and process skills, together with pronounced gender differences in performance that favour boys. This is a startling finding – how can children go backwards in their mathematics learning? Especially when teachers are working with a curriculum that is specifically designed to bridge between primary school and Junior Cycle mathematics? And why should a gender disparity still exist when there is so much focus on working towards gender equity in the STEM disciplines in Ireland?

Ryan and her colleagues identify several possible explanations for this conundrum. For example, they point to the contrast between primary and post-primary teaching and assessment methods, curriculum design, and educational philosophies; the lack of interaction and cooperation between teachers on either side of the school transition boundary; and the absence of coordination between teacher education for primary and post-primary teachers. Each of these issues needs to be given more attention by researchers, policy makers, school leaders, and teacher educators – preferably, working in collaboration.

Fortunately, the study also uncovered encouraging signs that students in their first year of post-primary schooling are eager to learn mathematics and willing to work hard to do well in the subject. Students are also supported by their parents, who believe in the importance of mathematics for further study and good jobs. To build on these positive dispositions, Ryan and colleagues argue that the primary–secondary transition presents opportunities for educators to reshape children's future learning trajectories by building mathematical understanding, interest and enjoyment.

This study comes at a critical time in the context of significant school curriculum reform in Ireland. The report clearly lays out the academic problems with transition, but also proposes realistic solutions to benefit the whole education system. It deserves to be widely read and acted upon by all those who are responsible for improving the continuity and richness of students' mathematical experience across the primary–secondary transition.

Professor Merrilyn Goos
Adjunct Professor
School of Education
University of Limerick

ACKNOWLEDGEMENTS

The authors wish to acknowledge financial support from EPI·STEM, National Centre for STEM Education – initially for Dr Ryan’s doctoral studies, and for funding the publication of this report. We are also grateful for the continuing professional support of colleagues at the National Centre. The actual preparation and production of such a report requires many inputs to bring it to publication and we wish to thank the EPI·STEM Executive Administrator, Helen Fitzgerald, for her assistance and contribution in that regard.

We acknowledge with thanks the essential contribution of the schools, teachers, students and parents who agreed to participate in this research. The authors would like to acknowledge and thank Dr Seán Lacey, Munster Technological University, for his review and suggestions relating to the Executive Summary.

CONTENTS

STRUCTURE OF REPORT

This report brings together in a single publication findings from a recent study on the mathematics transition from primary to post-primary school in Ireland. The purpose of the report is to strengthen the evidence base regarding this transition. The report departs from practice in design and presentation, in an attempt to make the findings available and more readily accessible to stakeholders in education including mathematics teachers, parents, teacher educators, policy makers, mathematics/education researchers, and other interested parties.

The report contains a number of dedicated concise sections devoted to important aspects of the study that together develop a strong consistent internal narrative about the study and its findings. Ryan's doctoral thesis gives a comprehensive report of the full project and is accessible at Ryan (2018). The authors attempt to keep repetition to a minimum throughout the report but some is inevitable due to overlap in the published papers, and between the papers and the Summary of Findings, Discussion and Recommendations section. Here the hope is that revisiting some topics adds emphasis rather than distraction. However, we did not feel the need to reproduce the thesis bibliography since it is available online and is embedded in the papers' lists of references.

The report sections include:

- Executive summary
- Overview of the study
- Peer-reviewed published journal papers
- Summary of findings, discussion and recommendations.

EXECUTIVE SUMMARY

This study investigated student performance in mathematics during the transition from primary to post-primary school in Ireland. Academic achievement in mathematics was measured using a customised standardised test at the end of sixth class of primary school and the end of first year of post-primary school. Progress in mathematics was measured over the transition by comparing these two test results for 249 students. This data was analysed for all students and for students grouped by gender, prior achievement, curriculum strand areas (Number, Measures, Shape and Space, Data, and Algebra) and process skills (Concepts and Facts, Computation, and Word Problems). To complement this research, a questionnaire based on the Fennema-Sherman scale examined student attitudes towards mathematics. Using a large sample of 304 students, this questionnaire examined students' interest in mathematics and their willingness to engage in mathematics including attitudes, emotions and self-related beliefs. This data was analysed for all students and for students grouped by gender and prior achievement.

The motivation for this study came from the author's (VR) personal experience of many years teaching mathematics to first-year students. The author observed, just as national research has shown (Smyth, McCoy, & Darmody, 2004), that students repeatedly demonstrate difficulty in mathematical topics that overlap sixth class and first year, and many students fail to make sufficient academic progress during first year. Recent reports suggest that all is not well with Junior Cycle mathematics, and in particular, underperformance in algebra has been identified (State Examinations Commission, 2015; Shiel & Kelleher, 2017). Such concerns point to issues with foundational topics in first-year post-primary mathematics that likely relate to the transition from primary to post-primary mathematics. However, at the time of this study there was a dearth of empirical evidence to shed light on such issues. Hence this empirical study was specifically designed to investigate the performance of students in mathematics at the end of sixth class (primary school) and the end of first year (post-primary school), and performance-related issues. The direction of the study and its focus are evident in the research questions pursued.

After reviewing the literature, the following research questions emerged, which provided the direction for this study in the context of the introduction of the new mathematics curriculum in 2010:

Academic

- What does the empirical performance data tell us about students' progress in mathematics in first year of post-primary school?

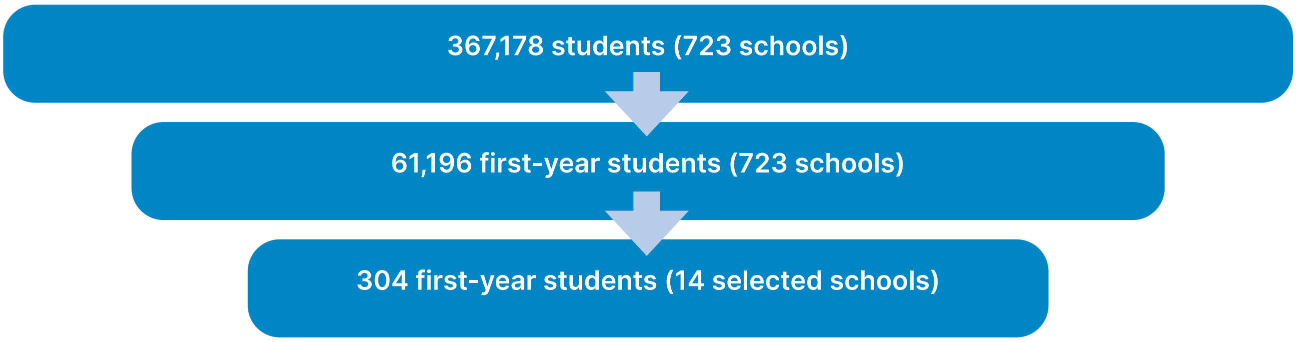
Affective

- What can we learn about students' engagement with mathematics from the questionnaire data on their interest, extrinsic motivation to study mathematics, and perseverance in learning mathematics?

The research questions were pursued through an action plan based on multiple subsidiary questions related to each area, leading to consideration of the implications of findings, and recommendations for improving performance.

The sample

The target population was first-year students in the Republic of Ireland commencing secondary education in September 2015. The sampling frame was the entire set of 723 post-primary schools in Ireland and this accounted for 367,178 students, which equated to 61,196 first-year students.



The first stage of the sample design involved stratifying the list of schools into the four distinct school types, namely: secondary, vocational, community and comprehensive. Separate school sampling sub-frames were constructed for each school type. Fourteen selected schools agreed to participate in the study. A simple random sample of first-year mathematics classes in a chosen school was used to select a class, and all students from the selected class were included in the sample. Ethical approval for this study was granted by the appropriate ethics committee at the University of Limerick (Code: 2015_09_01_S&E).

Research instruments

The research instruments used in this research study were the SIGMA-T, Drumcondra Primary Mathematics Test – Revised (DPMT-R), and the PISA 2012 Attitudinal Questionnaire. These instruments were already developed, extensively used and validated within the Irish school system prior to their use for this research study. Both Irish assessment tests are commercially available and standardised using an appropriate population of students in Ireland. They are used to measure student knowledge of the primary school mathematics curriculum.

The student questionnaire used in this study was extracted from the PISA 2012 student questionnaire and examined students' engagement with mathematics by assessing their interest in mathematics, extrinsic motivation to study mathematics and perseverance in learning mathematics (OECD, 2013b). The author (VR) provided hard copies of the questionnaire to the cooperating teachers in each of the 14 schools who subsequently administered the questionnaire to the sample.

---

[1] Secondary schools are privately owned and managed. Vocational schools are governed by the state through Education and Training Boards (ETBs), while Boards of Management manage community and comprehensive schools.

Curriculum map

The Common Introductory Course bridges the primary mathematics curriculum in Ireland to the first-year post-primary mathematics curriculum. A curriculum map was constructed for the purposes of checking the extent to which the learning outcomes of the sixth-class (primary school) mathematics curriculum corresponded to the learning outcomes of the first-year Common Introductory Course (post-primary/lower secondary school). This analysis showed that 82% of the learning outcomes of the sixth-class mathematics curriculum are repeated in the first-year Common Introductory Course. This very high level of correspondence between curricula reinforced our confidence in the approach taken in this study and the instruments used.

Statistical analysis

For Paper 1, the data was imported into SPSS for quantitative analysis. An analysis of students' pre- and post-test scores was carried out to determine the effects of the transition from primary to secondary education on students' achievement. The authors categorised student data into three appropriately defined groups: A, B, C. A paired t-test was employed on each of the three groups to determine whether there was a statistically significant mean difference in the results obtained at the end of sixth class and the end of first year. The purpose of the comparison was to assess student progress in mathematics during the first year in post-primary education. For Paper 2, a combination of inferential (independent t-tests) and descriptive statistics was employed to investigate the mathematical knowledge of students at the end of year 1, examine the data for gender differences, and identify potential inhibitors to progress in year 1 mathematics. Paper 3 used descriptive statistics to assess interest and engagement in mathematics at the end of the first year of post-primary school. All the model assumptions for all tests were checked and satisfied, and details of these tests are provided in Ryan (2018). Both Paper 2 and Paper 3 used descriptive statistics.

A discussion of the research design, methodology, statistical analyses, and implementation is available in various sources relating to different aspects of the study, e.g. later in this report, Ryan (2018), and published papers.

Key findings

The research questions were examined in light of the empirical evidence generated in the study and findings reported in separate papers reproduced below in the Peer-Reviewed Journal Papers section. Key findings are presented in this summary but interested readers are directed to Ryan's doctoral thesis and the published papers for a full report of the study at Ryan (2018).

Academic

- This project established a statistically significant decline, more pronounced than any international study of the transition in mathematics, in student performance across the transition.
- On average, students' raw scores decreased by 7% from sixth class to first year despite

an additional year of instruction ($p < 0.001$).

- The results showed statistically significant losses in each strand area and in each process skill ($p < 0.001$).
- A component analysis of student academic performance at the end of the first year of post-primary school showed consistent poor performance and statistically significant female underperformance in each strand area and each process skill.

Affective

- The results of this study show high levels of student engagement, motivation and positive self-belief in mathematics.
- The authors compared academic performance with questionnaire responses and found students demonstrated high levels of motivation irrespective of performance.
- In addition, questions with the strongest correlations to performance are those relating to mathematics self-concept and anxiety.
- This study also highlights a gender disparity in mathematics self-beliefs, particularly in relation to self-efficacy, self-concept and anxiety.

Limitations

The design of the main transition study dictated the characteristics of the sample and the nature of data collected. This reality had a bearing on the production of each published paper and issues treated and the manner of that treatment. Overall coherence was maintained by reference to the design of the main study (Ryan, 2018).

We draw attention to a small number of relevant issues; readers should consult the actual papers for their treatment:

- The target sample size of 382 students to ensure 95% confidence interval and a 5% margin of error was not achieved due to reluctance of post-primary schools to participate. Instead, 301 students completed the test instrument. The achieved sample size of 301 students maps to a 6% margin of error at 95% level of confidence.
- The sample is not a sample of individual first-year students chosen individually, but rather 301 out of 323 students (22 were absent on the day the test was administered) from 14 first-year class groups from the participating schools. Sixth-class standardised test results were traced back for 249 of these students and these results were compared with the results obtained by students sitting the test at the end of first year.
- The researchers had no control over the gender balance that emerged in schools included in the sample, and consequently the proportion of boys (59%) and girls (41%) among the 301 students who sat the test. Although the difference in proportion is significant, it has a small effect size $h = 0.37$ (computed using $h = 2*(ASIN(SQRT(0.59))-ASIN(SQRT(0.41)))$) (Zaiontz, 2018).
- While cooperating class teachers administered the test following specific written instructions supplied by the researcher, there is no way of knowing if they strictly adhered to these instructions in practice. However, the researcher adhered to normal practice in the circumstances (Cohen, Manion, & Morrison, 2007).

OVERVIEW OF THE STUDY

Introduction

According to Bicknell and Hunter (2012), the transition process is central to student confidence and the sustainment of student interest and passion for learning as students pass from primary to secondary school. Transition to post-primary school, once the preserve of a few, is now seen as an automatic rite of passage in Ireland and is a momentous period of change for students and one of the greatest challenges experienced by students (Prendergast, O’Meara, Harbison, & O’Hara, 2016). Transition to post-primary school demands that students adjust to a new school setting, a longer school day, increased homework, new subjects, new uniform, new teachers and a new school culture. The comfort they once felt in being the most senior group in primary school is replaced with a sense of vulnerability and anxiety in the realisation that they are now at the bottom of the pecking order in post-primary school. It has been shown that transition is a time of excitement but also stress for first-year students (O’Brien, 2001). The subject-driven, examination-focused post-primary system replaces the child-centred pastoral learning environment of primary school. Adjustment to secondary school is a worrying time for both students and their parents/guardians (Galton, Morrison, & Pell, 2000). Unsuccessful transition to second level has implications both socially and academically and often the disengagement with education that follows will continue into adult life (Galton et al., 2000). It can be a negative experience characterised by academic decline, a decrease in self-esteem and the development of a dislike towards certain subjects (Galton et al., 2000). This study investigates the literature on transition, specifically the transition from primary to post-primary school. It focuses on the need to investigate the transition and the factors necessary for a successful transition. The authors examine transitional challenges from academic, social and psychological standpoints. As Ireland seeks to increase its ranking among Organisation for Economic Co-operation and Development (OECD) countries in terms of mathematical proficiency (Eivers, Shiel, & Cunningham, 2007), very little has been done to address the difficulties that first-year students now face in attempting to cope with the new mathematics curriculum and the new methods teachers are employing to deliver this curriculum.

Background to the study

The new mathematics curriculum marks a complete overhaul of the syllabus, examination papers, textbooks and traditional teaching methodologies in Ireland. The new mathematics curriculum began, on a phased basis, in 24 pilot schools in 2008 and was implemented nationally in 2010. It was launched in response to a number of perceived shortcomings in school mathematics: the low percentage of students pursuing Higher-level Leaving Certificate mathematics, the discontinuity between primary and post-primary mathematics, the poor standard of answering in state examinations, disappointing performances in international assessments, and low levels of mathematical knowledge recorded at third level (NCCA, 2005). The philosophy underpinning the new mathematics curriculum, Realistic Maths Education (RME), was developed by the Freudenthal Institute in the Netherlands (NCCA, 2005; Lubienski, 2011). The new mathematics curriculum emphasises the need for students to be active learners. It focuses on the development of problem-solving abilities which promote the application of mathematical understanding and skills in students’ lives outside of school (NCCA, 2005; Lubienski, 2011). The new mathematics curriculum syllabus at Junior and Senior

Cycle consists of five strands:

- Strand 1: Statistics and probability
- Strand 2: Geometry and trigonometry
- Strand 3: Number
- Strand 4: Algebra
- Strand 5: Functions.

The curriculum represents a move away from procedural routine mathematics and rote learning towards the development of a deeper understanding of mathematical concepts (Cosgrove, Perkins, Shiel, Fish, & McGuinness, 2012). By comparing PISA results from 2003 and 2009, Cosgrove et al. (2012) found a decline in the mathematics achievement of high-achieving students. More generally, international comparisons have identified the need for Ireland to seek ways of improving the nation's approach to mathematics. The Irish government's investment in the new mathematics curriculum is testament to a national commitment to improving the mathematical skills of post-primary students. However, while the aspirations of the new mathematics curriculum are clearly desired, initial research found that 47.5% of teachers surveyed for PISA did not know if it was having a positive influence (Cosgrove et al., 2012).

Reform is ongoing, extending to teaching, learning and assessment at Junior Cycle and the new Junior Cycle mathematics programme involves 240 hours of mathematics over three years. The new Junior Certificate syllabus has taken into account the need to recognise a wide range of learning, has reduced the focus on terminal examinations, has increased the importance of classroom-based assessment, has increased teacher collaboration and has given parents/guardians more information on student learning (Department of Education and Skills, 2015). Currently, mathematics is offered at Higher and Ordinary level only. Dual assessment has been introduced, which involves an externally assessed state-certified examination coupled with classroom assessment.

Significance of the study

> *Successful academic performance during adolescence is a key predictor of lifetime achievement, including occupational and social success.*
> (Serbin, Stack, & Kingdon, 2013, p. 1331)

Efforts to support transition in Ireland have concentrated on the social and the psychological ramifications of transition. There is an absence of research both nationally and internationally on the academic transition that is taking place at this time (Galton, Hargreaves, & Pell, 2003; Carmichael, 2015). Repeated difficulty with first-year mathematics topics has been identified (Smyth et al., 2004) and surfaces again in PISA and Chief Examiner reports (Perkins, Shiel, Merriman, Cosgrove, & Moran, 2013; State Examinations Commission, 2015), but is under-researched. The authors address this gap in the literature by examining the mathematical transition of sixth-class students entering post-primary schools and facing a new mathematics curriculum. The only Irish study on academic transition measured computation scores in September and May of first year and was carried out 20 years ago (Smyth et al., 2004). The educational landscape has changed extensively since Smyth's study (2004). The research presented in this study focuses solely on mathematics and assesses how the revised mathematics curriculum affects student progress in first year by using a large, nationally representative sample. Getting the academic transition in mathematics from primary to post-primary school right is extremely important for the future education of the nation's children; children's psychological well-being; their academic future; not forgetting the national economic well-being of the country and issues of social justice and participation.

Furthermore, the transition from primary to secondary school is a critical time in forecasting academic success (Neild, Stoner-Eby, & Furstenberg, 2008; Benner and Graham, 2009; Serbin et al., 2013). While it foreshadows academic success, it also marks a significant point where failure and disengagement can develop and fester (Vorderman, Porkess, Budd, Dunne, & Rahman-Hart, 2011, p. 5).

UK data shows there is significant correlation between student difficulties in mathematics in primary and under-achievement in secondary school. Similarly, there is a strong interconnection between high achievement by the end of primary school and high achievement in secondary school (Torgerson et al., 2011). In effect, students who achieve at an early stage continue to succeed. The negative consequences of poor early achievement in school mathematics are known for decades. For example, the gap between the highest and lowest achieving students widens as they advance through secondary schooling and by the time a student turns 16, there already exists a seven-year difference in mathematics achievement between the highest and lowest achieving students (Denvir & Brown, 1987). However, while Neild et al. (2008) have shown using US data that ninth-grade outcomes are major predictors of dropout, they also argue that the transition to high school is a time where a student's educational trajectory can be reshaped. If this is true, first year at post-primary school not only establishes a base for mathematical advancement but more importantly represents a huge opportunity for educators. As a nation, we are lagging behind in our mathematics education compared to our international counterparts in both TIMSS and PISA testing (Perkins et al., 2013; Shiel, Kavanagh, & Miller, 2014; Clerkin, Perkins, & Cunningham, 2016). Mathematical knowledge is important for each individual's personal development and functioning within society and from an economic standpoint, since economic prosperity is heavily dependent on good mathematics education. The academic progression in mathematics of students during the critical first year of post-primary school in Ireland has not been explored in sufficient depth to support national reforms in mathematics education. We do not know how well students have adapted to the new mathematics curriculum but initial reports by the National Foundation for Educational Research (NFER) signal that the new curriculum has not instigated any improvement in achievement (Jeffes et al., 2013). However, we do know that standardised achievement scores and prior grades are the strongest predictors of high-school Grade Point Average (Casillas et al., 2012). We need to know how students are performing across this transition. It is hugely significant that we get it right as a nation. Understanding this transition is imperative if we want to raise student levels of knowledge and understanding in mathematics. The economic and societal implications of increased knowledge are very significant.

Relevant literature

The authors examined transitional challenges from academic, social and psychological standpoints and used the literature to inform the study. A review of the general literature on transition together with a more specific concentration on mathematics transition projects led to a hybrid transition framework (Ryan, 2018) that guided the research, formulation of the problem and research questions, and methodology. The relative paucity of relevant mathematics transitional projects/research was noted but compensated by a close examination of identified international projects/research, the most notable being Cox and Kennedy (2008), Galton, Gray, and Ruddick (1999), Galton et al. (2003), Anderson, Jacobs, Schramm, and Splittgerber (2000), Eccles et al. (1993), Bicknell and Hunter (2012), West, Sweeting, and Young (2010), Barbeau and Taylor (2009), Diezmann and Watters (2002), Turner and Meyer (2004) and Pajares and Miller (1994).

References were updated during the preparation of papers and include van Rens, Haelermans, Groot, and van den Brink (2018), Prendergast et al. (2016), Attard (2010) and Carmichael (2015). A small number of points stand out as particularly noteworthy and are discussed briefly below. While the authors were keenly aware of the paucity of specific research in the area of interest (Galton et al., 2003), Carmichael (2015) offered insights into possible causes and suggested that the difficulty lay in the challenges associated with getting appropriate data, e.g. the availabilty of customised instruments for measuring the impact of the transition on students. Therefore, the use of customised instruments in this study is a noteworthy feature.

The literature underlines the fact that this transfer is not successful for many students, thus leading to both short-term and long-term consequences (van Rens et al., 2018). For example, in an early study, over 80% of teachers in post-primary schools in Ireland believed that the transfer to post-primary education needed explicit intervention (Irish National Teachers' Organisation, 2008). Rather than signalling a new beginning, an American study has shown that systemic transitions can signal the 'beginning of the end' for many students (Anderson et al., 2000; van Rens et al., 2018). Transition to post-primary education has emotional, academic and social implications. Emotionally, it can have a negative impact on self-esteem (Eccles et al., 1991); academically, it can create a break in progress for up to 40% of pupils (Galton et al., 1999); socially, it can mark the start of detachment from the school system (Anderson et al., 2000).

Academically, successful transition to post-primary school has a direct impact on the mathematical future of students. Eccles et al. (1993) found in their study based on 12 school districts in south-eastern Michigan, USA, that declines in achievement, motivation and students' self-concept of ability are more evident in mathematics than in any other subject following the transition to middle school. They also reported that girls are more susceptible to these negative effects than boys. In Ireland, students pursue mathematics at different levels, depending on their ability. Therefore, this period is a crucial time in a student's mathematical journey as it influences the level of mathematics that they follow during the remainder of their post-primary education. Ultimately, it also affects their career and college opportunities (Akos, Shoffner, & Ellis, 2007).

PEER-REVIEWED JOURNAL PAPERS

The main findings of the study of transition from primary to post-primary school mathematics in Ireland are presented through three peer-reviewed published journal papers which are reproduced here in final pre-publication version with permissions from the respective publishers. The main study focused on analysing the academic transition and student attitude towards mathematics. The item analysis central to Paper 2 is based on the bank of data generated during the main study. The papers are:

1. Ryan, V., Fitzmaurice, O. and O'Donoghue, J., 2021. A study of academic achievement in mathematics after the transition from primary to secondary education. *SN Social Sciences*, 1(7), 1-24. https://doi.org/10.1007/s43545-021-00177-8
2. Ryan, V., Fitzmaurice, O. and O'Donoghue, J., 2021. Investigating student knowledge in mathematics at the end of the end of their first year of post-primary education in Ireland: A case study. *Teaching of Mathematics*, 24(2), 55-75.
3. Ryan, V., Fitzmaurice, O., & O'Donoghue, J., 2022. Student interest and engagement in mathematics after the first year of secondary education. *European Journal of Science and Mathematics Education*, 10(4), 436-454. https://doi.org/10.30935/scimath/12180

Note: These papers are reproduced below as they were published, with minor adjustments of wording, punctuation and style to correct errors and ensure consistency.

PAPER 1:
A STUDY OF ACADEMIC ACHIEVEMENT IN MATHEMATICS AFTER THE TRANSITION FROM PRIMARY TO SECONDARY EDUCATION

Abstract

A successful transition from primary to secondary school is central to student confidence and the sustainment of student interest in and passion for learning. The literature indicates that difficult transitions can result in decreased levels of motivation, negative attitudes towards school, decreased levels of confidence, and disengagement, particularly in relation to mathematics. This study investigated student performance in mathematics after the transition from primary to secondary education in Ireland. It comes in the aftermath of major educational reform in mathematics in Ireland at both primary and secondary level and is the first Irish study to examine the effect of the transition on mathematical achievement. Academic achievement in mathematics was measured using a standardised test at the end of the final year of primary school and the end of first year of secondary education. Progress in mathematics was measured over the transition by comparing these two test results for 249 students. On average, students' raw scores decreased by 7% from sixth class (final year of primary school) to the end of first year of secondary education despite an additional year of instruction and extensive overlap of both syllabi. The results showed statistically significant losses in each strand area and in each process skill. This academic transition is not unique to Ireland and the findings from this research study will be of interest to the mathematics education community internationally since it extends the evidence base for studies in school transition.

1. Introduction

> *Successful academic performance during adolescence is a key predictor of lifetime achievement, including occupational and social success.*
> (Serbin, Stack, & Kingdon, 2013, p. 1331)

Transition to secondary education, once the preserve of a few, is now seen as an automatic rite of passage in Ireland and it is a transition experienced by over 50,000 students each year (Smyth, McCoy, & Darmody, 2004). It is a momentous period of change for students and one of the greatest challenges experienced by students in their school career (Prendergast, O'Meara, O'Hara, Harbison, & Cantley, 2019). Researchers have recognised the transition from primary to secondary education to be a major milestone in the educational journey of the student and much has been reported on this transition both nationally (Irish National Teachers' Organisation, 2008; O'Brien, 2001; Smyth et al., 2004) and internationally in recent years (Anderson, Jacobs, Schramm, & Splittgerber, 2000; Doyé & Hurrell, 1997; Midgley, Feldlaufer, & Eccles, 1989; van Rens et al., 2018). Indeed, international experience shows the transfer to post-primary school is not successful for many students, creating both short-term and long-term consequences (van Rens et al., 2018). Galton, Morrison, and Pell (2000) observed, in their UK study, that unsuccessful transition to secondary school has implications both socially and academically, and often the disengagement with education that follows from an unsuccessful transition will continue into adult life. Galton et al. (2000) also showed that transition can be a negative experience characterised by academic decline, decline in self-esteem and development of a dislike towards certain subjects. There is an absence of research globally on the academic transition that is taking place at this time (Galton et al., 2003). In this paper, the authors focus on the academic transition in mathematics in Irish schools, measuring student performance for a specific cohort of students using a representative national sample, and identify and discuss issues that impact on this transition. Getting the academic transition in mathematics from primary to secondary education right is very challenging and extremely important for the future education of the nation's children; children's psychological well-being; their academic future; not forgetting the national economic well-being of the country and issues of social justice and participation.

2. Transition and mathematics – the literature

In a New Zealand study, Bicknell and Hunter (2012) found that the transition process is central to student confidence and the sustainment of student interest in and passion for learning as students pass from primary to secondary school. The literature shows us that difficult transitions can result in decreased levels of motivation, negative attitudes towards school, decreased levels of confidence, and disengagement, particularly in relation to mathematics (McGee, Ward, Gibbons, & Harlow, 2003).

> *If you are on the scrapheap by the age of 11, you are likely to remain there.*
> (Vorderman, Porkess, Budd, Dunne, & Rahman-Hart, 2011, p. 5)

Students who achieve at an early stage continue to succeed. In the UK, 94% of those who exceed the Statutory Assessment Test (SAT) target in the Key Stage 2 National Test (typically 10–11 years of age) will pass their General Certificate of Secondary Education (GCSE) mathematics (typically 15–16 years of age). 90% of those who do not attain the SAT target in the Key Stage 2 National Test at the end of primary school will fail their GCSE mathematics (Vorderman et al., 2011). The gap between the highest and lowest achieving students widens as they advance through secondary schooling and by the time a student turns 16, there already exists a 10-year difference in mathematics achievement between the highest and lowest achieving students (Brown & Armstrong, 1982). Bicknell and Hunter (2012) studied the experiences of year six students (aged between 11 and 12) in New Zealand making the transition and they focused on these students' experience of mathematics. They found that students' loss of motivation to engage in mathematics might be a result of their initial experiences of secondary school characterised by academic pressures and discontinuity of learning context. In their Australian study featuring 194 students spanning both middle school and high school, Martin, Way, Bobis, and Anderson (2015) highlighted that aspirations in mathematics and engagement in the subject decline over time. Research in Ireland has highlighted that teachers feel there is a lack of fluidity in the transition process from primary to secondary education (Prendergast et al., 2016). As the New Zealand study found, orientation support such as school visits, information and teachers focusing on the skills needed for the transition are vital for academic success in mathematics (Bicknell & Hunter, 2012; Bicknell & Riley, 2012). However, while Neild, Stoner-Eby, and Furstenberg (2008) show using US data that ninth grade outcomes are major predictors of dropout they also argue that the transition to high school is a time where a student's educational trajectory can be reshaped. If this is true, the first year of secondary education not only establishes a base for mathematical advancement but also more importantly represents a major opportunity for educators.

2.1 Studies on mathematics achievement over the transition

Several studies have been carried out to assess the implications of the transition process (Ashton, 2008; Bloyce & Frederickson, 2012; Chedzoy & Burden, 2005; Lucey & Reay, 2000), but very few have concentrated on the academic transition (Carmichael, 2015; Cox & Kennedy, 2008; Galton et al., 2003; Smyth et al., 2004).

Despite strong interest internationally in transition studies, there is a gap in the international research on education transitions specifically in relation to studies that quantify the impact of the transition on mathematics achievement, and it is suggested that this is attributable to difficulties associated with finding valid measures of mathematical achievement that reflect the first-year post-primary curriculum (Carmichael, 2015). In an Australian study involving 3345 students, Carmichael (2015) showed that the transition to secondary school negatively affects the mathematics performance of students. However, this decrease in performance is not witnessed when students change from one primary school to another. Carmichael suggests this may be due to discontinuity in learning between primary and secondary schooling.

In England, the ORACLE (Observation Research and Classroom Learning Evaluation) study of transfer from 1975 to 1980 discovered that almost 45% of boys and 35% of girls scored less at the end of their first academic year at secondary school than the final term of primary school in the exact same standardised mathematics skills test. The replication of this study two decades later still found 34% of students scoring less on the standardised mathematics tests after a year in secondary school than they did in the last term of primary (Galton et al., 2000). This academic decline is accompanied by a decline in motivation and enthusiasm for school (Galton, Gray, & Ruddick, 1999). In mathematics, there was also a decline in work rate with pupil engagement in the work set by the teacher falling from 61% to 50% following transfer to secondary school (Galton et al., 2000). It is important to note that the second study showed the same results despite extensive educational reform in the intervening years with the introduction of the National Curriculum. Galton et al. (1999) suggest that schools should concentrate on measures to guarantee academic progress and sustained commitment to learning. While one of the objectives of the National Curriculum was to ensure curriculum continuity, problems remain with curriculum continuity at the time of transition. Galton et al. (1999) suggest that the differences in teaching approaches between primary and secondary education need to be investigated and suggests that secondary teachers are still advocating a 'fresh start' approach despite the evidence to suggest that this is not an effective strategy.
In an Irish study, Smyth et al. (2004) found that the majority of students do not make progress in computation between the September and May of first year in post-primary school (lower secondary education). Only 10% of students showed a significant improvement in computation. Smyth found that students who had low computation scores in September made the most progress. She also found that parental involvement correlates positively with progress in computation scores. Smyth suggests that the change in teaching styles between sixth class and first year could be a possible cause for the failure of students to make academic progress in mathematics in first year. Students were more likely to find mathematics in secondary education

to be more difficult than primary level if there was a mismatch between teaching methods across the transition. 75% of students reported that subjects were taught in a different way in primary school than in secondary schools. Many students felt there was a 'mismatch' between the mathematics taught in both schools and those that feel there was a mismatch take more time to settle into first year. Only approximately 50% of mathematics teachers considered the primary school syllabus was a good foundation for mathematics in first year.

The Students' Transition from Primary to Secondary Schooling study was an exploratory study undertaken in New Zealand to investigate the impact of transition on student achievement as students move from primary to secondary schooling (Cox & Kennedy, 2008). Students in this study were assessed in the following content areas in mathematics: geometric operations, number operations and measurement (Cox & Kennedy, 2008). Student achievement from Phase 1 (students were completing their last weeks of primary or intermediate school) to Phase 2 (students were completing their last weeks of term one in their secondary school) showed a decline, possibly attributed to the summer break (Cox & Kennedy, 2008). By Phase 3 (students were completing their last weeks of term four, at end of Year 9), the majority of students were achieving at or above the level achieved in Phase 1. Average mathematics scores declined between Phase 3 and Phase 4 (students were completing their last weeks of term one of year 10) even though there was not a change of school (Cox & Kennedy, 2008). The decline was not as dramatic as the decline between Phase 1 and Phase 2 (Cox & Kennedy, 2008).

These studies, along with the composite theoretical framework, were used to guide the research study with a view to ultimately improving both first-year students' experience of school mathematics and professional practice in school mathematics teaching.

2.2 The Irish context

The study was conducted against a backdrop of major curriculum reform in mathematics in Ireland in recent years, and this reform has included changes across the transition. A new mathematics curriculum was implemented to address various shortcomings in the post-primary (secondary) school curriculum. These included issues such as the low percentage of students pursuing Higher-level Leaving Certificate mathematics – the Leaving Certificate examination is the high-stakes final examination in the Irish post-primary education system, and mathematics can be pursued at Higher level, Ordinary level or Foundation level for this exam. Other concerns were the poor standard of answering in state examinations; disappointing performances in international assessments; and low levels of mathematical knowledge witnessed in third level (NCCA, 2005). Importantly for this study, the discontinuity between primary and post-primary or secondary mathematics was identified as an area of concern.

The new mathematics curriculum represents a move away from procedural routine mathematics and rote learning towards the development of a deeper understanding of mathematical concepts (Cosgrove, Perkins, Shiel, Fish, & McGuinness, 2012). The new revised curriculum organises the syllabus content in five strands: statistics and probability, geometry and trigonometry, number, algebra, and functions. Despite the introduction of the new curriculum, which was fully implemented by 2012, Ireland as a nation still lags behind in its mathematics education in both TIMSS and PISA testing compared to its international counterparts (Clerkin, Perkins, & Cunningham, 2016; Shiel, Kelleher, McKeown, & Denner, 2015). In Ireland, it has been shown that transition is a time of excitement but also stress for first-year students (students in year one of their secondary education in Ireland) (O'Brien, 2001). A later study by Smyth et al. (2004) discussed below, reported significant student underperformance in computation after the transition in question. It is not surprising that efforts in Ireland to support transition followed the general trend and have concentrated on the social and the psychological ramifications of transition. Despite targeted efforts to improve matters in the context of the recent mathematics education reforms, recent research in Ireland, focused on teachers, has identified continuity across the transition from primary to post-primary (secondary) education as a significant concern (Prendergast et al., 2016).

The academic progression in mathematics of students during the critical first year of secondary education in Ireland was not explored in detail until this study. This paper is based on an extensive PhD study (Ryan, 2018) that addresses this gap, and helps to explain, challenge and extend existing knowledge on transition.

3. Key factors affecting success in transition

The literature reviewed identified factors that affect success in the academic transition from primary to post-primary (secondary) education. The authors highlight three factors here for discussion because they have a significant negative impact on the transition in Ireland: academic discontinuity, the 'fresh start' approach, and instruction time. These same factors emerge later in the study because they have a significant bearing on its outcomes and recommendations for improvements.

3.1 Discontinuity

The negative impact of academic discontinuity has been flagged in Ireland, and students who feel this discontinuity take longer to settle into secondary school (NCCA, 2004). Cooperation between primary and secondary schools is necessary for successful transition and is also important to parents (NCCA, 2004). Subject teachers need to take into account not only the curriculum at primary level, but also the methodologies used to deliver the curriculum and the strengths and weaknesses of the individual making the transfer. Gorwood (1991) looked at transition in the UK following the introduction of the National Curriculum and found little contact between primary and secondary teachers. In 2004, Smyth et al. (2004) reported that only half of secondary teachers in Ireland are familiar with the primary curriculum. Twelve years later, Prendergast et al. (2016) found very similar results, with 56% of primary sixth-class teachers (sixth class is the final year of eight years of primary education) and 49% of secondary teachers reported being either highly or slightly unfamiliar with each other's syllabi. 73% of final-year primary teachers and 77% of first-year secondary mathematics teachers reported being unfamiliar with the teaching methodologies employed in the teaching of mathematics in secondary and primary school respectively (Prendergast et al., 2016). Failure to recognise what and how students learn in primary school mathematics can lead to students becoming confused and believing it to be difficult (NCCA, 2005).

3.2 'Fresh start' approach

Academic discontinuity is evident in the 'fresh start' approach where secondary teachers prefer to start again and re-teach much of the material already covered in fifth and sixth class in primary school. Nearly a third of students in Ireland say that several first-year subjects are a repetition of what had already been learned in primary school (NCCA, 2005). Repetition of learning has also been reported as a factor impeding transitional success in New Zealand (Bicknell, Burgess, & Hunter, 2009). For the mathematical transition of exceptionally able students, this approach is especially detrimental as it negates their identification with primary school and the learning that occurred at primary level (Bicknell & Riley, 2012). Indeed, the distrust inherent in the 'fresh start' approach impedes smooth transition and halts academic progress for students of all ability. Galton et al. (2000) warn that this approach is likely to lead to boredom in students who already know the material, and on the other hand the speed of the revision classes could be too much for weaker students. The repetition of learning can lead to confusion or disengagement with mathematics (Bicknell & Hunter, 2012). Different methods of teaching the same topics between primary and secondary school are also likely to lead to confusion (Galton et al., 1999). Mathematics learning must be progressive and repetition of learning and assessment in first-year secondary school does not promote a positive attitude to the subject (Bicknell & Riley, 2012). Research in the UK has shown that students entering secondary education need to be challenged to build on progress made in sixth class and curriculum interest and continuity are key factors in successful transition (Evangelou et al., 2008).

3.3 Instruction time

The link between instruction time and academic achievement was originally highlighted by Carroll in 1963 (OECD, 2010) and since then, the significance of instruction for student performance has been widely investigated internationally (Clark & Linn, 2003; Lavy, 2015; OECD, 2010; Smith, 2000). The Third International Mathematics and Science Study (TIMSS) and other international studies have shown a positive correlation between academic performance and instruction time (Smith, 2000). Research from the 2003 cycle of the Programme for International Student Assessment (PISA) has shown that there is a strong correlation between mean performance in mathematics and total mathematics instruction time (OECD, 2010). Using US data, Smith (2000) concluded that the effect of instruction time can explain from 10% to 40% of the difference in student performance.

In Ireland, it is recommended that students in sixth class spend 50 minutes on mathematics per day (McCoy, Smyth, & Banks, 2012). On the other hand, a first-year secondary student in Ireland is more likely to spend 35 minutes per day on mathematics (Smyth et al., 2004). Students suffer an immediate reduction in mathematics instruction time after they enter first year of secondary education, 30% per day and 36% over the academic year. Furthermore, the mean number of weeks per academic year across Organisation for Economic Co-operation and Development (OECD) countries is 36–40 weeks (OECD, 2010). However, Ireland is considerably below this norm with 33 weeks and this is significant since performance is positively correlated to the length of the school year (OECD, 2010).

4 Theoretical frameworks

The composite framework underpinning this study takes elements of the following models: Rite of Passage (Clark & Lovric, 2009), Communities of Practice (Wenger, 2000) and Schlossberg's Theory on Adult Transitions (Schlossberg, 1981). This composite framework underpinned the methodology, analysis and recommendations.

Even though the Rite of Passage framework developed by Clark and Lovric (2009) has been applied to first-year university students, it examines transition over a two-year period, emphasising that adapting to transition takes time (Clark & Lovric, 2009). It is also a model designed to understand transition in mathematics and the lengthy period of analysis proposed by the Rite of Passage model (Clark & Lovric, 2009) allows for losses due to the absence of mathematical activity in the summer between the end of primary school and the start of post-primary school. In an effort to increase the validity of findings, their approach directed the timing of academic testing that took place in this study. These two time periods represent transition phases, namely the incorporation phase and the adjustment section of culture shock of the Rite of Passage model, where students have gained the ability to cope with the new situation. However, the academic data does question whether students have reached the adaptation stage of the culture shock. This culture shock phase is exacerbated by the differences in instruction time allocated to mathematics in primary and post-primary school in Ireland.

The Communities of Practice (Wenger, 2000) framework provides a sociocultural backdrop allowing for focus on the importance of relationships between members of the individual's community and the reconstruction of identity. This Community of Practice model is particularly suitable for this research study as it views learning as a social endeavour within a community that requires the collaboration of parents, children and teachers. It encourages students, teachers and parents to take an active role in planning learning activities. In addition, parents and teachers not only teach but also learn from their involvement with the child (Rogoff, Paradise, Arauz, Correa-Chávez, & Angelillo, 2003). If we view mathematical learning through the Community of Practice (Wenger, 1998) lens, we can see that collaboration of parents, students and teachers is necessary for transitional success. The strength of these relationships within this community is what leads to student engagement and mastery. This model highlights that the lack of collaboration between primary and post-primary teachers and the absence of significant parental involvement in mathematics education of first-year students are possible stumbling blocks in a student moving from the periphery to the centre of the community as competence increases. Indeed, it questions whether it is possible for the individual to move to the centre of the community given the absence of collaboration.

Schlossberg's Theory on Adult Transitions (Schlossberg, 1981) stresses that the experience of transition is unique to each student but all transition incorporates stress and is dependent on the individual's resources and deficits. Echoing the Communities of Practice (Wenger, 2000) framework, it emphasises the importance of support systems in successful transitions. It also recognises that the characteristics of the individual, such as sex and sex-role identification, and psychosocial competence and age impact greatly on successful transition. Schlossberg's Theory on Adult Transitions (Schlossberg, 1981) provided the following constituents of the composite framework:

- Adaptation to change relies on the individual's balance of resources to deficits at the time of transition but invariably involves a degree of stress for all students.

- The transition environment (interpersonal support systems, institutional support and the physical setting) can provide support to the student.
- The characteristics of the individual (internal locus of control, sense of responsibility, moderately favourable self-evaluation, sense of optimism, ability to plan for success, ability for enjoying success and ability to cope with failure, sex and sex-role identification, etc.) all impact an individual's success in managing transition.

Schlossberg (1981) enables us to identify the role change that students experience in first year. While the transition to post-primary school is expected and has a definite duration, it does involve a role change that causes stress and the stress is more pronounced depending on gender and gender identification. It is also coupled with the biological and physiological changes associated with age. Schlossberg stresses that most transitions involve both positive and negative emotions. Difficulties adapting to transition are exacerbated by lack of interpersonal support. This highlights the need for greater parental involvement in the mathematical transition of students from primary to post-primary education.

5 Method

5.1 Research problem and questions

The study investigated academic progress during the first year of post-primary school. After reviewing the literature and designing the composite framework, the following research questions emerged, which provided the direction for this study in the context of the introduction of the new mathematics curriculum in 2010:

- What progress, if any, do Irish students make in mathematics in the first year of post-primary school?
- How do students fare in the individual strand areas – Number, Measures, Shape and Space, Algebra, and Data – and in the process skills of Concepts and Facts, Computation and Word Problems that comprise the first-year mathematics curriculum?
- What implications can we draw from the first-year data in mathematics?

5.2 Research design

Careful consideration was given at the design stage as to how to measure progress in mathematics as intended, and what instruments would be used. The use of a custom self-constructed assessment instrument was ruled out in favour of two existing standardised tests as detailed below. Significant preliminary work was done to confirm that the choice was a good match for this study, e.g. the tests were already standardised for the same population of Irish students, the mathematics was appropriate and matched the expected outcomes of the current curriculum. Further, we were satisfied that appropriate statistical analyses would yield valid data and findings. Using these test instruments, the researchers were able to set up a pre- and post-test scenario and match pre scores to post scores, maintaining confidentiality and anonymity by working with school principals, teachers and students and various other stakeholders as required.

The two main standardised assessment instruments purposely designed for use within the Irish primary school system, and commercially available, are the SIGMA-T and Drumcondra Primary Mathematics Test – Revised. Both tests were standardised using a population of relevant students in Ireland and were designed to measure student knowledge of the curriculum. Given that standardised achievement scores and prior grades are the strongest predictors of high school grade point average (GPA) (Casillas et al., 2012), the authors used an appropriate standardised sixth-class (primary school) test to assess student progress across the transition. The Level 5 SIGMA-T contains 119 items to assess student achievement in the following five areas: number, measurement, geometry, elementary algebra, and data and statistics. These questions are mostly based on the mathematics curriculum from the last two years of primary school and require students to perform several mathematical procedures and solve word problems relating to the content studied (Wall, 2015). The Level 5 SIGMA-T provides a raw score, standard score, percentile rank and STEN score. The raw score relates to the number of questions answered correctly from a total of 119 questions in the SIGMA-T test. Raw scores can then be converted into standard scores, percentiles and STEN scores. A STEN score (Table 1) is a score from 1 to 10 that compares a student's result to that of the standardised sample (NCCA, 2008).

STEN Score	What does the STEN score mean?	Proportion of children with this score
8–10	"well above average"	⅙
7	"high average"	⅙
5–6	"average"	⅓
4	"low average"	⅙
1–3	"well below average"	⅙

Table 1 STEN Scores

The percentile rank is useful in comparing students in more detail than the STEN score and compares student results to that of the standardisation sample, at the end of sixth class. If a student obtains a percentile rank of 64, it means that the student has performed as well as, or better than, 64% of students who formed the standardisation sample at the end of sixth class. The percentiles assigned to all first-year data in this study are based on a sixth-class standardised sample.

The Drumcondra Primary Mathematics Test – Revised is a standardised mathematics assessment test and was developed in 1997 and revised in 2005. More than 16,000 pupils were used in the development of the norms for each level of the test. Level 6 of the test is used for students in sixth class. The test provides a raw score, standard score, STEN score and percentile rank, as well as scores on the strand areas and process skills. This was possible as the authors of the SIGMA-T compared the standard scores of 256 students who sat both the Drumcondra Primary Mathematics Test – Revised (Levels 5 and 6) and the SIGMA-T (Level 5) and the correlation was found to be .854.

The target population was first-year students in the Republic of Ireland commencing secondary education in September 2015. The sampling design used for this study was modelled on the sampling design used for PISA assessment (OECD, 2014). The sampling frame was the entire set of 723 post-primary schools in Ireland and this accounted for 367,178 students, which approximated to 61,196 first year students. Ethical approval for this study was granted by the appropriate ethics committee at the University of Limerick (Code: 2015_09_01_S&E). The first stage of the sample design involved stratifying the list of schools into the four distinct school types, namely: secondary, vocational, community and comprehensive.[2] It was decided to use these categories as data on the number of schools and students attending each school are readily available for each stratum. Separate school sampling sub-frames were composed for each school type and 14 schools were sampled using probability proportional to size systematic sampling. A simple random sample of first-year mathematics classes in a chosen school was used to select a class and all students from the selected class were included in the sample. These students had completed a competency test, SIGMA-T Level 5 or Drumcondra Primary Mathematics Test – Revised Level 6 at the end of primary school. The SIGMA-T Level 5 test was redistributed a year later to measure progress in academic achievement in May 2016.

The final sample size was 323 students. Due to absenteeism, 301 students sat the SIGMA-T at the end of first year. It was possible to obtain the sixth-class results for 249 of these students by contacting the primary school they attended. This was a very onerous but necessary task for the researcher and involved a major commitment of her personal resources over a long period as 109 primary schools were involved. It was not possible to obtain sixth-class data for 52 students due to non-cooperation or absence of records.

To determine the effects of the transition from primary to secondary education on students' achievement, an analysis of students' pre- and post-test scores was carried out. The purpose of the comparison was to assess student progress in mathematics during the first year in secondary education. The authors categorised student data into three groups:

- Students who completed the SIGMA-T standardised mathematics test in sixth class and also the SIGMA-T standardised mathematics test in first year (Student Group A),
- Students who completed the Drumcondra standardised mathematics test in sixth class and the SIGMA-T standardised mathematics test in first year (Student Group B),
- All students who completed either the Drumcondra or SIGMA-T standardised mathematics test in sixth class and the SIGMA-T standardised mathematics test in first year (Student Group C).

All the data was collected and imported into SPSS for quantitative analysis. A paired t-test was employed on each of the three groups to determine whether there was a statistically significant mean difference in the results obtained at the end of sixth class and the end of first year. The authors chose the paired t-test as the data was approximately normal and the paired t-test is robust enough to deal with departures from normality (Marshall, 2015) once the sample size is large enough ($n>30$ or 40) (Ghasemi & Zahediasl, 2012).

---

[2] Secondary schools are privately owned and managed. Vocational schools are governed by the state through Education and Training Boards (ETBs), while Boards of Management manage community and comprehensive schools.

5.3 Curriculum map

A curriculum map (Ryan, 2018) was constructed for the purposes of checking the extent to which the learning outcomes of the sixth-class (primary school) mathematics curriculum corresponded to the learning outcomes of the first year Common Introductory Course (post-primary/lower secondary school). The primary mathematics curriculum in Ireland is bridged to the Junior Cycle (years 1–3 of post-primary school) mathematics curriculum through the Common Introductory Course. The Common Introductory Course, introduced as part of the revised curriculum and followed by first-year students in secondary education, aims to build on the mathematics experiences of students in fifth and sixth class of primary school. This analysis showed that 82% of the learning outcomes of the sixth-class mathematics curriculum are repeated in the first-year Common Introductory Course. This very high level of correspondence between curricula reinforced our confidence in the approach taken in this study and the instruments used.

6 Results

In this section the authors present an overall summary of statistical results followed by a more detailed analysis focused on each student group, A, B and C.

6.1 Summary of results

The academic results of this study indicate that academic transition in mathematics is problematic for many students as they proceed from primary to post-primary education in Ireland and suggest that students are underperforming in mathematics during this phase of their education. This study found statistically significant decreases of 7.87 in raw score (n=163) and of .78 in STEN (n=176), between the end of sixth class and the end of first year, for the students who sat the SIGMA-T on both occasions. For the 249 students who sat either the SIGMA-T or Drumcondra in sixth class and the SIGMA-T at the end of first year, the decrease in STEN score was .77 and the decrease in percentile was 8.18. All decreases were statistically significant. In a comparison of STEN results for 249 students, 59.04% of students regressed, 6.43% of students showed an increased STEN result and 34.54% of students recorded no change in STEN. Since the STEN scores assigned to all first-year data are based on a sixth-class standardised sample, this means that the changes reported in this study are conservatively estimated and the losses incurred in first year are more pronounced. It was possible to compare results by strand area for 87 students and there was a statistically significant decrease across each of the five strands. Shape and Space results declined by 12.46%, followed by Data which declined by 11.55%, Algebra declined by 6.18%, Measures declined by 5.39% and Number declined by 3.82%. The greatest decline related to Shape and Space results and this has been repeatedly highlighted as an area of concern in PISA 2003 and PISA 2012 results (Perkins & Shiel, 2016). It was possible to compare results by process skill for 87 students and there was a statistically significant decrease across each of the three process skills. The greatest decline was in computation where this skill worsened by 8.75%, followed by word problems which worsened by 6.91%, and concepts and facts which worsened by 5.77%.

6.2 Student group A

Incomplete data from sixth class allowed comparison of raw scores for 163 out of 176 students. These students completed the SIGMA-T standardised mathematics test in sixth class and the SIGMA-T standardised mathematics test again at the end of first year of secondary education. The raw score relates to the number of questions answered correctly from a total of 119 questions. A paired-samples t-test was conducted to evaluate the impact of the first-year mathematics course on students' raw scores on the SIGMA-T test. There was a statistically significant decrease in scores from Time 1 to Time 2 (Table 2). These results question the effectiveness of the Common Introductory Course followed by first-year students and are indicative of the discontinuity and fresh start approach, which are known to hamper transitional success.

	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 Raw Score 1	76.245	163	20.2951	1.5896
Raw Score 2	68.374	163	21.3689	1.6737

Table 2 Raw Score Paired Samples Statistics

A Pearson product-moment correlation coefficient was computed to assess the relationship between raw score 1 and raw score 2. The data shows a positive correlation between raw score 1 and raw score 2, $r = 0.87$, $n = 163$, $p < .005$. The mean decrease in raw scores was 7.87 with a 95% confidence interval ranging from 6.20 to 9.54. The eta squared statistic (.35) was used to measure effect size or the size of the difference between the two sets of data. This represents a large effect size which is an effect that is so large and consistent that it is sometimes possible to see it with the naked eye (Coe, 2002). On average, students' raw scores decreased from 76 questions correct from a total of 119 to 68 questions correct from a total of 119 between the end of sixth class and the end of first year of secondary education.

6.3 Student group B

73 students in the overall sample completed the Drumcondra standardised test in sixth class and the SIGMA-T standardised test at the end of first year. As the Drumcondra Primary Mathematics Test – Revised (Levels 5 and 6) and the SIGMA-T (Level 5) have a strong positive correlation of .854, it was possible to compare both the two for these 73 students. A paired-samples t-test was conducted to evaluate the impact of the first-year mathematics course on students' percentile scores. There was a statistically significant decrease in percentiles from Time 1 to Time 2 (Table 3). The eta squared statistic (.37) indicated a large effect size. The results highlight that students fail to show mathematical advancement during the course of first year.

	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 Percentile 1	64.806	72	26.7201	3.1490
Percentile 2	52.806	72	28.3627	3.3426

Table 3 Percentile Paired Samples Statistics

A Pearson product-moment correlation coefficient was computed to assess the relationship between percentile 1 and percentile 2. The data shows a positive correlation between percentile 1 and percentile 2, r = 0.84, n = 72, p < .005.

6.4 Student group C

Student Group C is formed by combining Student Groups A and B. This accounts for 249 students who completed either the Drumcondra or SIGMA-T standardised mathematics test in sixth class and the SIGMA-T standardised mathematics test in first year. The results from this overall group show a decline in student mastery, which is perhaps partly attributable to the weakening of the strength of the relationships within this community of learning as students pass from primary to post-primary school. One of these relationships involves the knowledge of respective curricula and teaching methodologies between sixth-class and first-year teachers (Prendergast et al., 2016). The results also suggest a level of confusion which may be due to the different methods of teaching the same topics between primary and secondary school (Galton et al., 1999). There is a strong positive correlation between student performance on the two tests (r = .88 for STEN and r = .73 for percentile). A paired-samples t-test was conducted to evaluate the impact of the first-year mathematics course on students' STEN and percentile scores. There was a statistically significant decrease in STEN and percentile scores from Time 1 to Time 2 (Table 4). The mean decrease in STEN scores was .77 with a 95% confidence interval ranging from .65 to .89. The eta squared statistic (.40) indicated a large effect size. The losses recorded in each of the student groups are more pronounced than comparable studies (Cox & Kennedy, 2008; Galton et al., 2000). The mean decrease in percentile scores was 8.18 with a 95% confidence interval ranging from 5.46 to 10.89. The eta squared statistic (.12) indicated a large effect size.

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1 STEN Score 1	6.618	249	1.9227	.1218
STEN Score 2	5.847	249	1.9158	.1214
Pair 2 Percentile 1	61.916	249	30.3578	1.9238
Percentile 2	53.739	249	28.9468	1.8344

Table 4 STEN and Percentile Paired Samples Statistics

A Pearson product-moment correlation coefficient was computed to assess the relationship between STEN score 1 and STEN score 2. The data shows a positive correlation between STEN score 1 and STEN score 2, r = 0.88, n = 249, p < .005. A Pearson product-moment correlation coefficient was computed to assess the relationship between percentile 1 and percentile 2. The data shows a positive correlation between percentile 1 and percentile 2, r = 0.73, n = 249, p < .005. The data indicates negative outcomes for students across all the statistical tests used.

7 Discussion

7.1 Research questions revisited

The findings are surprising and worrying on several fronts from the perspective of the researchers who are experienced professional mathematics teachers and mathematics teacher educators. Using the methodology described earlier in the paper, the data shows a statistically significant decline in student performance in mathematics at the end of first year post-primary school. This decline is greater than that reported in other studies, e.g. Galton et al. (2000). For example, for student group A, where it was possible to compare raw scores at the end of sixth class with raw scores at the end of first year of post-primary, 81% of students dis-improved. This is surprising given the reform emphasis in mathematics and the bridging strategy employed based on a Common Introductory Course (CIC) that was designed specifically to ease the transition in mathematics.

How did students fare in the individual strand areas – Number, Measures, Shape and Space, Algebra, and Data – and in the process skills of Concepts and Facts, Computation and Word Problems that comprise the first-year mathematics curriculum? Research Question 2 investigated the performance of students in all strand areas in order to develop a more detailed profile of students' performance including their command of important process skills. This study recorded statistically significant decreases in all strand areas and in each process skill. Clearly, the TIMSS results for Ireland in 2015 (Clerkin et al., 2016), suggesting the reforms have been successful only at primary level, were an early warning that much more needed to be done at post-primary level.

What implications can we draw from the first-year data in mathematics? We are surprised to find that the sample as whole exhibits a significant decline in mathematics performance, and worried because this is so despite unprecedented attention and investment in a new post-primary mathematics curriculum and teacher professional development. This was unexpected as we had followed the Rite of Passage model (Clark & Lovric, 2009) ensuring our testing took place at the end of first year, which allowed for losses over the summer months and a lengthy settling in period. A previous Irish study (Smyth et al., 2004) pointed to issues with computation in the transtion but clearly there are wider concerns as this study indicates poor performance across all strands of the mathematics curriculum.

7.2 The influence of contextual factors

These poor results must be taken in context, and in this case they are mitigated somewhat by the prevailing circumstances at the time and immediately prior to it when the new mathematics curriculum was implemented on a phased basis and was 'bedding in', and the government was engaged in a major programme to upskill out-of-field teachers of mathematics. There is also the matter of the socio-cultural milieu in education and its impact on the transition. Historically in Ireland, school education is examinations-oriented with high-stakes State examinations at the end of schooling. This emphasis and its impact on professional practice in mathematics teaching has led to a narrow exam-oriented pedagogy in mathematics that is difficult to replace during reform of the curriculum. An additional layer of difficulty is added by circumstances in teacher education since there is complete separation between the teacher education for primary and post-primary teachers. The authors have attempted to understand and rationalise these issues as they impact on the academic transition in mathematics in Ireland by resorting to Bernstein's work. Bernstein's theory on classification and framing (Bernstein, 2000) offers another perspective on examination of the results. Post-primary schools in Ireland are typically associated with stronger classification and stronger framing than primary schools, given, for example, the multiplicity of teachers and subjects as well as the focus on examinations. The very nature of instruction in post-primary school, students going from a single teacher to multiple teachers in post-primary school, represents strong subject classification (Bernstein, 2000) and lessens the opportunities for integration. In addition, the lack of collaboration between primary and post-primary teachers points to strong classification and strong framing (Bernstein, 2000). The decreased instruction time and the focus on exam pressures at secondary level points to strong framing which limits the teacher's autonomy in choosing their teaching and learning methods. The academic decline may be correlated with the classification/boundaries in operation in a school environment and the framing/power teachers and students have on practice within this environment. How student knowledge is formed is a function of this classification and framing. In addition, the classification and framing of knowledge mould identity and consciousness through the distribution and re-contextualisation of the knowledge (Wheelahan, 2005). The academic decline highlighted by the results may be indicative of the differences in the level of control a first-year mathematics teacher and a sixth-class mathematics teacher have in relation to pedagogy, assessment and curriculum design.

Nevertheless, the results are a cause for concern. The results highlight an opportunity cost for students as they are failing to reach their full potential in mathematics in first year. This underperformance in first year has a knock-on effect in the remaining two years of Junior Cycle (lower secondary) school. This leads to students trying to make up lost ground in their subsequent two years of Junior Cycle mathematics and militates against more students achieving higher grades even for students who make up lost ground. While the national strategy target of 60% of students sitting the Junior Certificate Higher-level mathematics exam by 2020 (Department of Education and Skills, 2011) has been achieved, increased numbers of students sitting Higher-level mathematics is not a cause for celebration when significant improvements in mathematics have not been recorded by PISA and TIMSS in relation to post-primary schools (Clerkin et al., 2016; Perkins & Shiel, 2016).

7.3 Contributory factors related to underperformance in mathematics

This study points to the mathematical transition from primary to secondary education as a significant contributory factor in Irish students' underperformance in mathematics in Junior Cycle (lower secondary education). A number of factors, such as instruction time, collaboration of stakeholders and the Common Introductory Course, are important considerations in understanding how best to improve the transition process in mathematics. While The National Strategy to Improve Literacy and Numeracy among Children and Young People, 2011–2020 (Department of Education and Skills, 2011), and PISA and TIMSS testing highlight the importance of the transition from primary to secondary education, they do not specifically examine the transition. TIMSS testing in second year and PISA testing for students aged 15 do not show or examine the impact of transition on student mathematical advancement. This study addresses this gap and provides evidence of a significant decline in mathematical achievement between sixth class and first year in Irish schools.

7.3.1 Instruction time in school mathematics

The difference in instruction time between sixth class and first year of secondary school may account in part for the TIMSS 2015 results, which have shown significant improvements in fourth-class results (primary school) but no real improvements in second-year (post primary/ lower secondary) achievement data since 1995. In addition, PISA 2015 results show Irish students are not among the high-performing mathematics countries and no real improvement in achievement has been recorded despite the introduction of the new post-primary mathematics curriculum. To ensure continuity, the issue of instruction time may have to be revisited. Perhaps it would be prudent to, at least, match that of sixth class. In addition, it is important to recognise that at secondary school, either the teacher or the students must move to a different classroom and this disruption further affects the quantity and the quality of the instruction time. Improving performance is not simply about increasing the amount of instruction time available but about maximising instruction time to ensure students are engaged in tasks which provide a challenge and yet allow them to experience success (Aronson, Zimmerman, & Carlos, 1999). The decreased time afforded to mathematics in first year of secondary school in Ireland in comparison to sixth class impedes the continuity necessary for a successful transition.

7.3.2 Collaboration across the transition

Meaningful collaboration is necessary between sixth-class and first-year teachers. A greater awareness is needed of the curricula and teaching methodologies employed by each. Developing familiarity with the respective curricula and teaching methodologies should be a major concern of teacher educators at both levels and should be dealt with in teacher education programmes in primary and secondary education. The Communities of Practice model (Wenger, 2000) emphasises the importance of parental involvement in the transition process. It also stresses the need for collaboration of parents, students and teachers to ensure student engagement and mastery. There is a statistically significant positive correlation between parents' attitudes towards mathematics and their children's attitude towards mathematics (Mohr-Schroeder et al., 2017), and parents' interest in the school and parents' level of satisfaction in mathematics is linked to students' belief in their own ability (Surgenor, Millar, Close, & Shiel, 2006). Parents need to be given the tools to play a greater role in the mathematics education of their children in first year of secondary education to ensure transitional success. This is supported by the theoretical framework of both Schlossberg (1981) and Wenger (2000).

7.3.3 Effectiveness of the Common Introductory Course (CIC)

The academic results of this study question the effectiveness of the Common Introductory Course followed by first-year students. The decrease in computational skills points to a need for increased practice and a possible over-reliance on the calculator. This decline in computation is only evident because students were not allowed to use a calculator on either the test at the end of sixth class or the test at the end of first year in this study. Both student motivation and learning can be improved by a moderate level of challenge (Brophy, 2013; Stipek, 1993). While continuity is a key factor in successful transition, continuity for first-year students should not constitute a repetition of prior learning. The importance of student exposure to challenge in mathematics has been acknowledged by international research (Applebaum & Leikin, 2007; Taylor, 2005; Turner, 2010), and yet many of the learning outcomes of the Common Introductory

Course are exactly the same as the learning outcomes for the sixth-class mathematics syllabus. Therefore, it is hard to see how students can be sufficiently challenged under these circumstances by providing them with sufficient opportunities to develop understanding and reasoning skills.

In its present form, the Common Introductory Course undervalues the importance of building on student prior knowledge because a student's prior knowledge is not accessed as this course effectively assumes a fresh start approach where students are re-taught the material from sixth class. The fresh start approach in first year which disregards prior learning has been shown to have negative consequences for student engagement and learning (Bicknell & Hunter, 2012; Galton et al., 2003). Diezmann and Watters (2002) posit that challenge is fundamental to progress in mathematics education. There is limited cognitive value to activities or problems that are too easy or too hard (Diezmann & Watters, 2002). Motivation, interest and commitment or perseverance are all highly dependent on the provision of challenging tasks in the mathematics classroom (Diezmann & Watters, 2002; Turner & Meyer, 2004). Challenge in mathematics fosters qualities such as patience, perseverance and flexibility. It also allows students to enhance their mathematical understanding, develop their confidence and potential and ultimately allows for the experience of success and engagement with fellow learners (Barbeau & Taylor, 2009).

8. Contribution

This study is important because it contributes to the discourse on transition and adds new evidence-based knowledge to the area, albeit in the academic area of school mathematics. Whereas there exists an extensive research literature on transitions in general and from primary to post-primary (secondary education) from socio-cultural and psychological perspectives, the specific issues surrounding academic transitions are under-researched. The authors address this gap in the research by investigating student performance in mathematics after the transition from primary to secondary education in Ireland. Their study is underpinned by a theoretical framework that: integrates features of collaboration of parents, students and teachers; emphasises that adaptation to transition takes time; and uses the characteristics of the individual and the environment to explain and understand issues related to academic performance of students in mathematics.

The research intention and the design of the study are national in scope as they were directed at the Irish education system as a whole. While the problematic nature of the mathematics transition from primary school to post-primary school was acknowledged in official circles and by stakeholders, these concerns were not well established in research. Nevertheless, there was a significant effort to address the mathematics transition in the implementation of a reformed mathematics curriculum using a Common Introductory Course (CIC). The study uncovered unexpected shortcomings with the CIC programme and surprising levels of mathematical underperformance of students. The investigation established measures of underperformance and demonstrated that this underperformance was evident across all strands and not just in computation as reported in a previous study (Smyth et al., 2004). Contributory issues such as instruction time, lack of effective collaboration between primary and post-primary teachers (mathematics), and the 'fresh start' approach adopted by post-primary mathematics teachers have been highlighted by this research. The evidence developed through this research is available for policy makers, school leaders and teachers, and mathematics teacher educators as they grapple with the task of improving school mathematics education for all students.

It is expected that colleagues in the wider international mathematics education research community will be interested in this study, its findings and what it tells us about addressing a mathematical transition in the context of a major reform of the national curriculum in mathematics. More specifically, the study addresses a gap in the international literature on transition studies by focusing on the mathematical transition from primary to post-primary (secondary) school mathematics in Ireland in the context of major national reform of the mathematics curriculum; provides concrete data for comparisons with other similar studies in other countries; and provides opportunities for further learning by researchers and practitioners in the field. We can learn from successes and failures but also by studying serious attempts which fall short of the mark but are not yet failures because the whole story has not yet been enacted in the ongoing reform context.

9. Concluding remarks

This study is the first Irish study to provide a detailed analysis of academic achievement in mathematics over the transition period. Unlike Smyth's study (Smyth et al., 2004), this study allowed for losses during the summer break by taking results at the end of sixth class and comparing them to results at the end of first year; used a large stratified random sample; and measured achievement by strand area and process skill. The results of this study show that the Common Introductory Course is not working as the levels of regression and standstill in mathematics during the primary to post-primary transition are far higher than those of our international counterparts. In addition, this failure is connected to the first-year teachers' knowledge of the curriculum and teaching methodologies employed at primary level. The effectiveness of the Common Introductory Course in mathematics, designed to assist in the transition and followed by all students in their first year of education in post-primary school in Ireland, seems to be falling well short of its goals. As implemented, it represents much repetition of work already completed in sixth class and foregoes the opportunity to build on primary school mathematics.

The findings have major implications not only for our education system but for the personal development of young students, their present and future functioning within society, their career choices and the nation's economic prosperity. Therefore, it is very important that we address student underperformance in mathematics in first year of post-primary school. Understanding what is happening at this time in students' lives is necessary if we want to raise student levels of knowledge and understanding in mathematics, both nationally and internationally.

Conflict of interest
On behalf of all authors, the corresponding author states that there is no conflict of interest.

Funding
No funding was received for conducting this study.

The authors have no relevant financial or non-financial interests to disclose.

Data availability

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Ethical approval

Ethical approval for this study was granted by the appropriate ethics committee at the University of Limerick (Code: 2015_09_01_S&E). The parents, students, teachers and individuals involved in the study were informed of the purpose of the research in advance of data collection and they had the opportunity to withdraw from the study throughout the process. Approval was granted by the parents, school principals and the University of Limerick. Parental consent was secured for all participating students. In addition, school principals from both primary and post-primary schools were asked to consent to the research on behalf of their staff and students. Once overall consent was agreed, individual staff and students were sent a letter of consent. As part of the process of gaining their informed voluntary consent, the purpose and methodology of the study was explained to all participants. Each student was allocated a number to guarantee confidentiality. In June 2015, a letter of consent was sent to all parents, teachers and principals involved explaining their role and that of the students involved in the study. Leaflets containing relevant information explaining the research purposes and procedures were also provided to students and their parents/guardians to inform their decision regarding whether to agree to participate.

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Veronica Ryan, Dr Olivia Fitzmaurice and Prof. John O'Donoghue. The first draft of the manuscript was written by Veronica Ryan and all authors commented on the manuscript and subsequent changes were made to the manuscript. All authors read and approved the final manuscript.

Conceptualization: Dr Veronica Ryan, Dr Olivia Fitzmaurice and Prof. John O'Donoghue.
Methodology: Veronica Ryan, Dr Olivia Fitzmaurice and Prof. John O'Donoghue
Formal analysis and investigation: Dr Veronica Ryan; Writing – original draft preparation: Veronica Ryan; Writing – review and editing: Dr Olivia Fitzmaurice and Prof. John O'Donoghue. Funding acquisition: N/A; Resources: N/A; Supervision: Dr Olivia Fitzmaurice and Prof. John O'Donoghue.

Acknowledgement

Nothing to declare.

References

Anderson, L. W., Jacobs, J., Schramm, S., & Splittgerber, F. (2000). School transitions: beginning of the end or a new beginning? *International Journal of Educational Research*, 33(4), 325-339. doi:10.1016/s0883-0355(00)00020-3

Applebaum, M., & Leikin, R. (2007). *Teachers’ conceptions of mathematical challenge in school mathematics*. Paper presented at the Proceedings of the 31st International Conference for the Psychology of Mathematics Education, Korea.

Aronson, J., Zimmerman, J., & Carlos, L. (1999). Improving Student Achievement by Extending School: Is It Just a Matter of Time? San Francisco: WestEd.

Ashton, R. (2008). Improving the transfer to secondary school: how every child’s voice can matter. *Support for Learning*, 23(4), 176-182.

Barbeau, E. J., & Taylor, P. J. (Eds.). (2009). Challenging mathematics in and beyond the classroom: the 16th ICMI study. New York: Springer.

Bernstein, B. B. (2000). Pedagogy, symbolic control, and identity: Theory, research, critique (Vol. 5): Rowman & Littlefield.

Bicknell, B., Burgess, T., & Hunter, R. (2009). Explorations of Year 8 to Year 9 transition in mathematics. *Findings from the New Zealand Numeracy Development Projects*, 145-157.

Bicknell, B., & Hunter, R. (2012). School Transition from Year 6 to Year 7: A Focus on Mathematics. *International Journal for Mathematics Teaching & Learning*.

Bicknell, B., & Riley, T. (2012). Investigating transitions in mathematics from multiple perspectives. *Mathematics Education Research Journal*, 24(1), 1-17. doi:10.1007/s13394-011-0027-y

Bloyce, J., & Frederickson, N. (2012). Intervening to improve the transfer to secondary school. *Educational Psychology in Practice*, 28(1), 1-18.

Brophy, J. E. (2013). *Motivating students to learn*. New York: Routledge.

Brown, J. M., & Armstrong, R. (1982). The Structure of Pupils’ Worries During Transition from Junior to Secondary School. *British Educational Research Journal*, 8(2), 123-131. doi:10.1080/0141192820080202

Carmichael, C. (2015). Transitioning to secondary school: The case of mathematics. *Australian Journal of Educational & Developmental Psychology,* 15.

Casillas, A., Robbins, S., Allen, J., Kuo, Y.-L., Hanson, M. A., & Schmeiser, C. (2012). Predicting early academic failure in high school from prior academic achievement, psychosocial characteristics, and behavior. *Journal of Educational Psychology*, 104(2), 407.

Chedzoy, S. M., & Burden, R. (2005). Making the move: Assessing student attitudes to primary-secondary school transfer. *Research in Education*, 74(1), 22-35.

Clark, D., & Linn, M. C. (2003). Designing for knowledge integration: The impact of instructional time. *Journal of the Learning Sciences*, 12(4), 451-493. doi:10.1207/s15327809jls1204_1

Clark, M., & Lovric, M. (2009). Understanding secondary–tertiary transition in mathematics. *International Journal of Mathematical Education in Science and Technology*, 40(6), 755-776. doi:10.1080/00207390902912878

Clerkin, A., Perkins, R., & Cunningham, R. (2016). *TIMSS 2015 in Ireland: Mathematics and science in primary and post-primary schools*. Retrieved from Dublin: http://www.erc.ie/wp-content/uploads/2016/11/TIMSS-initial-report-FINAL.pdf

Coe, R. (2002). *It’s the effect size, stupid:*

What effect size is and why it is important. Paper presented at the The 2002 Annual Conference of the British Educational Research Association, University of Exeter, Exeter, Devon, England. http://www.leeds.ac.uk/educol/documents/00002182.htm

Cosgrove, J., Perkins, R., Shiel, G., Fish, R., & McGuinness, L. (2012). *Teaching and Learning in Project Maths: Insights from Teachers who Participated in PISA 2012*. Retrieved from Dublin: http://www.erc.ie/documents/p12teachingandlearningproject-maths.pdf

Cox, S., & Kennedy, S. (2008). Students' achievement as they transition from primary to secondary schooling: Report no. 1 on the students' transition from primary to secondary schooling study (0478137982). Retrieved from Wellington: https://www.educationcounts.govt.nz/publications/schooling/31857

Department of Education and Skills. (2011). *Literacy and numeracy for learning and life: The national strategy to improve literacy and numeracy among children and young people, 2011-2020*. Retrieved from Dublin: https://www.education.ie/en/Publications/Education-Reports/pub_ed_interim_review_literacy_numeracy_2011_2020.PDF

Diezmann, C. M., & Watters, J. J. (2002). The importance of challenging tasks for mathematically gifted students. *Gifted and Talented International*, 17(2), 76-84.

Doyé, P., & Hurrell, A. (1997). *Foreign language learning in primary schools (age 5/6 to 10/11)*. Strasbourg: Council of Europe.

Evangelou, M., Taggart, B., Sylva, K., Melhuish, E., Sammons, P., & Siraj-Blatchford, I. (2008). Effective pre-school, primary and secondary education 3-14 project (EPPSE 3-14): What makes a successful transition from primary to secondary school? (1847750850). Retrieved from Nottingham: http://eprints.ioe.ac.uk/5267/1/Taggart2008Whatmakesasuccessful1.pdf

Galton, M., Gray, J., & Ruddick, J. (1999). The impact of school transitions and transfers on pupil progress and attainment. London: DfEE.

Galton, M., Hargreaves, L., & Pell, T. (2003). Progress in the middle years of schooling: Continuities and discontinuities at transfer. *Education 3-13*, 31(2), 9-18. doi:10.1080/03004270385200161

Galton, M., Morrison, I., & Pell, T. (2000). Transfer and transition in English schools: reviewing the evidence. *International Journal of Educational Research, 33*(4), 341-363. doi:10.1016/s0883-0355(00)00021-5

Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: a guide for non-statisticians. *International journal of endocrinology and metabolism, 10*(2), 486.

Gorwood, B. (1991). Primary–secondary transfer after the national curriculum. *School Organisation, 11*(3), 283-290. doi:10.1080/0260136910110304

Irish National Teachers' Organisation. (2008). *Transitions in the primary school.* . Paper presented at the INTO Consultative Conference on Education, Dublin. https://www.into.ie/ROI/Publications/TransitionsPrimarySchool.pdf

Lavy, V. (2015). Do differences in schools' instruction time explain international achievement gaps? Evidence from developed and developing countries. . *The Economic Journal, 125*(588). doi:10.3386/w16227

Lucey, H., & Reay, D. (2000). Identities in transition: anxiety and excitement in the move to secondary school. *Oxford Review of Education, 26*(2), 191-205.

Marshall, E. (2015). The statistics tutor's quick guide to commonly used statistical tests. Retrieved from http://www.statstutor.ac.uk/resources/uploaded/tutorsquickguidetostatistics.pdf

Martin, A. J., Way, J., Bobis, J., & Anderson, J. (2015). Exploring the ups and downs of mathematics engagement in the middle years of school. *The Journal of Early Adolescence, 35*(2), 199-244.

McCoy, S., Smyth, E., & Banks, J. (2012). The primary classroom: Insights from the growing up in Ireland study. Dublin: ESRI and NCCA.

McGee, C., Ward, R., Gibbons, J., & Harlow, A. (2003). *Transition to secondary school: A literature review*. Retrieved from Hamilton: https://www.researchgate.net/profile/Ann_Harlow/publication/45626499_Transition_to_secondary_school_A_literature_review/links/02bfe50e416f6e6ef3000000/Transition-to-secondary-school-A-literature-review.pdf

Midgley, C., Feldlaufer, H., & Eccles, J. S. (1989). Student/teacher relations and attitudes toward mathematics before and after the transition to junior high school. *Child Development, 60*(4), 981. doi:10.2307/1131038

Mohr-Schroeder, M. J., Jackson, C., Cavalcanti, M., Jong, C., Schroeder, D. C., & Speler, L. G. (2017). Parents' attitudes toward mathematics and the influence on their students' attitudes toward mathematics: A quantitative study. *School Science and Mathematics, 117*(5), 214-222.

NCCA. (2004). *NCCA commentary on ESRI research into curriculum provision and school integration among first year students*. Retrieved from Dublin: https://www.juniorcycle.ie/NCCA_JuniorCycle/media/NCCA/Curriculum/ESRI_NCCACommentary_1stYear.pdf

NCCA. (2005). *Review of mathematics in post-primary education: Discussion paper.* Retrieved from Dublin: https://www.maths.tcd.ie/pub/ims/bull57/riancca1.pdf

NCCA. (2008). *Your child and standarised testing – Understanding the STEN score*. Retrieved from http://www.ncca.ie/en/Curriculum_and_Assessment/Parents/Primary/Standardised_Tests/STenEng.pdf

Neild, R. C., Stoner-Eby, S., & Furstenberg, F. (2008). Connecting entrance and departure: The transition to ninth grade and high school dropout. *Education and Urban Society, 40*(5), 543-569.

O'Brien, M. (2001). A study of student transfer from primary to second level schooling: pupils', parents' and teachers' perspectives. Dublin: Department of Education and Science.

OECD. (2010). *Mathematics teaching and learning strategies in PISA*. Retrieved from Paris: http://www.oecd.org/edu/school/programmeforinternationalstudentassessmentpisa/mathematicsteachingandlearningstrategiesinpisa.htm

OECD. (2014). *PISA 2012 Technical Report*. Retrieved from Paris: https://www.oecd.org/pisa/pisaproducts/PISA-2012-technical-report-final.pdf

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

Prendergast, M., O'Meara, N., Harbison, L., & O'Hara, C. (2016). A Difficult Crossing: The Transition from Primary to Secondary School Mathematics. *Education Matters Yearbook 2016–2017* (pp. 339-343). Dublin.

Prendergast, M., O'Meara, N., O'Hara, C., Harbison, L., & Cantley, I. (2019). Bridging the primary to secondary school mathematics divide: Teachers' perspectives. *Issues in educational research, 29*(1), 243-260.

Rogoff, B., Paradise, R., Arauz, R. M., Correa-Chávez, M., & Angelillo, C. (2003). Firsthand learning through intent participation. *Annual Review of Psychology, 54*(1), 175-203. doi:10.1146/annurev.psych.54.101601.145118

Ryan, V. (2018). Making the transition: A student's mathematical journey from primary to post-primary school in Ireland [Unpublished doctoral dissertation]. University of Limerick.

Schlossberg, N. K. (1981). A model for analyzing human adaptation to transition. *The Counseling Psychologist, 9*(2), 2-18. doi:10.1177/001100008100900202

Serbin, L. A., Stack, D. M., & Kingdon, D. (2013). Academic success across the transition from primary to secondary schooling among lower-income adolescents: Understanding the effects of family resources and gender. *Journal of youth and adolescence, 42*(9), 1331-1347.

Shiel, G., Kelleher, C., McKeown, C., & Denner, S. (2015). *Future ready? The performance of 15-year-olds in Ireland on science, reading literacy and mathematics in PISA 2015*. Retrieved from Dublin: http://www.erc.ie/wp-content/uploads/2016/12/PISA2015_FutureReady.pdf

Smith, B. (2000). Quantity matters: Annual instructional time in an urban school system. *Educational administration quarterly, 36*(5), 652-682.

Smyth, E., McCoy, S., & Darmody, M. (2004). *Moving up: The experiences of first-year students in post-primary education* (1904148514). Retrieved from Dublin: https://www.esri.ie/pubs/BKMNEXT36.pdf

Stipek, D. J. (1993). *Motivation to learn: From theory to practice*. Boston: Allyn & Bacon.

Surgenor, P., Millar, D., Close, S., & Shiel, G. (2006). Counting on success: *Mathematics achievement in Irish primary schools* (0755773195). Retrieved from Dublin: https://www.education.ie/en/Publications/Education-Reports/Counting-on-Success-Mathematics-Achievement-in-Irish-Primary-Schools.pdf

Taylor, P. (2005). *Challenging mathematics and its role in the learning process*. Paper presented at the Making Mathematics Vital, Australia.

Turner, J. C. (2010). Unfinished business: Putting motivation theory to the "classroom test". In S. Karabenick & T. Urdan (Eds.),*The decade ahead: Applications and contexts of motivation and achievement*, 109-138. Emerald Group Publishing Limited.

Turner, J. C., & Meyer, D. K. (2004). A classroom perspective on the principle of moderate challenge in mathematics. *The Journal of Educational Research, 97*(6), 311-318.

van Rens, M., Haelermans, C., Groot, W., & van den Brink, H. M. (2018). Facilitating a Successful Transition to Secondary School:(How) Does it Work? A Systematic Literature Review. *Adolescent Research Review, 3*(1), 43-56.

Vorderman, C., Porkess, R., Budd, C., Dunne, R., & Rahman-Hart, P. (2011). *A world-class mathematics education for all our young people*. Retrieved from London: http://www.tsm-resources.com/pdf/VordermanMathsReport.pdf

Wall, E., & Burke, K. (2015). SIGMA-T standardised Irish graded mathematics attainment tests level 5 test manual. Kildare: CJ Fallon.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.

Wenger, E. (2000). Communities of practice and social learning systems. *Organization, 7*(2), 225-246.

Wheelahan, L. (2005). The pedagogic device: the relevance of Bernstein's analysis for VET. In J. Searle, F. Beven, & D. Roebuck (Eds.), *Vocational learning: transitions, interrelationships, partnerships and sustainable futures*. Proceedings of the 13th Annual International Conference on Post-Compulsory Education and Training, Gold Coast, Queensland, 5–7 December, 2005, 543-550. Brisbane: Australian Academic Press.

PAPER 2:
INVESTIGATING STUDENT KNOWLEDGE IN MATHEMATICS AT THE END OF THEIR FIRST YEAR OF POST-PRIMARY EDUCATION IN IRELAND: A CASE STUDY

Abstract

This paper reports on performance data obtained as an integral part of a major research study on the effect of the transition from primary to post-primary education on Irish students’ mathematics performance (Ryan, 2018). The data were obtained using a standardised test designed for use in Irish primary schools to assess student mathematical knowledge at the end of their first year of post-primary school. The results highlight significant underperformance across all curriculum strands of the official mathematics curriculum, indicating an unsatisfactory grasp of mathematical knowledge at this stage of students’ development. The item analysis also shows statistically significant differences in performance between male and female students. These findings are concerning in the context of major recent reforms of the national post-primary mathematics curriculum and targeted measures to avoid negative outcomes in mathematics as students make the transition from primary to post-primary education. In research terms, the end of year 1 in post-primary education is a neglected milestone in students’ mathematics education that straddles a key period in students’ mathematical journey when students negotiate academic and emotional transitions that affect their performance, attitudes and dispositions towards mathematics. This paper gives a recent appraisal of the mathematical knowledge of students entering year 2 of post-primary education in Ireland. It discusses factors affecting these student outcomes in mathematics in the context of the students’ transition from primary to post-primary school/mathematics. Finally, it sheds light on a neglected mathematics milestone for students, and its potential to influence future student outcomes in mathematics.

Keywords

- Transition in mathematics
- Mathematics milestone
- Mathematical achievement

1. Introduction

The convergence of government education, economic and competitiveness policies internationally has a significant influence on mathematics and STEM education. Therefore, it matters that mathematics/mathematics education is an integral part of government economic strategy and is regarded as underpinning all STEM disciplines.

International experience shows the transfer to post-primary school is often not successful for many students, creating both short- and long-term consequences (van Rens et al., 2018). It is acknowledged that the academic achievement of students in mathematics during and after the transition from primary to post-primary education is a cause for concern (Galton, Morrison, & Pell 2000; Galton, Hargreaves, & Pell 2003; Anderson et al., 2000; Attard, 2010, 2013; Carmichael, 2015), but nevertheless is extremely important for students individually and as citizens, as they pursue their educational and career trajectories. Research suggests that the transition in question negatively affects students' achievement in mathematics and their attitudes towards mathematics as exhibited in underperformance and lack of engagement as they continue their educational journeys (Midgley, Feldlaufer, & Eccles, 1989; Galton et al., 2000).

1.1 Issues and opportunities around academic transition

The transition from primary to post-primary education assumes added significance because it straddles a period in students' mathematical journey when negative attitudes and dispositions towards mathematics are formed which are known to be extremely difficult to change later, thus closing down career options for students and reducing the talent pool for the STEM economy. It follows, therefore, that the congruence of education and economic policy imperatives warrants a sharper focus on this important education transition, not least because of policies designed to benefit students and their mathematics education, and the economy. Therefore, it is an opportune time to intervene in students' mathematical education. It is important to act expeditiously because there is a significant opportunity cost associated with delay and inaction.

This transition is worthy of attention because successful transition to post-primary education has a direct impact on the mathematical future of students. Eccles et al. (1993) found that declines in achievement, motivation and students' self-concept of ability are more evident in mathematics than any other subject following the transition to middle school in their study based on 12 school districts in the US. They reported that girls are more susceptible to these negative effects than boys are. In a later US study, Neild, Stoner-Eby, and Furstenberg (2008) show that ninth-grade outcomes are major predictors of dropout, and they argue that the transition to high school is a time when a student's educational trajectory can be reshaped. Nowadays, it is an important educational goal for students that they make the transition successfully because the consequences have a significant impact on students' academic trajectory (Department of Education and Skills, 2017; Education and Training Inspectorate, Department of Education and Skills Inspectorate, 2015). It is a given that the first year of post-primary education establishes a base for mathematical advancement but it is now clear that it is also a major opportunity for educators to influence their students' mathematics trajectory in a positive way. Therefore, there is an opportunity to tackle the negative impact of the transition by completely avoiding or mitigating extreme consequences. Recent studies confirm and extend our knowledge and understanding of the mathematics transition and facilitators and inhibitors of success (Attard, 2013; Carmichael, 2015).

By recognising year-end attainment in mathematics in Junior Cycle (lower secondary education) as a significant milestone in students' mathematics development, we can bring a sharper focus to bear on the effect of this transition on mathematical performance and potential improvements to facilitate better onward progress. While all post-primary schools in Ireland measure student performance across the curriculum at year end, including mathematics, there is a dearth of research on students' mathematical knowledge and attainment at these progression points (neither TIMSS nor PISA collect data for year 1). Thus, the perspective developed in this paper has the potential to offer a significant knowledge base for teachers to improve student outcomes in mathematics as they progress through post-primary education. A critical look at the implemented mathematics programme in year 1 (in this case, the Common Introductory Course (CIC) (NCCA, 2016) in the first year of secondary education) may point to inhibitors to progress, if they exist.

1.2. Purpose and contribution of paper

The item analysis central to this study is one pillar of a larger doctoral study on student transition in mathematics from primary to post-primary education in Ireland (Ryan, 2018). Unexpected results from the main study highlighted significant underperformance in mathematics at the end of the first year in post-primary education compared to their performance at the end of primary education, and greater underperformance than that reported in other studies internationally. The quantitative analysis showed that, on average, students' raw scores decreased by 7% from sixth class to first year despite an additional year of instruction. The results indicate statistically significant losses in each curriculum content strand area and in each process skill, and statistically significant female underperformance compared to male students (Ryan, 2018).

These surprising results warrant further attention as no obvious explanations are available from existing research data. While The National Strategy to Improve Literacy and Numeracy among Children and Young People, 2011–2020 (Department of Education and Skills, 2011), PISA and TIMSS testing highlight the importance of the transition from primary to post-primary education, they do not specifically examine student knowledge following transition, at the end of their first year of post-primary education. TIMSS testing in second year and PISA testing for students aged 15 do not show the impact of transition on student mathematical performance. However, these studies do confirm that regression in post-primary mathematics is an issue and point to the problematic nature of the transition from primary to post-primary mathematics as a contributory factor (Education and Training Inspectorate, DES Inspectorate, 2015).

Consequently, the authors reasoned that a closer look at the actual performance as measured by the test instrument (Level 5 SIGMA-T standardised test) at the end of year 1, item by item, would yield important insights. Therefore, the focus in this paper is on the test data generated as part of the main study, using it to develop an understanding of the mathematics knowledge of students entering their second year of post-primary education in the study's 14 post-primary schools.

A previous Irish study on transition measured computation scores in September and May (beginning and end) of first year and was carried out 17 years ago (Smyth, McCoy, & Darmody, 2004). The educational landscape has changed extensively since Smyth's study with the introduction of a new post-primary mathematics curriculum. The main study (Ryan, 2018) referred to above presented an opportunity for an item analysis that uses a large representative sample, and represents the first evidence-based assessment of student mathematical knowledge at the end of their first year of post-primary education. This analysis assumes added significance because it relies on data collected after the introduction of the new mathematics curriculum, and in particular, the CIC (NCCA, 2016) in Junior Cycle (lower secondary education). The CIC is a bridging course designed to improve the link between primary and post-primary mathematics and ease the transition. The authors use a standardised test (Level 5 SIGMA-T) to measure student performance in mathematics for a sample of 301 students. This data is analysed for all students grouped by syllabus sections/strands (Number, Measures, Shape and Space, Data, and Algebra), process skills (Concepts and Facts, Computation, and Word Problems), and by gender.

While transitions in mathematics education are being treated more comprehensively (Gueudet, 2016), a gap remains in the international research that quantifies the impact of this particular transition on mathematics achievement. Research suggests that this is attributable to difficulties associated with finding valid measures of mathematical achievement that reflect the first-year post-primary curriculum (Carmichael, 2015). The data in this paper was generated as part of a major transition study in Ireland that deals with those issues by quantifying the impact of the transition on students' achievement in mathematics using a fit-for-purpose measure of achievement that relates specifically to the first-year post-primary mathematics curriculum as taught. Thus, this data offers an opportunity to explore an extra, hitherto unexplored, dimension of a specific focus on students' mathematical progress in year 1. Further, the authors examine the role of the teacher and pedagogical and curriculum continuity across the transition in the context of the quality of teaching experienced by students, as sub-optimal teaching has been identified as a possible contributory factor requiring further research (Carmichael, 2015).

The paper's unique contribution is that it brings a research focus to an important and hitherto under-researched milestone in Irish post-primary students' mathematics journey, including an important academic transition from primary to post-primary education. The authors offer insights based on an analysis of students' mathematical knowledge at this stage in their education, all with a view to improving student outcomes in mathematics. A fine-grained analysis of the mathematics transition from primary to post-primary education focusing on students' performance at the end of their first year in post-primary education sits well with international research in this area (Carmichael, 2015). Such an investigation is warranted because the mathematics transition is important in its own right and is recognised internationally as such because of the intrinsic value of mathematics, and its importance as an underpinning discipline for all STEM disciplines and others besides. In addition, it is widely acknowledged that this academic transition is not negotiated well by many students, as international research shows, and is marked by underperformance and poor dispositions towards mathematics with potentially lifelong consequences for students. Despite negative outcomes in mathematics for students, there is optimism that a better knowledge and understanding of this challenging transition and its impact on students will lead to successful interventions and better outcomes for students.

Consequently, this work is important in the Irish context but is no less important for colleagues in the international community of mathematics education researchers.

2. Background and context for the research

2.1 Brief sketch of the Irish education context

The Irish school system is highly centralised and comprises primary and post-primary schools. Virtually all schools are state-funded and follow the relevant centrally devised curriculum. The period of compulsory education is from six to 16 years but many children start school around five years of age, and after a period of eight years transfer to post-primary school aged 12–13 years.

Post-primary education is organised academically and administered as a compulsory Junior Cycle (three years) followed by a Senior Cycle (two years) where curriculum subjects are offered at Higher and Ordinary levels. A non-academic sixth year, called Transition Year, may be taken by students at the end of Junior Cycle.

While mathematics is not compulsory, virtually all students (90% +) study mathematics throughout their school careers up to and including Leaving Certificate mathematics. This is largely because a satisfactory performance in mathematics in the Leaving Certificate examination is an entry requirement for many degree and other programmes in the higher-education sector.

2.2 Mathematics education context

The school mathematics landscape in Ireland has changed dramatically in recent years because of a major ongoing government reform agenda in education (Department of Education and Skills, 2017). A new primary-school mathematics curriculum introduced in 1999 is currently under review. The primary mathematics curriculum is organised in five strands: Number, Measures, Shape and Space, Algebra, Data. Each strand is associated with year-appropriate outcomes for Irish children (Department of Education and Science, 1999). A new post-primary mathematics curriculum known locally as Project Maths was introduced in 2010. This new curriculum aims to develop greater students' understanding of mathematical concepts and their problem-solving abilities in real contexts (Cosgrove et al., 2012). The new curriculum content is organised in five content strands: Number, Measures, Algebra, Shape and Space, and Data. This content organisation sits well on top of the primary-school mathematics curriculum that is similarly organised in similar content strands. In addition, the curriculum design includes a common year-long bridging programme, the CIC (NCCA, 2016), to address content continuity issues in the transition from primary to post-primary mathematics. A major national programme of professional development for existing post-primary mathematics teachers accompanied the mathematics reform.

3. Relevant literature

Key factors identified in the literature review as impacting negatively on academic performance in mathematics in the transition include the role of the teacher, pedagogical and curriculum continuity (or rather, discontinuity), the 'fresh start' approach, and the quantum of instruction time (Ryan, 2018). For example, Attard's study of Australian students found that student engagement in mathematics is based on positive teacher–student and student–student relationships in the middle years (Attard, 2010). The quality of mathematics teaching is also an important factor in successful transition (Darling-Hammond, 2000). In addition, the teacher and quality of their teaching affect student attitudes towards mathematics, which ultimately affect their engagement with the subject in both the short and long term (Midgley, Feldlaufer, & Eccles, 1989; Galton et al., 2000). Bicknell and Riley (2012) reported that problems arise around curriculum continuity when there is a 'fresh start' approach. The authors discuss these factors later when they revisit the research aims in the context of this investigation and its findings. In addition, the authors introduce a gender perspective on student performance at the end of their first year of post-primary school.

4. Research design

In this paper, the authors examine data for 301 students who sat the Level 5 SIGMA-T standardised test as part of the main transition study. They analyse the data with a view to learning more about the mathematical knowledge of these students at this point in their mathematics education, and explore what this might tell us about the mathematical knowledge of Irish students in general at this milestone.

The research aims are:

- to investigate the mathematical knowledge of students at the end of year 1,
- to examine the data for gender differences, and
- to identify potential inhibitors to progress in year 1 mathematics.

4.1 Sample

The sampling design used for this study was modelled on the sampling design used for PISA assessment (OECD, 2014). The sampling frame for the main transition study was the official list of 723 post-primary schools in Ireland, which accounted for 367,178 students and equated to 61,196 first-year students starting post-primary school in September 2015 (Ryan, 2018). Schools were stratified by school type, namely: secondary, vocational, community, comprehensive,[3] and this division formed new sub-frames for the sampling. The projected sample size for the main study was 382 students, assuming a population of 61,196 students, a 95% confidence level and a 5% margin of error.

The initial sample consisted of 20 schools and 11 agreed to take part in the study. Nine replacement schools were then selected and four of these replacement schools agreed to participate. Subsequently, one of the original schools selected refused to participate. Finally, 14 selected schools agreed to participate. The researcher selected participating schools using probability-proportional-to-size systematic sampling. Replacement schools were selected when the initial 20 schools were identified. All 14 schools had multiple first-year mathematics

---

[3] Secondary schools are privately owned and managed. Vocational schools are governed by the state through Education and Training Boards (ETBs), while Boards of Management manage community and comprehensive schools

classes. A simple random sample of first-year mathematics classes in a chosen school was used to select a class, and all students from the selected class were included in the main sample. This process resulted in a final sample size of 323 students. Due to absenteeism on the day, 301 students sat the test (Level 5 SIGMA-T) at the end of first year. The mean age of these 301 students on the day of testing was 13.47 years. Ethical approval was granted by the appropriate ethics committee at the University of Limerick (Code: 2015_09_01_S&E).

4.2 Research instrument

The Level 5 SIGMA-T test is the research instrument used to generate the results reported in this paper. The SIGMA-T is a standardised mathematical attainment test purposely designed for use within the Irish school system. Form A and Form B represent parallel forms of the Level 5 SIGMA-T test and are used to minimise the possibility of copying.

This test measures student achievement in number, measurement, geometry, elementary algebra, and data and statistics, and is mostly based on the curriculum from the final two years of primary school. These topics feature in the post-primary Junior Cycle CIC (NCCA, 2016) but are subsumed under easily recognisable strand headings used for the post-primary mathematics curriculum. It is important to note that the primary mathematics curriculum is bridged to the Junior Cycle curriculum through the CIC (NCCA, 2016).

Each of the questions from the Level 5 SIGMA-T assesses a process skill and strand area for the primary mathematics curriculum, and similarly for the post-primary mathematics CIC (NCCA, 2016) in this investigation. The validity of this approach is discussed in the appropriate section below. The 119 test questions also require students to perform several mathematical procedures and solve word problems related to the content studied (Wall, 2015). Table 1 summarises the distribution of the 119 questions by strand area and process skill.

Strand	Understanding Concepts and Recalling Facts	Performing Computations and Procedures	Solving Word Problems	Total
Number	21 (17.65%)	17 (14.29%)	9 (7.56%)	47 (39.50%)
Measures	5 (4.20%)	9 (7.56%)	22 (18.49%)	36 (30.25%)
Shape and Space	11 (9.24%)	2 (1.68%)	0 (0.00%)	13 (10.92%)
Algebra	2 (1.68%)	4 (3.36%)	0 (0.00%)	6 (5.04%)
Data	6 (5.04%)	8 (6.72%)	3 (2.52%)	17 (14.29%)
Total	45 (37.82)	40 (33.61%)	34 (28.57%)	119 (100%)

Table 1: Number and Percentages of Questions in Level 5 SIGMA-T by Strand and Process Skill

While each of the process skills is assessed, there is not an even distribution, with more attention given to understanding concepts and recalling facts (37.82%) and less attention given to solving word problems (28.57%). Given the focus the new curriculum places on problem solving, it is important that a considerable part of the assessment test (almost 30%) focus is on this skill. The test assesses each of the strands, but the SIGMA-T places a major emphasis on the Number and Measures strands. Number and Measures constitute 69.75% of the questions on the SIGMA-T (Table 1). Shape and Space only accounts for 10.92% of questions, Algebra accounts for only 5.04% of questions and Data accounts for 14.29% of questions.

Level 5 SIGMA-T gives the following scores: raw score, standard score, percentile rank and STEN score. The raw score is the number of questions answered correctly from the total number of questions in the test. Standard scores, percentiles and STEN scores are derived from raw scores. A STEN score (Table 2) is a score from 1 to 10 that compares a student's result to that of the standardised sample (NCCA, 2008). The authors use caution and cite relevant limitations when they analyse the results reported in this paper, and inferences drawn in this context.

STEN Score	What does the STEN score mean?	Proportion of children with this score
8–10	"well above average"	⅙
7	"high average"	⅙
5–6	"average"	⅓
4	"low average"	⅙
1–3	"well below average"	⅙

Table 2: STEN Scores (*Source: NCCA, 2008)*

4.2.1 Test marking

The author (VR) manually corrected all test items for all students. It is worth noting that all testing was carried out without the use of a calculator. One mark was awarded for a correct answer and no marks were awarded for a partial or incorrect answer. One test from every 10 marked was randomly selected and re-marked in order to counter human error in the marking of the attainment tests. If the combined results of the re-marked scripts showed average errors of more than five marks in individual tests, all scripts were re-marked. Accuracy was promoted by using a system of running totals on each page of the attainment test and checking the total on the last page with the overall total of the script.

4.2.2 Validity of research instrument

The Level 5 SIGMA-T test was used with first-year students in this study because the learning outcomes for the target groups are a very good match, and the test was purposely designed for use in Irish schools. Of the learning outcomes of the sixth-class mathematics curriculum, 82% are repeated in the first year CIC (NCCA, 2016). This correspondence was established by the construction of a curriculum map to check the level of repetition between the sixth-class and first-year learning outcomes (Ryan, 2018). First-year students in post-primary education follow the CIC (NCCA, 2016), which was introduced under the new mathematics curriculum to link the primary mathematics curriculum to the Junior Cycle (years 1–3 of second-level) mathematics curriculum. The SIGMA-T was standardised using a nationally representative sample of over 13,000 students, and it allows for comparisons to be made within schools and also nationally (Wall, 2015).

5. Results

The results of the first-year item analysis are considered in detail in terms of the basic mathematical knowledge and skills students have at the end of their first year of post-primary education. On the day, 301 first-year students sat the test, producing 35,819 individual test items for marking distributed across the mathematics curriculum. The test items were marked and analysed by strand area and process skill. Gender-related data were analysed and included to give a more rounded view of the findings.

5.1 Key Indicators of performance

Raw data is presented in Table 3.

		Total No. of Questions		Total No. of Correct Responses		% of Questions Answered Correctly		% of Questions Answered Incorrectly		
		Form A	Form B	Form A	Form B	Form A	Form B	Form A	Form B	Overall
Strand Area	Number	6862	7285	4277	4401	62%	60%	38%	40%	39%
	Measures	5256	5580	2408	2612	46%	47%	54%	53%	54%
	Shape & Space	1898	2015	938	1073	49%	53%	51%	47%	49%
	Algebra	876	930	548	594	63%	64%	37%	36%	37%
	Data	2482	2635	1674	1699	67%	64%	33%	36%	34%
Process Skills	Concepts & Facts	6570	6975	4246	4465	65%	64%	35%	36%	36%
	Computation	5840	6200	3240	3462	55%	56%	45%	44%	44%
	Word Problems	4964	5270	2359	2452	48%	47%	52%	53%	53%

Table 3: Questions Answered by Strand Area and Process Skills – All Students

54% of questions on Measure and 49% of the questions on Shape and Space were answered incorrectly. Over one third of the questions on each of the other three strands were answered incorrectly. Similarly, 53% of Word problems, 44% of Computation questions and 36% of Concepts and Facts questions were answered incorrectly. In only one strand area (Measures), and one process skill (Word Problems) were scores above 50% recorded, and notably these were the highest scores achieved.

5.2 Analysis by gender

The independent samples t-test is used to assess if there is a statistically significant difference between male and female student performance at the end of first year. Raw score, strand areas and process skills are each analysed and Levene's Test shows homogeneity of variances for all comparisons. A student's raw score is the number of questions the student answered correctly from 119 test questions. Students' raw scores are summarised by gender in Table 4.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Raw Score	Female	122	62.5574	20.31327	1.83908
	Male	179	70.3464	20.30145	1.51740

Table 4: Raw Score by Gender (Summary)

There is a statistically significant difference in raw scores of female students (M = 62.56, SD = 20.31) and male students (M = 70.35, SD = 20.30), t (299) = -3.27, p < .001 (two-tailed) and on average, male students' raw scores are 7.79% higher than female students' raw scores.

The analyses by syllabus section (strand) and process skills further underscore female underperformance. The category process skills includes separate scores for Concepts and Facts, Computation and Word Problems, and these are summarised in Table 6. Strand area scores are summarised in Table 5.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Number	Female	122	59.5738	19.79478	1.79214
	Male	179	67.1061	19.85410	1.48397
Measures	Female	122	42.3852	17.42206	1.57732
	Male	179	49.0223	18.01122	1.34622
Shape and Space	Female	122	48.3852	21.65219	1.96030
	Male	179	53.4302	19.87007	1.48516
Algebra	Female	122	56.5738	22.20674	2.01050
	Male	179	67.7374	21.20428	1.58488
Data	Female	122	63.3443	18.05308	1.63445
	Male	179	67.6480	18.66060	1.39476

Table 5: Strand Areas Scores by Gender (Summary)

There is a statistically significant difference in the all strand area scores between female students and male students, with male students scoring higher in all strand areas (Table 5). The highest difference occurs in the Algebra strand (11.16%), with the Data strand showing the least difference (4.30%).

Process skills include scores for three sub-categories: Concepts and Facts, Computation, Word Problems. A summary of students' process skills scores is presented in Table 6.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Concepts	Female	122	59.4508	18.92355	1.71326
and Facts	Male	179	67.6536	18.05182	1.34926
Computation	Female	122	52.5574	17.84648	1.61574
	Male	179	58.1899	17.57513	1.31363
Word Problems	Female	122	43.7295	17.43798	1.57876
	Male	179	49.2067	19.31195	1.44344

Table 6: Process Skills by Gender (Summary)

There is a statistically significant difference in the Concepts and Facts scores between female students (M = 59.45, SD = 18.92) and male students (M = 67.65, SD = 18.05), t (299) = -3.80, p < .001 (two-tailed). The mean difference in raw scores is -8.20 with a 95% confidence interval ranging from -12.46 to -3.95. On average, male students' scores are 8.20% higher than female students' raw scores. There is a statistically significant difference in the Computation scores between female students (M = 52.56, SD = 17.85) and male students (M = 58.19, SD = 17.58), t (299) = -2.71, p < .007 (two-tailed). The mean difference in raw scores is -5.63 with a 95% confidence interval ranging from -9.72 to -1.55. On average, male students' scores are 5.63% higher than female students' raw scores. There is a statistically significant difference in the Word Problems scores between female students (M = 43.73, SD = 17.44) and male students (M = 49.21, SD = 19.31), t (299) = -2.51, p < .013 (two-tailed). The mean difference in raw scores is -5.48 with a 95% confidence interval ranging from -9.77 to -1.19. On average, male students' scores are 5.48% higher than female students' raw scores.

6. Discussion

The data presented here document in detail the mathematical performance of a sample of first-year students at the end of year 1 of their post-primary education in Ireland. The analysis sheds light on the state of their mathematical knowledge and competence at this time. However, the authors recognise that mathematical performance is but one indicator, albeit an important one, of the state of students' mathematical knowledge at any time, which is shaped by many other factors. While school factors obviously affect the transition from primary to post-primary mathematics and the nature of the mathematical performance recorded in response to the test, they were not specifically included in the research focus of this study. However, the authors are concerned with inhibitors to success in negotiating the transition, and a number of obstacles and facilitators are identified in the literature, in particular in the cited mathematics studies relevant to this work. The authors address a small number of obstacles that they consider to have a significant bearing on the findings reported here based on the literature review and their experience.

6.1 Mathematical knowledge of students at the end of first year

It is difficult to associate a once-off test result with the level of mathematical knowledge and command of that knowledge students' actually have. However, in this instance the authors believe it is possible to paint a plausible picture for the group as a whole using a 'broad brush-strokes' approach. A number of factors are relevant here. We have argued that the taught curriculum (CIC) (NCCA, 2016) matches very well the primary mathematics curriculum on which the test instrument is validated (82% of the learning outcomes are repeated in the CIC (NCCA, 2016), and there is a strong content match via strand areas). The test addresses all five strands of the taught curriculum (but not equally) and related process skills, and the test is a repeat test for all students in the sample (in a different version). Returning to the task in hand, we use the test performance as one important element of the mathematical profile of these students as a group, since end-of-year assessments are widely used as indicators of readiness and preparation for the subsequent year's work in mathematics. As we have established, this group/sample shows consistent underperformance in the respective domains across all strand areas and process skills, and a pronounced gender disparity in performance favouring boys. Consequently, we use a number of indicators to sketch a picture of the mathematical knowledge of first-year post-primary students at the end of their first year and as they enter their second year of study in post-primary education. These include the Level 5 SIGMA-T test, performance data on the test, official measures (e.g. STEN scores), official learning outcomes, relevant policy statements and targets, and some international comparisons.

6.1.1 Basic mathematical knowledge and skills

The item analysis highlighted significant numbers of students lacking basic mathematical skills that are necessary for personal progression in mathematics, and for functioning in their personal lives and within society. Basic questions such as subtraction of a three-digit number from a four-digit number highlighted that, for many students, the level of mathematics the CIC (NCCA, 2016) demands of them is beyond them. Overall, the analysis shows consistent underperformance by first-year students who have had a further year of instruction, on a test designed for students in sixth class. The item analysis across the strand areas and process skills shows consistent poor performance in the respective domains. Taken together as a measure of academic performance in content and process skills, the data confirm significant underperformance in mathematics of first-year students in post-primary education, and in particular, female students. Almost three out of every 10 students are considered 'low average' or 'well below average' using the STEN scores categories and descriptors.

The level of mathematical knowledge indicated by the findings has a direct impact on future outcomes in mathematics for underperforming students, and a significant bearing on numeracy achievement, which is a key national educational goal (DES, 2011, 2017). Many of these findings would not have been evident if students had completed the test with a calculator. While we recognise the movement towards increased use of the calculator, there is still an argument for learning certain foundational skills without the use of a calculator. The item analysis is consistent with PISA 2015 test results, which found that 15% of Irish students (15-year-olds) are lower-performing students who have inadequate mathematical skills to apply mathematics to real-life situations or be in a position to benefit from future learning opportunities (Shiel et al., 2015).

6.1.2 Indicators of mathematical knowledge

The following section gives results relating to specific questions on the test. These indicators were chosen as examples of performance in strand areas and process skills, and are used to shed light on the state of students' mathematical knowledge at the time. 8% of students were not able to draw a time on a clock face while 26% of respondents could not write the time a digital watch image provided. 36% of students could not convert from kilograms to grams. 16% of students could not subtract a three-digit number from another three-digit number, while 19% of students could not subtract a three-digit number from a four-digit number. Similarly, 22% of students could not do an elementary short-division calculation. 41% of students could not solve a basic fraction word problem. 44% of students were unable to draw a line at a right angle to another given line. 23% of students did not know the number of sides of a specific shape. 28% of students did not know that the angles in a triangle sum to 180 degrees. 47% of students could not get the perimeter of a rectangle given its length and width. 51% of students could not calculate how many 50ml measuring jugs would be needed in order to fill a 1.5 litre bottle. 60% of students could not add two mixed fractions. Almost a quarter of those examined failed to find the correct answer for a word problem involving subtracting two three-digit numbers. 85% of students failed to find the correct answer for a problem that involved calculating a percentage and fraction of a total number of people. 37% of students could not write a mixed fraction in decimal form. Such results are concerning in the context of national aspirations and policies promoting improved mathematics outcomes in post-primary mathematics for the whole cohort of students.

However, they may not be very compelling if viewed as isolated data unrelated to a wider context. The authors found it instructional to look at corresponding learning outcomes for mathematics at this stage in other countries. A detailed matching exercise tabulating corresponding learning outcomes was undertaken comparing the Irish CIC (NCCA, 2016), the relevant outcomes for the National Mathematics Curriculum in England (Department of Education England, 2013), and the Australian Mathematics Curriculum (Year 7) (Australian Curriculum Assessment and Reporting Authority, 2013). They were found to be broadly similar. An indicative sample for two topic/strand areas is given in Table 7.

Number	Percentages	Data/Statistics and Probability
Common Introductory Course, Ireland	• calculate percentages • use the equivalence of fractions, decimals and percentages to compare proportions	• recognise that probability is a measure on a scale of 0–1 of how likely an event is to occur • explore different ways of collecting data
National Maths Curriculum, England	• define percentage as 'number of parts per hundred', interpret percentages and percentage changes as a fraction or a decimal, interpret these multiplicatively, express one quantity as a percentage of another, compare two quantities using percentages, and work with percentages greater than 100% • interpret fractions and percentages as operators	• record, describe and analyse the frequency of outcomes of simple probability experiments involving randomness, fairness, equally and unequally likely outcomes, using appropriate language and the 0–1 probability scale • understand that the probabilities of all possible outcomes sum to 1
Australian Maths Curriculum, Year 7	• connect fractions, decimals and percentages and carry out simple conversions (ACMNA157) • find percentages of quantities and express one quantity as a percentage of another, with and without digital technologies (ACMNA158)	• assign probabilities to the outcomes of events and determine probabilities for events (ACMSP168) • identify and investigate issues involving numerical data collected from primary and secondary sources (ACMSP169) • construct sample spaces for single-step experiments with equally likely outcomes (ACMSP167)

Table 7: Sample of indicative learning outcomes

As a comparison of outcomes across a number of countries shows, Irish expectations in terms of published official learning outcomes are not out of line with expectations in the international arena.

6.2 Gender perspective on the test results

The first-year data provides clear evidence of a gender gap in performance favouring boys. There are statistically significant gender differences in raw scores, strand areas and process skills. Considering the female under-engagement in the STEM workforce in Ireland (STEM Education Review Group, 2016) the differences seen here affect gender parity in STEM professions in the future. The results show that the gender gap in mathematics is already firmly established in first year post-primary education in Ireland. These findings are reflected in consistent female underperformance at Leaving Certificate Higher level when successive cohorts of students progress through post-primary education. For example, the Leaving Certificate 2015 data shows a higher percentage of male (28.9%) than female (26.0%) candidates sitting Higher-level mathematics. Males outperformed female students in achieving A grades and A/B/C grades in 2015 and this pattern has been consistent since the new mathematics curriculum was introduced (State Examinations Commission, 2015). Results from 2019 indicate more males than females obtaining higher (H1 and H2) grades (State Examinations Commission, 2019).

Gender disparity evident in first year continues throughout post-primary education. PISA 2015 data has shown that the gender gap, on average, is more pronounced in Ireland than across OECD countries (Shiel et al., 2015). However, female underperformance is a complex issue and teacher training alone is not enough to address the issue. Gender equality must be promoted in the home, school and society as a whole, as research tells us that female underperformance in mathematics is eliminated in cultures that are more gender-equal (Guiso et al., 2008). The transition from primary to post-primary education is a pivotal point for female students and it is important that the stereotype of mathematics as a male domain is challenged while students are making the transition. It is important that teachers be aware of how they treat both genders in the classroom because student self-beliefs, achievement and participation in mathematics are affected (Leder, 1990).On a positive note, Spencer, Steele, and Quinn (1999) found that reducing stereotype threat increased female mathematics performance and decreased anxiety in female students.

6.3 Inhibitors of successful transition in mathematics

6.3.1 Role of the teacher

The authors now return to discuss key inhibitors of successful transition identified earlier in Section 3 and localise them in the Irish context. This study was undertaken during a period when a new post-primary mathematics curriculum was being implemented in Irish schools. In terms of teaching quality, a contemporary report by Ní Ríordáin and Hannigan (2011) found that 48% of teachers teaching mathematics in Irish post-primary schools did not hold a mathematics teaching qualification, and in the main, these teachers were deployed in non-examination classes and confined to Junior Cycle. These teachers were referred to as out-of-field teachers of mathematics in the report, following this designation in Darling-Hammond (2000).

These findings speak directly to (a) the capacity of this same teaching force to deliver the new curriculum as envisaged, including the CIC (NCCA, 2016), (b) the quality of mathematics education experienced by Junior Cycle students. Both issues would have a direct bearing on whether or not a successful transition was achieved. In the event, the authorities addressed both issues comprehensively in the rollout of the new curriculum. The DES and the NCCA implemented the most comprehensive CPD programme in the history of the state for any subject, and funded a part-time Professional Diploma in Mathematics for Teaching (PDMT) to upskill out-of-field teachers of mathematics, starting in 2012 and continuing (Goos, 2020). Initial reports by the National Foundation for Educational Research (NFER), however, signalled that the new curriculum had not yet been associated with any improvement in achievement (Jeffes et al., 2013). Gains appear to be hard to achieve still at Junior Cycle (Shiel & Kelleher, 2017), but a reasonable expectation is that there will be improved outcomes when the new curriculum is well established. While necessary steps to improve teaching quality were taken, these steps alone were not sufficient to ensure a successful transition, as authors' findings show.

6.3.2 Curriculum continuity

Pedagogical and curriculum continuity are identified in the research as necessary conditions for successful transition from primary to post-primary mathematics (Bicknell & Riley, 2012). The authors acknowledge overlap between the two named constructs but first they focus on issues related to curriculum continuity, and some pedagogical issues emerge.

The new post-primary mathematics curriculum in Ireland was engineered to address continuity issues in a number of ways. The mathematics content is organised in five key cognate strands – Number, Measures, Algebra, Shape and Space, and Data – that subsume and develop primary curriculum strands. Thus, a curriculum map with learning outcomes exists that recognises students' prior learning and provides mathematics content horizons for students and teachers. The CIC (NCCA, 2016) is deliberately embedded in year 1 of the new mathematics curriculum to facilitate the successful transition from primary to post-primary mathematics. Viewed as a bridging framework, it is intended as a tool to combat wide variations in mathematical knowledge and competency of first-year students who arrive in post-primary school from different feeder primary schools (the 14 schools in this study were served by 109 feeder schools). Taken together, these steps represent an important contribution to subject continuity across the transition, but clearly the central component, the CIC (NCCA, 2016), is not functioning as intended (Shiel & Kelleher, 2017).

The research literature also points to the importance of the quantum of instruction time allocated to mathematics classes. The TIMSS studies and other international studies such as PISA have shown a positive correlation between academic performance and instruction time (Smith, 2000). In Ireland, students in sixth class spend 50–60 minutes on mathematics per day and experience a significant reduction in instruction time when they transfer to post-primary schools. These issues have been investigated by Smyth, McCoy, and Darmody (2004), McCoy, Smyth, and Banks (2012), and have recently been highlighted by O'Meara and Prendergast (2017). A diminution of class time devoted to mathematics immediately when students transition to post-primary school represents a discontinuity that affects curriculum and pedagogy. While sufficient mathematics instruction time in mathematics is important, O'Meara and Prendergast make the point that more instruction time alone will not suffice if used inefficiently.

6.3.3 Pedagogical continuity

Academic discontinuity is evident in this 'fresh start' approach where post-primary teachers re-teach much of the curriculum from fifth and sixth class in primary school. While continuity is a key factor in successful transition, continuity for first-year students based on a repetition of prior learning only is unlikely to succeed. The importance of student exposure to challenge in mathematics is acknowledged by international research (Taylor, 2005; Applebaum & Leikin, 2007; Turner, 2010), and it is well known that student motivation and learning in mathematics can be improved by a moderate level of challenge (Brophy, 2013; Stipek, 1993). A 'fresh start' approach applied to first-year students which disregards prior learning has been shown to have negative consequences for student engagement and learning (Galton et al., 2003; Bicknell & Hunter, 2012). A high level of repetition is particularly detrimental to students as it offers no challenge to a large number of students and affects their motivation, commitment and interest in mathematics (Diezmann & Watters, 2002; Turner & Meyer, 2004). Repetition represents a flat or decreased level of challenge for students. Research tells us this affects engagement, interest, commitment, motivation and the development of reasoning processes (Powell et al., 2009; Barbeau & Taylor, 2009; Fullerton, 2014; Taylor, 2005; Bussi et al., 2009; Diezmann & Watters, 2002; Turner & Meyer, 2004). Insufficient challenge occasioned through this repetition affects the mathematical trajectory of students through post-primary education and beyond. Other researchers point out that the distrust inherent in the 'fresh start' approach impedes smooth transition and halts academic progress for students of all abilities and affects attitude towards mathematics (Galton et al., 2000; Bicknell & Riley, 2012).

The introduction of the CIC (NCCA, 2016) is a very positive step to support students in the transition from primary to post-primary mathematics. However, its efficacy is undermined by a common response in post-primary schools. In order to 'level up' variations in mathematical knowledge and competency of new first-year students, post-primary mathematics teachers implement a 'fresh start' approach in first-year mathematics classes. This level of repetition, particularly when there is not sufficient additional challenge, undermines mathematical learning because it fails to exploit students' prior learning and fails to engage and motivate students. Consequently, the authors believe that the 'fresh start' approach is a significant contributory factor in the lack of efficacy of the CIC (NCCA, 2016). Other contributory factors to academic discontinuity include lack of knowledge of their respective school mathematics curricula by primary and post-primary teachers. Prendergast et al. (2016) found that approximately half of primary sixth-class teachers and post-primary teachers reported being either highly or slightly unfamiliar with each other's syllabi.

6.3.4 Limitations of the study

We acknowledge limitations to this study. The main transition study dictated the characteristics of the sample and the nature of data collected. The target sample size of 382 to ensure a 95% confidence interval and a 5% margin of error was not achieved due to reluctance of post-primary schools to participate. Instead, 301 students completed the test instrument. Two further points are worth noting in the context of this paper. The sample is not a sample of individual first-year students chosen individually, but rather 301 out of 323 students from 14 first-year class groups from the participating schools. The researchers had no control over the gender balance that emerged in schools included in the sample, and consequently the proportion of boys and girls among the 301 students who sat the test.

Finally, cooperating class teachers administered the test following specific written instructions supplied by the researcher (VR). However, there is no way of knowing if these instructions were strictly adhered to in practice.

7. Summary and conclusions

This paper focuses on the mathematical knowledge of students at the end of year 1 in post-primary school in Ireland. It identifies a significant underperformance in mathematics and discusses factors affecting these student outcomes in mathematics in the context of the students' transition from primary to post-primary school mathematics. The authors argue that the end of year 1 in post-primary education is a significant milestone in students' mathematical education that is under-researched and offer one approach to improve matters in this regard. Academic transition in mathematics at this interface, and new insights particularly in the context of ongoing curriculum reform, are matters of interest internationally, and since transition happens at local level, studies such as this are important in the international debate.

The underperformance identified in this study is considered in the broader context of mathematical knowledge, skills and competencies that are foundational for school and life careers. The results highlight the possibility that students are missing an opportunity to develop some basic mathematical skills, including estimation, and may be over-reliant on calculators for doing simple calculations. The data warrant further observations and consideration in this regard. Undoubtedly, a majority of the students will recover from this situation and go on to do well in school mathematics, but the weaker students are unlikely to do so. It is also probable that, among those who do recover, for significant numbers of them their recovery will fall short of what they might have achieved had their transition been more successful, and this represents an opportunity cost for them and the nation.

Looking to the future, issues remain with first-year Junior Cycle mathematics. It was expected that the CIC (NCCA, 2016) in mathematics would address anticipated difficulties with the transition. This has not been entirely successful, as the authors' study demonstrates. Shiel and Kelleher (2017) give an excellent appraisal of the issues surrounding the CIC (NCCA, 2016) and its implementation. In our view, the CIC (NCCA, 2016) provides a very good mathematical framework for teachers to address the academic transition in mathematics successfully. It provides adequate content, and scope for selected additional content to meet the challenge, but the kernel of the issue is the mathematical pedagogy employed by the teachers. To our minds, a failure to fully embrace the CIC (NCCA, 2016) represents a lack of confidence in, and knowledge of, the mathematical outcomes of the primary-school curriculum, and a reluctance to move away from traditional approaches. To improve continuity, consideration ought to be given to matching mathematics instruction time in the first year of post-primary education with that of sixth class, and assigning the most experienced and qualified teachers to teach first-year classes/students. These steps are necessary to ensure that the transition is negotiated well by all students. Research has shown that the best mathematics teachers are not being deployed in first year across all schools (Ni Ríordáin & Hannigan, 2011). There are some grounds for optimism in the knowledge that significant numbers of newly qualified out-of-field teachers of mathematics (c.17% of the entire mathematics teaching force in post-primary schools), who qualified through the Department of Education and Skills upskilling programme, are now deployed, mostly in the Junior Cycle classes. It is reasonable to expect that the contribution of a large cohort of qualified mathematics teachers in the early years of post-primary education, who were previously out-of-field teachers of mathematics, will lead to better outcomes in the future.

References

Anderson, L. W., Jacobs, J., Schramm, S., & Splittgerber, F. (2000). School transitions: beginning of the end or a new beginning? *International Journal of Educational Research, 33*(4), 325-339. doi:10.1016/s0883-0355(00)00020-3

Applebaum, M., & Leikin, R. (2007). *Teachers' conceptions of mathematical challenge in school mathematics*. Paper presented at the Proceedings of the 31st International Conference for the Psychology of Mathematics Education, Korea.

Attard, C. (2010). *Students' experiences of mathematics during the transition from primary to secondary school*. Paper presented at the Mathematics Education Research Group of Australasia, Fremantle, Perth.

Attard, C. (2013). If I had to pick any subject, it wouldn't be maths: foundations for engagement with mathematics during the middle years. *Mathematics Education Research Journal, 25*(4), 569-587.

Australian Curriculum Assessment and Reporting Authority. (2013). *Australian Curriculum* v3.0: Mathematics for Foundation–10.

Barbeau, E. J., & Taylor, P. J. (Eds.). (2009). Challenging mathematics in and beyond the classroom: the 16th ICMI study. New York: Springer.

Bicknell, B., & Hunter, R. (2012). School Transition from Year 6 to Year 7: A Focus on Mathematics. *International Journal for Mathematics Teaching & Learning*.

Bicknell, B., & Riley, T. (2012). Investigating transitions in mathematics from multiple perspectives. *Mathematics Education Research Journal, 24*(1), 1-17. doi:10.1007/s13394-011-0027-y.

Brophy, J. E. (2013). *Motivating students to learn*. New York: Routledge.

Bussi, M. G. Bartolini, Gade, S., Janvier, M., Kahane, J.-P., Matsko, V. J., Maschietto, M., Ouvrier-Buffet, C., & Saul, M. (2009). Mathematics in context: Focusing on students. In E. J Barbeau & P. J. Taylor (Eds.), *Challenging mathematics in and beyond the classroom*, 171-203. US: Springer.

Carmichael, C. (2015). Transitioning to secondary school: The case of mathematics. *Australian Journal of Educational & Developmental Psychology, 15*.

Cosgrove, J., Perkins, R., Shiel, G., Fish, R., & McGuinness, L. (2012). *Teaching and Learning in Project Maths: Insights from Teachers who Participated in PISA 2012*. Retrieved from Dublin: http://www.erc.ie/documents/p12teachingandlearningprojectmaths.pdf

Darling-Hammond, L. (2000). Teacher quality and student achievement. *Education policy analysis archives* 8:1.

Department of Education and Science. (1999). *Primary School Curriculum*. Dublin: Government Publications.

Department of Education and Skills. (2011). *Literacy and numeracy for learning and life: The national strategy to improve literacy and numeracy among children and young people, 2011-2020*. Retrieved from Dublin: https://www.education.ie/en/Publications/Education-Reports/pub_ed_interim_review_literacy_numeracy_2011_2020.PDF

Department of Education and Skills. (2017). *National strategy: Literacy and numeracy for learning and life 2011–2020*. Interim review: 2011–2016; new targets: 2017–2020. Dublin: Department of Education and Skills.

Department of Education England. (2013). National curriculum in England. Mathematics programmes of study: key stage 3

Diezmann, C. M., & Watters, J. J. (2002).

The importance of challenging tasks for mathematically gifted students. *Gifted and Talented International, 17*(2), 76-84.

Eccles, J. S., Wigfield, A., Midgley, C., Reuman, D., Mac Iver, D., & Feldlaufer, H. (1993). Negative effects of traditional middle schools on students' motivation. *The Elementary School Journal 93*(5), 553-574. doi:10.1086/461740.

Education and Training Inspectorate, Department of Education and Skills Inspectorate. (2015). A Joint Report by the Education and Training Inspectorate and the Department of Education and Skills Inspectorate on Promoting and Improving Numeracy in Post-Primary Schools. Dublin.

Fullerton, T. (2014). Game design workshop: a playcentric approach to creating innovative games. Amsterdam: Morgan Kaufmann.

Galton, M., Hargreaves, L., & Pell, T. (2003). Progress in the middle years of schooling: Continuities and discontinuities at transfer. *Education 3-13, 31*(2), 9-18. doi:10.1080/03004270385200161

Galton, M., Morrison, I., & Pell, T. (2000). Transfer and transition in English schools: reviewing the evidence. *International Journal of Educational Research, 33*(4), 341-363. doi:10.1016/s0883-0355(00)00021-5

Goos, M., O'Donoghue, J., Ní Ríordáin, M., Faulkner, F., Hall, T., & O'Meara, N. (2020). Designing a national blended learning program for "out-of-field" mathematics teacher professional development. *ZDM*, 1-13.

Gueudet, G., Bosch, M., DiSessa, A. A., Nam Kwon, O., & Verschaffel, L. (2016). *Transitions in mathematics education.* Edited by Springer Nature: Springer Nature.

Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Culture, gender, and math. *Science, 320*(5880), 1164-1165.

Jeffes, J., Jones, E., Wilson, M., Lamont, E., Straw, S., Wheater, R., & Dawson, A. (2013). *Research into the impact of Project Maths on student achievement, learning and motivation.* Slough: National Foundation for Educational Research.

Leder, G. C. (1990). Gender and classroom practice. In L. Burton (Ed.), *Gender and mathematics. An international perspective, 9-20*. Strand: Cassell.

McCoy, S., Smyth, E., & Banks, J. (2012). The primary classroom: Insights from the growing up in Ireland study. Dublin: ESRI and NCCA.

Midgley, C., Feldlaufer, H., & Eccles, J. S. (1989). Student/teacher relations and attitudes toward mathematics before and after the transition to junior high school. *Child Development, 60*(4), 981. doi:10.2307/1131038

NCCA. (2008). *Your child and standarised testing – Understanding the STEN score.* Accessed 14 April 2013 at http://www.ncca.ie/en/Curriculum_and_Assessment/Parents/Primary/Standardised_Tests/STenEng.pdf

NCCA. (2016). *Common Introductory Course First Year Teacher Handbook.* Accessed 14 October 2016 at https://www.projectmaths.ie/wp-content/uploads/2015/01/1st-Year-Handbook-July-2016.pdf.

Neild, R. C., Stoner-Eby, S., & Furstenberg, F. (2008). Connecting entrance and departure: The transition to ninth grade and high school dropout. *Education and Urban Society, 40*(5), 543-569.

Ní Ríordáin, M., & Hannigan, A. (2011). Who teaches mathematics at second level in Ireland? *Irish Educational Studies 30*(3), 289-304.

O'Meara, N., & Prendergast, M. (2017). TIME in Mathematics Education (TiME): A national study analysing the time allocated to mathematics at second level in Ireland.

Limerick: EPISTEM.

OECD. (2014). PISA 2012 *Technical Report*. Retrieved from Paris: https://www.oecd.org/pisa/pisaproducts/PISA-2012-technical-report-final.pdf

Powell, A. B, Borge, I. C., Fioriti, G. I., Kondratieva, M., Koublanova, E., & Sukthankar, N. (2009). Challenging tasks and mathematics learning. In E. J Barbeau & P. J. Taylor (Eds.), *Challenging mathematics in and beyond the classroom*, 133-170. New York: Springer.

Prendergast, M., O'Meara, N., Harbison, L., & O'Hara, C. (2016). A Difficult Crossing: The Transition from Primary to Secondary School Mathematics. *Education Matters Yearbook 2016–2017* (pp. 339-343). Dublin.

Ryan, V. (2018). Making the transition: A student's mathematical journey from primary to post-primary school in Ireland [Unpublished doctoral dissertation]. University of Limerick.

Shiel, G., Kelleher, C., McKeown, C., & Denner, S. (2015). Future ready? *The performance of 15-year-olds in Ireland on science, reading literacy and mathematics in PISA 2015*. Retrieved from Dublin: http://www.erc.ie/wp-content/uploads/2016/12/PISA2015_FutureReady.pdf

Shiel, G., & Kelleher, C. (2017). An evaluation of the impact of Project Maths on the performance of students in Junior Cycle mathematics. Dublin: Education Research Centre.

Smith, B. (2000). Quantity matters: Annual instructional time in an urban school system. *Educational administration quarterly, 36*(5), 652-682.

Smyth, E., McCoy, S., & Darmody, M. (2004). Moving up: The experiences of first-year students in post-primary education. Dublin: Liffey Press.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of experimental social psychology 35*(1), 4-28.

State Examinations Commission. (2015). Leaving Certificate Examination 2015 Mathematics Chief Examiner's Report.

State Examinations Commission. (2019). Leaving Certificate 2019 Gender Statistics.

STEM Education Review Group. (2016). A Report on Science, Technology, Engineering and Mathematics (STEM) Education. Analysis and Recommendations.

Stipek, D. J. (1993). *Motivation to learn: From theory to practice*. Boston: Allyn & Bacon.

Taylor, P. (2005). *Challenging mathematics and its role in the learning process.* Paper presented at the Making Mathematics Vital, Australia.

Turner, J. C. (2010). Unfinished business: Putting motivation theory to the "classroom test". In S. Karabenick (Ed.), *The decade ahead: Applications and contexts of motivation and achievement*, 109-138. Emerald Group Publishing Limited.

Turner, J. C., & Meyer, D. K. (2004). A classroom perspective on the principle of moderate challenge in mathematics. *The Journal of Educational Research, 97*(6), 311-318.

van Rens, M., Haelermans, C., Groot, W., & van den Brink, H. M. (2018). Facilitating a Successful Transition to Secondary School: (How) Does it Work? A Systematic Literature Review. *Adolescent Research Review 3*(1), 43-56.

Wall, E., & Burke, K. (2015). SIGMA-T standardised Irish graded mathematics attainment tests level 5 test manual. . Kildare: CJ Fallon.

PAPER 3:

STUDENT INTEREST AND ENGAGEMENT IN MATHEMATICS AFTER THE FIRST YEAR OF SECONDARY EDUCATION

Abstract

The end of first year in secondary mathematics education is an important yet neglected milestone in the literature. It represents a crucial period in a student's mathematical lifetime when they have negotiated the physical, academic and emotional bridges between primary and secondary education, bridges which have been shown to impact considerably on students' performance and attitudes to mathematics. This study, which investigated students' motivation in mathematics and their willingness to engage in it, including attitudes, emotions and self-related beliefs at the end of students' first year of secondary education in Ireland, formed part of a larger study on student transition in mathematics from primary to secondary education in Ireland (Ryan, 2018). It is the first study of its kind since the introduction of a new mathematics curriculum in Ireland in 2010. Using a large sample of 304 students, the data was analysed for all students and also for students grouped by gender. The results of this study show high levels of student engagement, motivation and positive self-belief in mathematics, despite recorded declines in mathematical performance after a full year's instruction. This study also highlights a gender disparity in mathematics self-beliefs, particularly in relation to self-efficacy, self-concept and anxiety.

Keywords
Self-efficacy, self-concept, maths anxiety, self-belief, mathematics, interest, engagement, primary–secondary transition.

1. Introduction

Insights into student mathematical knowledge and engagement at important stages in their mathematical trajectories can inform enriched, enduring outcomes for students as they continue to navigate through the education system (Cox & Kennedy, 2008; Deieso & Fraser, 2019; Galton, Gray, & Ruddick, 1999; Smyth, McCoy, & Darmody, 2004). This paper investigates the mathematical motivation and engagement levels of a large sample of students as they proceed into their second year of secondary education, a mathematics juncture often neglected in the literature yet one that has a substantial bearing on future student progress in mathematics (Deieso & Fraser, 2019; Vorderman, Porkess, Budd, Dunne, & Rahman-Hart, 2011). The research presented in this paper formed part of a larger study on student transition in mathematics from primary to secondary education in Ireland, which demonstrated that students scored significantly lower in mathematics on the same test instrument at the end of the first year in secondary education compared to their performance one year earlier at the end of primary education, despite an additional year of mathematics instruction (Ryan, 2018). On average, students' raw scores decreased by 7% from sixth class (final year of primary school) to first year of secondary education, despite an additional year of instruction and extensive overlap of the syllabi. In addition to academic performance, affective constructs were also examined in the study on transition in mathematics from primary to secondary school.

The affective domain relates to three main constituents: beliefs, attitudes and emotions – as well as related concepts that include confidence in learning mathematics, self-concept, self-efficacy, mathematics anxiety, causal attribution, effort and ability attributions, learned helplessness, and motivation (McLeod, 1992). Affective issues are central to teaching and learning (Casey & Fernandez-Rio, 2019). Attitudes, beliefs and emotions are important considerations when investigating students' interest in and response to mathematics (OECD, 2013a). Positive emotions towards mathematics provide a better platform for the learning of mathematics than negative emotions. Students who exhibit positive attitudes, emotions and beliefs towards mathematics are predisposed to using mathematics in everyday contexts (OECD, 2013a). An important function of mathematics education therefore is to cultivate attitudes, beliefs and emotions in a way that not only encourages students to utilise and apply the mathematics they currently know, but to inspire them to continue studying mathematics for personal, academic and social gain (Al-Mutawah & Fateel, 2018; OECD, 2013a).

2. Relevant literature

2.1 Student engagement and motivation in mathematics

Student engagement in mathematics is multifaceted and has affective, cognitive and behavioural constructs; the level of engagement affects the quality of the learning outcome (Al-Mutawah & Fateel, 2018; Fredricks, Blumenfeld, & Paris, 2004; Kong, Wong, & Lam, 2003). When students believe that they will experience success in mathematics, they are more likely to engage in and enjoy the subject (Middleton & Spanias, 1999; Putwain, Symes, Nicholson, & Becker, 2018). Cultivating student engagement is as important as the design of the curriculum itself (Kong et al., 2003). Evidence of motivation to engage in mathematics can be observed early in a child's education. Students in kindergarten and first grade are motivated to engage and they relate success to a mix of effort and ability, but this changes, and by the middle grades, these students attribute success in mathematics to ability rather than effort (Kloosterman & Gorman, 1990). Student engagement in mathematics and attitude are directly related to the supportiveness of the teacher and the classroom environment (Ivowi, 2001; Lazarides, Buchholz, & Rubach, 2018; Middleton & Spanias, 1999; Valås & Søvik, 1994). According to Meece, Wigfield, and Eccles (1990), students' performance expectancies predict future performance in assessment, while student value perceptions predict student intention to engage in a course involving mathematics in the future (OECD, 2013a). Motivation is what determines a person's drive and persistence towards the participation in or completion of a task, and is categorised as either extrinsic, if it is determined by an external factor such as material gains, or intrinsic, if a task is pursued or completed for one's own personal satisfaction (Fischer, Malycha, & Schafmann, 2019). The teacher plays a key role in the development of intrinsic motivation and this can be achieved by the teacher highlighting the usefulness and importance of the mathematical concepts being taught, aided by the use of real-life problem solving (Cronbach & Meehl, 1955; Ivowi, 2001; Middleton & Spanias, 1999). Middleton and Spanias (1999) and Lazarides et al. (2018) stress that motivation, while generally stable, is not simply the result of mathematical ability but can be changed through appropriate intervention strategies, such as instructional practices, and can lead to students enjoying and valuing the subject.

2.2 Mathematics behaviours, intentions and subjective norms

Students who engage in mathematics-related behaviours, including taking part in mathematics competitions, mathematics clubs, chess and computer programming, are more likely to enjoy and value the subject (OECD, 2013b). Mathematics-related intentions indicate the likelihood of students pursuing mathematics or mathematics-related disciplines in higher (tertiary, post-secondary) education (OECD, 2013b). Subjective norms are the beliefs a student holds about themselves that are formed according to perceived societal/peer pressure (Kul & Çelik, 2018). Students' subjective norms have a direct impact on behaviour, so if the people who are important to the student see mathematics as important, it is likely that the student also will see the value and importance of mathematics. The Programme for International Student Assessment (PISA) seeks to compare the value, equity and effectiveness of schools across 70 participating countries. Information about the highest-performing school systems may then allow governments to adapt their education policies and practices to improve national performance (OECD, 2013b). PISA is also concerned with equipping each student with the necessary skills to reach their potential, enter the workforce, and participate fully in society (OECD, 2013b). PISA examines the skills of 15-year-olds in reading, mathematics, science and problem-solving, and the questions require students to apply their knowledge and understanding to both familiar and unfamiliar contexts (OECD, 2013b). PISA 2012 results show that Irish students are less likely to intend to have a career in mathematics or intend to study mathematics compared to students across all OECD countries (Perkins, Shiel, Merriman, Cosgrove, & Moran, 2013). In addition, Irish students are among the third-lowest group, across all OECD countries, to participate in mathematics-related activities such as mathematics clubs and competitions (Perkins et al., 2013). Research has shown that participation in mathematics club leads to improved performance in standardised tests in concepts, application and computation (Sherman & Catapano, 2011). Results from PISA 2012 on attitude have revealed gender differences in attitude towards mathematics and engagement with mathematics (Perkins et al., 2013). The theory of reasoned action posits that if an individual has a positive attitude towards the suggested behaviour, and if they perceive that people important to them would want them to perform the behaviour, then this will increase their motivation to perform the behaviour and, consequently, the likelihood of the behaviour being performed (Fishbein & Ajzen, 1977). Irish students have shown higher levels of subjective norms relating to mathematics than students from other OECD countries (Perkins et al., 2013). Therefore, the opinions on mathematics of the significant others in the lives of the students have a particularly strong influence on the importance Irish students attribute to the subject. Fishbein and Ajzen (1977) have shown that high levels of subjective norms increase motivation towards a desired behaviour and the prospect of that behaviour being exhibited. Parents' interest in the school and parents' level of satisfaction in mathematics are linked to students' belief in their own ability (Gladstone, Häfner, Turci, Kneißler, & Muenks, 2018; Surgenor, Millar, Close, & Shiel, 2006).

2.3 Self-beliefs

Student beliefs are a component of the affective domain (McLeod, 1992). They shape behaviour and have significant consequences (Pitsia, Biggart, & Karakolidis, 2017; Schoenfeld, 2009). Students' beliefs are evident in the classroom in the way students ask questions, answer questions, and how they approach and work on problems (Spangler, 1992). According to Schoenfeld (2009), students' beliefs about mathematics are generated through their experience in the mathematics classroom. These beliefs determine how students cope with uncertainty and manage contradiction and conflict (Fleener, 1996). According to Brassell, Petry, and Brooks (1980), when the specific areas of self-concept and anxiety are taken in isolation, it can be seen that these areas impact performance. A moderate to strong correlation exists between mathematics self-beliefs and performance in mathematics (Perkins et al., 2013). This highlights the importance of promoting self-efficacy and self-concept and minimising mathematical anxiety.

The self-concept and self-efficacy components have been shown to have considerable effect on student performance, perseverance, motivation and career choices (Bandura, 1977, 1982; Hackett & Betz, 1989; Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006; Pajares & Miller, 1994; Stankov, Morony, & Lee, 2014; Zimmerman, 2000). Mathematics self-efficacy, mathematics self-concept and mathematics anxiety affect how students gauge their own performance, set learning objectives and the learning strategies they employ (Pitsia et al., 2017; Thomson, Hillman, & De Bortoli, 2013). Mathematics self-efficacy affects students' motivation and determination on a mathematics task and refers to students' self-belief in their ability to learn mathematics (Thomson et al., 2013). If students believe in their own ability, they will devote time to learning strategies that will help them achieve success in mathematics (Karakolidis, Pitsia, & Emvalotis, 2016; Pitsia et al., 2017; Thomson et al., 2013). Mathematical anxiety occurs when students feel intimidated by the mathematical task and feelings of helplessness emerge. Self-efficacy relates to how students believe they will succeed in a particular task, and how students believe they will succeed are strong predictors of performance (Bandura, 1986; Pitsia et al., 2017). Mathematical self-efficacy is centred on student confidence in achieving success in mathematics given a specific task, while mathematical self-concept is a judgement of a student's success but not confined to that particular task (Pajares & Miller, 1994). Therefore, a student with low mathematical self-concept may show high mathematical self-efficacy in a particular topic in mathematics. Blumenfeld, Pintrich, Meece, and Wessels (1982) found that a positive self-concept of ability was linked to frequency of positive academic feedback. In particular, students' efficacy beliefs are lower in classes with frequent teacher criticism (Parsons, Adler, & Kaczala, 1982). Findings from an undergraduate study carried out by Pajares and Miller (1994) show that student mathematical self-efficacy is an important predictor of future performance. Indeed, they argue that self-efficacy assessments should be introduced early in the education of a student to inform interventions that may alter self-efficacy beliefs. Self-belief is a predictor of performance:

> *It should come as no surprise that what people believe they can do predicts what they can actually do and affects how they feel about themselves as doers of that task.*
> (Pajares & Miller, 1994, p. 200)

According to Bandura (1977), perceived self-efficacy affects participation in a situation or activity. Low perceived levels of self-efficacy lead to an individual avoiding the activity. Low levels of perceived self-efficacy also affect the coping efforts and persistence of the individual once the activity or situation has commenced (Bandura, 1977, 1982). According to Bandura (1977), a student who engages in a safe activity that they consider threatening gains corrective experiences that in turn strengthen their levels of self-efficacy. A student who does not engage or engages only for a short time holds on to their fears and low expectations.

Self-efficacy is a powerful predictor of student motivation, learning, persistence, achievement and career choices (Bandura, 1977, 1982; Hackett & Betz, 1989; Kenney-Benson et al., 2006;

Pajares & Miller, 1994; Pitsia et al., 2017; Zimmerman, 2000) and the importance of self-belief in achievement is evident by its inclusion in international assessments such as PISA (Khine, Fraser, & Afari, 2020; Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014). Research has shown that self-efficacy plays a key role in successful problem solving and students' beliefs about themselves are key predictors of performance (Kenney-Benson et al., 2006; Pajares & Miller, 1994).

Mathematics self-efficacy affects both performance and career choice (Hackett & Betz, 1989; Khasawneh, Gosling, & Williams, 2021; Pajares & Miller, 1994). In a US study of 280 university science students, Larson et al. (2015) found that university graduation status was significantly linked to mathematics/science self-efficacy from the first semester. Measures of mathematics aptitude and prior achievement contributed significantly less to graduation status than mathematics/science self-efficacy. In their longitudinal Australian study, Parker et al. (2014) reported that mathematics self-efficacy was a significant predictor of entry to university and mathematics self-concept was a significant predictor for the undertaking of STEM disciplines in higher education. Mathematics self-efficacy levels also determine the choice of college majors (Czocher, Melhuish, & Kandasamy, 2020; Evans, Chen, & Hudes, 2020; Hackett & Betz, 1989). Understanding how self-efficacy beliefs are developed is important as, despite successful experiences and established mathematical skills, some students show an extreme lack of confidence in their ability (Pajares & Miller, 1994). According to Pajares and Miller (1994), many students may avoid maths-related courses and careers because of inaccurate perceptions of their ability.

Given the far-reaching effects of mathematics self-efficacy, Hackett and Betz (1989) urge teachers of mathematics to recognise the importance of self-efficacy and consequently "pay as much attention to self-evaluations of competence as to actual performance" (Hackett & Betz, 1989, p. 271). Self-efficacy affects persistence. Students who perceive that a task is beyond their capability are less likely to spend time and exert effort to complete the task (Bandura, 1982; Czocher et al., 2020; Pajares & Miller, 1994). Deficits in self-efficacy are a likely contributor to the low number of women pursuing STEM-related disciplines and careers (O'Brien, Martinez-Pons, & Kopala, 1999). Gender gaps in mathematics self-efficacy increase with age from early adolescence (Huang, 2013). Research shows ambiguous findings in relation to gender and self-efficacy (Kenney-Benson et al., 2006; Lapan, Shaughnessy, & Boggs, 1996; Pajares, 2005). In a longitudinal study in the US consisting of 101 university students, Lapan et al. (1996) found that mathematics self-efficacy plays an important role "in the developmental process through which women either embrace or reject math/science college majors." (Lapan et al., 1996, p. 289). They also found that females displayed lower levels of self-efficacy than males. However, the US study by Kenney-Benson et al. (2006) contradicts these findings and this study found no evidence of higher self-efficacy levels in males in their longitudinal study of 518 students in fifth grade and then again in seventh grade. On the other hand, in their meta-analysis featuring 187 studies, Huang (2013) found males exhibiting higher levels of self-efficacy than females.

According to Pajares (2005), there is no evidence of gender differences in self-efficacy in primary school but females' confidence in their ability is undermined as they enter secondary school, and the perception of mathematics as a male domain is established. Similarly, by middle school Fennema and Hart (1994) found that girls tend to exhibit less confidence in their mathematical ability. Huang (2013) found no significant gender differences in mathematics self-efficacy levels in groups of students aged 6 to 10 years of age and 11 to 14 years of age.

However, in all groups over 14 years of age, there is a statistically significant difference between female and male levels of self-efficacy, with males exhibiting higher levels of mathematics self-efficacy. There may be an unwelcome price to pay for accurate self-evaluation because realistic or under-confident evaluation may affect participation and persistence in mathematics. According to Pajares (1996),

> *Accurate self-perceptions may enable students to more accurately assess their problem-solving strategies, but the danger of "realistic" self-appraisals is that they may be purchased at the cost of lower optimism and lower levels of self-efficacy's primary functions—effort, persistence, and perseverance.*
>
> (Pajares, 1996, p. 340)

Anxiety affects affective engagement in mathematics (Kong et al., 2003). The mathematics anxiety construct is defined by Middleton and Spanias (1999) as a perception that mathematics is difficult and a tendency to steer clear of the subject. Students' willingness to engage in mathematics is weakened by experiencing failure in mathematics, by believing that failure is caused by lack of ability and also by learned helplessness (Kong et al., 2003; Middleton & Spanias, 1999). According to Fennema and Sherman (1976), high levels of anxiety in mathematics are associated with low levels of student confidence in mathematics. In addition, high levels of anxiety are related to lower levels of performance in mathematics (Perkins et al., 2013). Students who display medium and low levels of anxiety about mathematics attained a mean score in PISA 2003 testing that was significantly higher than those with high levels of anxiety (Perkins et al., 2013). Much of the interest in studying anxiety in mathematics has established gender differences in mathematics anxiety, with female students displaying higher levels of mathematics anxiety than male students (Ashcraft & Faust, 1994; Baloglu & Kocak, 2006; Ho et al., 2000). Irish students, in particular females, have increased levels of anxiety relating to mathematics compared to OECD averages (Perkins et al., 2013).

2.4 Work ethic, self-responsibility for failure and openness to problem solving in mathematics

Self-responsibility for failure in mathematics requires students to imagine that they had performed badly on a series of short mathematics tests and to consider the possible explanations. PISA's self-responsibility index is based on these responses, and students with a high value blame themselves for poor performance while students who record a low value on this index attribute failure to other people or other factors. Typically, female students tend to attribute failure in mathematics to a lack of ability but they are not inclined to attribute success to ability (Degol, Wang, Zhang, & Allerton, 2018; Middleton & Spanias, 1999). Successful students are often those who attribute their successes to ability, whereas unsuccessful students are those who attribute failure to lack of ability (Middleton & Spanias, 1999). Consequently, students who believe that mathematics ability is not fixed and can be increased through effort experience more success in the subject and spend more time studying mathematics (Middleton & Spanias, 1999). The self-responsibility index shows that Irish students are more likely to blame external factors rather than themselves for failure in mathematics compared to other OECD countries (Perkins et al., 2013). However, there is a negative correlation between self-responsibility for failure and successful performance in mathematics (Perkins et al., 2013). Interestingly, it is the students who blame factors other than themselves for failure in mathematics who have higher results in mathematics than students who blame themselves for failure (Perkins et al., 2013). Students' openness to problem solving and work ethic are two further constructs measured by PISA. The objective is to investigate how students approach problem solving and if it is something they enjoy. Work ethic enquires how hard they work in class, at their homework and in preparation for examinations.

2.5 Research questions

- Using the questionnaire data, what can we learn about students' engagement with and interest in mathematics, their motivation to study mathematics, their mathematics self-beliefs, and their perseverance in learning mathematics?
- In which of the affective areas measured is there a difference between male and female students?

The research questions were pursued through an action plan based on multiple subsidiary questions related to each area, leading to consideration of the implications of findings, and recommendations for improving performance.

3. Research design

3.1 Sample

The authors adopted the design used in PISA assessment (OECD, 2014) to acquire their sample of first-year students attending school in the Republic of Ireland in 2015. The sample involved all 723 second-level schools in receipt of funding from the Department of Education and Skills. All 723 schools were stratified by school types, namely: secondary, vocational, community and comprehensive.[4] This division provided new sub-frames for sampling. Approximately 61,196 first-year students were included in the sampling frame. The researcher selected participating schools using probability-proportional-to-size systematic sampling.

The projected sample size for the main study was 382 students, assuming a 95% confidence level and a 5% margin of error. This preliminary sample accounted for 20 schools and 11 of the 20 schools agreed to take part in the study. Nine replacement schools were then selected, and of these replacement schools, four agreed to take part. One of these four replacement schools subsequently refused to participate, which left the research team with 14 participating schools. As the sampling frame was ordered by school type, this ensured that the replacement schools were the same school type as the original school selected.

Within each of the 14 schools, there were multiple mixed-ability first-year classes. A single first-year mathematics class from each school was chosen using a simple random sampling. All students from the selected class were included in the main sample. Due to absenteeism, 304 out of the 323 first-year students who made up the sample completed the attitudinal questionnaire in May 2016. The students were given two hours on a regular school day to complete the survey instruments. The university associated with the authors granted ethical approval for the research (Code: 2015_09_01_S&E).

[4] Secondary schools are privately owned and managed. Vocational schools are governed by the state through Education and Training Boards (ETBs), while Boards of Management manage community and comprehensive schools.

3.2 Student questionnaire to assess attitude

The student questionnaire used in this study was extracted from the PISA 2012 student questionnaire and examined students' engagement with mathematics by assessing their interest in mathematics, motivation to study mathematics and perseverance in learning mathematics. It assessed the students' self-beliefs and student anxiety, which both influence performance. It also looked at learning strategies employed by students and how these strategies affect motivation, self-beliefs and academic success. Students' characteristics, self-responsibility for failure in mathematics and openness to problem solving are examined. Predicted future engagement with mathematics is assessed through questions focusing on mathematics-related behaviours, mathematics-related intentions and students' subjective norms. The PISA 2012 student questionnaire draws on the theory of planned behaviour model proposed by Ajzen (1991) to predict work ethic, intention, study behaviour and mathematics performance. It achieves this using questions based on students' attitudes, subjective norms and perceptions of control (OECD, 2013b). Attitude towards mathematics is examined through the PISA 2012 student questionnaire by analysing students' interest in mathematics and students' willingness to engage in mathematics. Interest in mathematics is investigated by looking at present and future engagement in mathematics. Students' opinion of the usefulness of mathematics, students' interest in the mathematics they are studying in school, their intention to embark on further study or pursue a career that will require mathematics are all examined through the student questionnaire (OECD, 2013b). Students' willingness to engage in mathematics is gauged through questions on the attitudes, emotions and beliefs that predispose students to successfully employ the mathematics they have learned. If students are confident in their mathematics ability they are more likely to engage in mathematical activity outside of school. Mathematics anxiety, enjoyment of mathematics, confidence, self-efficacy, self-concept, student experience in class, student experience in tests and the opportunity to learn are all examined in the student questionnaire to assess students' willingness to engage in mathematics (OECD, 2013b).

Students' engagement with mathematics is assessed under three domains: intrinsic motivation, extrinsic motivation and perseverance. Students' beliefs about themselves were examined under mathematics self-efficacy, mathematics self-concept and mathematics anxiety. The student questionnaire examines memorisation, elaboration and control strategies, as well as how students employ these strategies to process, integrate and apply their mathematical knowledge. Self-responsibility for failure in mathematics was measured by asking students to imagine that they had performed badly on a series of short mathematics tests. The students were then asked to attribute the cause to a list of possible explanations. A self-responsibility index was constructed based on these responses and students with a high value blame themselves for poor performance while students who record a low value on this index attribute failure to other people or other factors. Students who engage in mathematics-related behaviours are more likely to enjoy and value the subject (OECD, 2013b). Mathematics-related intentions indicate the likelihood of students pursuing mathematics or mathematics-related disciplines in higher education (OECD, 2013b). Students' subjective norms have a direct impact on behaviour so if the people who are important to the student see mathematics as important, it is likely that the student also will see the value and importance of mathematics.

3.3 Limitations of study

The researcher relied on the cooperating mathematics teacher in each of the sample schools to administer the test. It was not possible to ensure that all students had the same experience of the test environment. It was not possible to ensure that the cooperating teacher adhered rigorously to the instructions for the testing and the administration of the questionnaire. Furthermore, the authors were constrained by the main study in relation to the sample used and also by the willingness of schools to participate in the study. Even though the sample was randomly selected, a smaller sample size than originally desired may mean that that findings of the study are not generalisable to the entire population of students.

4. Results

4.1 Profile of student groups

304 first-year students completed the student questionnaire. The mean age of participants was 13.47 years, which is the expected age for students at the end of their first year of secondary education in Ireland. The proportion of male students in the sample is higher than expected and this is due to the fact that four out of the 14 schools selected for the sample were all-boys schools.

		Frequency	Percent
Valid	F	121	39.8
	M	183	60.2
	Total	304	100.0

Table 5 Gender of Students in Sample

4.2 Student responses: about learning mathematics and problem solving experiences

4.2.1 About learning mathematics

The mean and standard deviations for the responses on 62 questions in relation to learning mathematics were calculated. Low mean scores indicate a high level of student agreement on positively worded statements and a low level of student agreement on negatively worded statements. The lowest mean score of 1.39 is attributed to the statement “My parents believe it’s important for me to study mathematics”, with 98% of respondents agreeing or strongly agreeing with the statement. The second-lowest mean score is attributed to the statement “If I put in enough effort I can succeed in mathematics”, with a mean score of 1.42. This corresponds to 96% of participants agreeing or strongly agreeing with the statement. The highest mean score of 3.9 is attributed to question “I participate in a mathematics club”, with only 2% of respondents answering, always or almost always. 64% of students in this sample plan to take additional mathematics courses after school finishes and 73% are willing to study harder in their mathematics class than is required. 69% plan on pursuing a career that involves a lot of mathematics and 69% plan on studying a course at higher-education institutions that requires mathematics skills, indicating a positive attitude towards mathematics. Students in this sample study mathematics by working out exactly what they need to learn (61%); learning as much as they can off by heart (42%); trying to figure out which ideas they still have not understood properly (46%); and going through examples again and again in order to remember the method for solving a mathematics problem (53%).

Table 6: Student Responses about Learning Mathematics Summary Statistics

	N		Mean	Std. Deviation
	Valid	Missing		
1. I enjoy reading about mathematics.	303	1	2.44	0.73
2. Making an effort in mathematics is worth it because it will help me in the work that I want to do later on.	304	0	1.46	0.56
3. I look forward to my mathematics lessons.	304	0	2.30	0.86
4. I do mathematics because I enjoy it.	302	2	2.39	0.89
5. Learning mathematics is worthwhile for me because it will improve my career chances.	303	1	1.44	0.59
6. I am interested in the things I learn in mathematics.	304	0	2.08	0.78
7. Mathematics is an important subject for me because I need it for what I want to study later on.	302	2	1.67	0.76
8. I will learn many things in mathematics that will help me get a job.	303	1	1.55	0.61
9. Mathematics is useful for dealing with tasks in everyday life.	303	1	1.72	0.73
10. Most of my friends do well in mathematics.	304	0	1.99	0.56
11. Most of my friends work hard at mathematics.	303	1	2.10	0.66
12. My friends enjoy taking mathematics tests.	301	3	3.10	0.67
13. My parents believe it's important for me to study mathematics.	304	0	1.39	0.53
14. My parents believe that mathematics is important for my future career.	302	2	1.51	0.64
15. My parents like mathematics.	301	3	2.06	0.77
16. Working out from a train timetable how long it would take to get from one place to another.	303	1	1.92	0.78
17. Calculating how much cheaper a TV would be after a 30% discount.	303	1	2.10	0.92
18. Calculating how many square metres of tile you need to cover a floor.	304	0	2.23	0.92

	N		Mean	Std. Deviation
	Valid	Missing		
19. Understanding graphs presented in newspapers.	303	1	1.80	0.81
20. Solving an equation like 3x + 5 = 17.	303	1	1.85	0.92
21. Finding the actual distance between two places on a map with a 1:10,000 scale.	303	1	2.71	0.94
22. Simplifying an expression like 2(x + 3) + (x + 3) (x - 3).	304	0	2.24	1.03
23. Calculating the rate of petrol consumption of a car.	304	0	2.45	0.89
24. I often worry that mathematics classes will be difficult for me.	303	1	2.39	0.95
25. I am just not good at mathematics.	303	1	2.07	0.90
26. I get very tense when I have to do mathematics homework.	302	2	1.95	0.86
27. I get good grades in mathematics.	302	2	2.02	0.77
28. I get very nervous doing mathematics problems.	301	3	2.10	0.83
29. I learn mathematics quickly.	301	3	2.17	0.85
30. I have always believed that mathematics is one of my best subjects.	302	2	2.32	1.13
31. I feel helpless when doing a mathematics problem.	300	4	1.95	0.82
32. In my mathematics class, I understand even the most difficult work.	302	2	2.53	0.88
33. I worry that I will get poor grades in mathematics.	302	2	2.50	1.00
34. If I put in enough effort I can succeed in mathematics.	302	2	1.42	0.56
35. Whether or not I do well in mathematics is completely up to me.	302	2	1.86	0.80
36. Family demands or other problems prevent me from putting a lot of time into my mathematics work.	303	1	2.03	0.88
37. If I had different teachers I would try harder in mathematics.	301	3	1.88	0.94
38. If I wanted to I could do well in mathematics.	301	3	1.81	0.82
39. I do poorly in mathematics whether or not I study for my exams.	300	4	2.01	0.94
40. I'm not very good at solving mathematics problems.	298	6	2.37	0.94
41. My teacher did not explain the concepts well this week.	298	6	1.87	0.89

	N		Mean	Std. Deviation
	Valid	Missing		
42. This week I made bad guesses on the test.	298	6	2.10	0.96
43. Sometimes the course material is too hard.	297	7	2.56	0.94
44. The teacher did not get students interested in the material.	299	5	2.08	0.99
45. Sometimes I am just unlucky.	298	6	2.26	1.06
46. I have my homework finished in time for mathematics class.	299	5	1.45	0.69
47. I work hard on my mathematics homework.	298	6	1.74	0.69
48. I am prepared for my mathematics exams.	298	6	1.87	0.75
49. I study hard for mathematics tests.	296	8	2.09	0.80
50. I keep studying until I understand mathematics material.	297	7	2.07	0.80
51. I pay attention in mathematics class.	295	9	1.66	0.61
52. I listen in mathematics class.	294	10	1.60	0.59
53. I avoid distractions when I am studying mathematics.	296	8	2.13	0.85
54. I keep my mathematics work well organised.	296	8	1.85	0.78
55. I talk about mathematics problems with my friends.	297	7	3.48	0.76
56. I help my friends with mathematics.	297	7	2.78	0.83
57. I do mathematics as an extracurricular activity.	292	12	3.58	0.75
58. I take part in mathematics competitions.	296	8	3.61	0.80
59. I do mathematics more than 2 hours a day outside of school.	297	7	3.67	0.65
60. I play chess.	297	7	3.26	1.00
61. I program computers.	296	8	3.43	0.90
62. I participate in a mathematics club.	297	7	3.90	0.46

The mean and standard deviations for the responses on 22 questions in relation to problem solving experiences were calculated. The lowest mean score of 2.20 is attributed to the statement "When confronted with a problem I give up easily", with 69% of respondents identifying with the response "not much like me" or "not at all like me". The highest mean score of 3.8 is attributed to the statement "I like to solve complex problems", with 13% of respondents responding "very much like me". The lowest mean score of 1.86 is attributed to the statement "I think about what might have caused the problem and what I can do to solve it", with 83% of respondents likely to take this approach. The highest mean score of 2.82 is attributed to the statement "I read the manual", with 36% of respondents likely to take that approach.

Table 7: Student Responses about Problem Solving Experiences Summary Statistics

	N		Mean	Std. Deviation
	Valid	Missing		
1. When confronted with a problem I give up easily.	292	12	2.20	1.05
2. I put off difficult problems.	293	11	2.42	1.08
3. I remain interested in the tasks that I start.	292	12	2.46	1.04
4. I continue working on tasks until everything is perfect.	292	12	2.60	1.10
5. When confronted with a problem I do more than what is expected of me.	294	10	2.97	1.05
6. I can handle a lot of information.	291	13	2.53	1.10
7. I am quick to understand things.	290	14	2.48	1.15
8. I seek explanations for things.	290	14	2.49	1.07
9. I can easily link facts together.	291	13	2.64	1.07
10. I like to solve complex problems.	291	13	3.17	1.30

Table 8: Student Responses about Problem Solving Experiences Summary Statistics

	N		Mean	Std. Deviation
	Valid	Missing		
1. I press every button possible to find out what is wrong	283	21	2.49	1.03
2. I think about what might have caused the problem and what I can do to solve it.	287	17	1.86	0.78
3. I read the manual.	283	21	2.82	1.04
4. I ask a friend for help.	285	19	2.14	0.90
5. I read the zoo brochure to see if it says how to get there.	285	19	2.08	0.97
6. I study a map and figure out the best route.	286	18	2.40	1.03
7. I leave it to my brother to worry about how to get there.	286	18	1.96	0.96
8. I know roughly where it is, so I suggest we just start driving.	283	21	2.52	0.91
9. I check how similar it is to other ticket machines I have used.	283	21	2.05	0.84
10. I try out all the buttons to see what happens.	284	20	2.27	1.01
11. I ask someone for help.	282	22	2.01	0.87
12. I try to find a ticket office at the station to buy a ticket.	283	21	2.01	0.91

4.3 Motivation to learn mathematics

Students' motivation to learn mathematics was assessed using three clusters of items:

- intrinsic motivation to learn mathematics,
- instrumental motivation to learn mathematics, and
- perseverance in learning mathematics.

Students in this sample show an eagerness to learn and show high levels of intrinsic motivation, instrumental motivation and perseverance. Similar levels of intrinsic motivation exist for both male and female students in this study.

Table 9: Intrinsic Motivation Questionnaire Results

Intrinsic Motivation	**Participants Who Agree Or Strongly Agree**
I enjoy reading about mathematics	56.1% (F=54.5%, M=57.1%)
I look forward to my mathematics lesson	62.5% (F=61.2%, M=63.4%)
I do mathematics because I enjoy it	54.3% (F=50.0%, M=57.1%)
I am interested in the things I learn in mathematics	74.0% (F=69.4%, M=77.0%)

Table 10: Instrumental Motivation Questionnaire Results

Instrumental Motivation	**Participants Who Agree Or Strongly Agree**
Making an effort in mathematics is worth it because it will help me in the work that I will do later on	96.7% (F=95.9%, M=97.3%)
Learning mathematics is worthwhile for me because it will improve my career prospects and chances	95.0% (F=91.7%, M=97.3%)
Mathematics is an important subject for me because I need it for what I want to study later on	88.1% (F=84.3%, M=90.6%)
I will learn many things in mathematics that will help me get a job	95.0% (F=93.3%, M=96.2%)

Male students record higher perseverance levels than female students in all measures of perseverance in this study.

Table 11: Perseverance Questionnaire Results 1

Perseverance	**Participants Who Agree Or Strongly Agree**
I remain interested in the tasks that I start	58.6% (F=53.4%, M=61.9%)
I continue working on tasks until everything is perfect	49.3% (F=44.3%, M=52.5%)
When confronted with a problem I do more than is expected of me	32.3% (F=29.3%, M=34.3%)

Over one quarter of male students are likely to identify as giving up easily when confronted with a problem, compared to almost 40% of female students

Table 12: Perseverance Questionnaire Results 2

Perseverance	**Participants Who Disagree Or Strongly Disagree**
When confronted with a problem, I give up easily	68.8% (F=60.9%, M=74.0%)
I put off difficult problems	58.0% (F=55.7%, M=59.6%)

In summary, intrinsic motivation, instrumental motivation and perseverance results combine to show students who are motivated and determined to succeed in the subject. Almost all students (96.7%) believe that making an effort in mathematics is worth it because it will help in the work that they will do later on. Three in every four students are interested in the things they learn in mathematics, while 58.6% of students remain interested in the tasks that they start. Males showed higher levels of instrumental motivation, intrinsic motivation and perseverance than females on every question.

4.4 Students' learning strategies

The student questionnaire examines memorisation, elaboration and control strategies, as well as how students employ these strategies to process, integrate and apply their mathematical knowledge. Elaboration strategies may involve integration of new and existing knowledge and the application of the new knowledge to other situations. It necessitates an understanding of the new material. Control strategies relate to how students manage how they learn. Students need to self-assess what they have learned already and what they need to learn. This study showed students favouring a traditional approach to learning mathematics. 42.1% of students study for a mathematics test by learning as much as they can off by heart. 45.7% try to figure out which ideas they still have not understood properly when studying mathematics. 61.4% study mathematics by working out exactly what they need to learn. 53.1% go through examples again and again in order to solve a mathematics problem.

4.5 Mathematics self-beliefs

Students' mathematics self-beliefs were assessed using three clusters of items:

- mathematics self-efficacy,
- mathematics self-concept, and
- mathematics anxiety.

Self-efficacy, self-concept and anxiety affect engagement with mathematics in the short and long term. Overall, the self-concept and self-efficacy indicators show students as having positive self-belief. In this study, students are, in general, confident in applying their mathematical skills to real-life situations.

80.5% of students are confident or very confident in understanding graphs presented in newspapers and 79.5% of students are confident or very confident in their ability to work out how long it would take to get from one place to another from a train timetable. Students were less confident in working out the petrol consumption of a car (49.7%) and finding the actual distance between two places on a map with a 1:10,000 scale (38.0%). The self-efficacy questionnaire results reveal considerable differences in male and female levels of confidence relating to specific tasks in mathematics. It also reveals that one third of students are not confident in applying a 30% discount to an item. Only 61.2% (female = 50.4%, male = 68.3%) identify as confident or very confident with the statement: "Calculating how many square metres of tile you need to cover a floor".

In terms of self-concept, two thirds of students believe they learn mathematics quickly and 76.5% identify as getting good grades in mathematics. 57.9% of students in this sample believe that mathematics is one of their best subjects. The self-concept questionnaire results reveal considerable gender differences, with male students showing considerably higher levels of self-concept than their female counterparts. 35.5% of females compared to only 19.2% of males agree or strongly agree with the statement "I am just not good at mathematics".
However, anxiety indicators show less favourable results. One fifth of students get very tense when doing their mathematics homework and one fifth of students feel helpless when doing a mathematics problem. Almost half of all the students in the sample worry that they will get poor grades in mathematics and 45.5% of students worry that that they will experience difficulties in mathematics class. All students, but particularly female students, experience high levels of anxiety in relation to mathematics, worrying about homework, solving problems, class material and grades. 45.5% (female = 56.2%, male = 38.5%) agree or strongly agree with the statement "I often worry that it will be difficult for me in mathematics classes" and 49.0% (female = 59.5%, male = 42.0%) agree or strongly agree with the statement "I worry that I will get poor grades in mathematics".

4.6 Students' work ethic, openness to problem solving and attributions of failure in mathematics

Students at the end of the first year of secondary education show a strong work ethic indicating high levels of preparedness and engagement. 95.9% of respondents answered always or almost always to the statement "I listen in mathematics class". 93.0% (female = 87.2%, male = 96.7%) of students agree or strongly agree with the statement "I have my homework finished in time for mathematics class". 89.3% (female = 89.7%, male = 89.0%) of students agree or strongly agree with the statement "I work hard on my mathematics homework".

Less than one third of students identify as enjoying solving complex problems, which are problems requiring application of knowledge and can often be presented in an unfamiliar context. Also in relation to problem solving, approximately half of all the students in this sample identify as being able to handle a lot of information, being quick to understand things, seeking explanations for things and easily linking facts together. 47.1% of students believe they can easily link facts together and the lowest score of 32.0% is the percentage of students who like to solve complex problems. Male students are more open to problem solving than female students: 11.1% more males than females like to solve complex problems, 11.7% more males than females believe they can easily link facts together, and 10.7% more males than females identify as being quick to understand things.

49.5% of students are likely or very likely to attribute the test failure to the course material being too hard. 44.6% of students are likely or very likely to attribute failure in tests to themselves: "I'm not very good at solving mathematics problems". We know from research literature that higher achievement results are linked to students who blame other factors than themselves for their failure in mathematics (Perkins et al., 2013). Similar to the findings of Middleton and Spanias (1999), this study shows that female students are more likely to attribute failure to lack of ability.

4.7 Students' mathematics-related behaviours, students' intentions to study mathematics further, and students' subjective norms

Three clusters of items were considered for this section:

- mathematics-related behaviours,
- mathematics-related intention, and
- subjective norms.

In this study, 10.1% (female = 11.2%, male = 9.4%) of students responded always or almost always or often to the statement "I talk about mathematics problems with my friends". However, almost three quarters of the students in the survey identify as willing to study harder in their mathematics classes than is required. Students in this sample are unlikely to have mathematics-related behaviours. Just 2.7% participate in a mathematics club. Only 9.6% do mathematics as an extracurricular activity. The mathematics-related activity with the highest score of 31.0% was attributed to students helping their friends with mathematics. 11.2% more male students than female students identified with this statement.

Students' desires to study mathematics in the future are high at the end of their first year. The majority of students in this sample intend to pursue mathematics after school, either in college or by taking additional mathematics classes, and throughout their career. 68.9% (female = 66.0%, male = 70.6%) of students agree or strongly agree with the statement "I am planning on pursuing a career that involves a lot of mathematics". 63.7% (female = 65.5%, male = 62.6%) of students agree or strongly agree with the statement "I plan to take additional mathematics courses after school finishes".

Students believe their parents and friends value the importance of mathematics and 80% believe their friends work hard at mathematics, eager to succeed. 93.4% (female = 89.9%, male = 95.6%) of students agree or strongly agree with the statement "My parents believe that mathematics is important for my future career". Students in this study recorded extremely high levels in each of the questions relating to subjective norms. 98.4% of students agree or strongly agree that their parents believe it's important for them to study mathematics, 93.4% of students agree or strongly agree that their parents believe mathematics to be important for their future career, and three quarters of students surveyed believe that their parents like mathematics. These students also judge that their friends do well in mathematics (87.5%) and work hard in mathematics (77.9%).

4.8 Gender differences in questionnaire responses

A difference of more than 10% in male and female answering occurred in the following questions. A difference of -20% means that female students in the sample recorded a value 20% lower than male students in the sample and a difference of +20% means that female students in the sample recorded a value that was 20% higher than male students in the sample for that particular question.

Table 13 : Gender Differences in Questionnaire Responses

Question	Difference	Question Type
Calculating how much cheaper a TV would be after a 30% discount.	-20.20%	Self-Efficacy
Finding the actual distance between two places on a map with a 1:10,000 scale.	-19.20%	Self-Efficacy
Calculating how many square metres of tile you need to cover a floor.	-17.90%	Self-Efficacy
Working out from a train timetable how long it would take to get from one place to another.	-17.20%	Self-Efficacy
I learn mathematics quickly.	-15.80%	Self-Concept
Calculating the rate of petrol consumption of a car.	-15.20%	Self-Efficacy
When confronted with a problem I give up easily.	-13.10%	Perseverance
I have always believed that mathematics is one of my best subjects.	-12.60%	Self-Concept
I can easily link facts together.	-11.70%	Openness to Problem Solving
I help my friends with mathematics.	-11.20%	Mathematics' Students' Behaviours
I like to solve complex problems.	-11.10%	Openness to Problem Solving

I am quick to understand things.	-10.70%	Openness to Problem Solving
I feel helpless when doing a mathematics problem.	13.90%	Anxiety
I get very nervous doing mathematics problems.	13.90%	Anxiety
I am just not good at mathematics.	16.30%	Self-Concept
I worry that I will get poor grades in mathematics.	17.50%	Anxiety
I often worry that mathematics classes will be difficult for me.	17.70%	Anxiety

5. Discussion

This study provides an insight into students' disposition towards mathematics for 304 students at the end of their first year of secondary education. In general, the results point to students who have a positive disposition towards the subject and who are motivated to succeed in mathematics. Research has shown that a positive emotional disposition towards the subject is linked to success in the subject, is a key school outcome and affects the career intentions of the students (Haladyna, Shaughnessy, & Shaughnessy, 1983). Overall, the self-concept and self-efficacy indicators show students as having positive self-belief, a valuable finding as self-efficacy is an important predictor of future performance (Pajares & Miller, 1994).

The majority of students in this study plan on pursuing a career involving mathematics. They are eager to learn mathematics and show high levels of preparedness and engagement. This finding is in contrast to those of PISA (2012), which showed that Irish students are less likely to intend to have a career in mathematics or intend to study mathematics compared to students across all OECD countries (Perkins et al., 2013). The majority of students believe their friends and parents value mathematics, which is an important finding, as parents' interest in the school and parents' level of satisfaction in mathematics are linked to students' belief in their own ability (Surgenor et al., 2006).

Almost three quarters of the students in the survey identify as willing to study harder in their mathematics classes than is required, but they are unlikely to have mathematics-related behaviours. Just 2.7% participate in a mathematics club. This is disappointing given that research has shown that participation in mathematics clubs leads to improved performance in standardised tests in concepts, application and computation (Sherman & Catapano, 2011). It echoes the findings of PISA in 2012 that showed Irish students are among the third-lowest group across all OECD countries to participate in mathematics-related activities such as clubs and competitions (Perkins et al., 2013).

Students' approaches to studying mathematics are less than satisfactory. This sample of students indicate that they study mathematics by working out exactly what they need to learn (61%); learning as much as they can off by heart (42%); trying to figure out which ideas they still have not understood properly (46%); and going through examples again and again in order to remember the method for solving a mathematics problem (53%). Memorisation strategies are important in retrieving information but not generally conducive to an in-depth understanding of the information and an ability to apply the mathematics to other contexts (O'Brien, 1999). According to O'Brien (1999), memorisation strategies are essentially 'parrot math' and have been shown to be detrimental to student performance in mathematics. An activity-based approach is favoured, which would involve skills such as problem solving, generalising and hypothesising. Elaboration strategies may involve integration of new and existing knowledge and the application of the new knowledge to other situations. It necessitates an understanding of the new material. Control strategies relate to how students manage how they learn. Students need to self-assess what they have learned already and what they need to learn. The preferences for studying mathematics uncovered are also not consistent with the ethos of the relatively recently introduced secondary-school curriculum (2010) entitled Project Maths, which endorses teaching and learning for understanding and the use of problem-solving strategies.

Gender differences are evident in perseverance, mathematics self-efficacy and mathematics anxiety. Male students show higher levels of self-efficacy and perseverance and lower levels of mathematics anxiety compared to their female counterparts. The greatest levels of gender differences in responses related to the student self-belief section of the questionnaire, with females recording significantly higher levels of anxiety and lower levels of self-efficacy and self-concept. 17.5% more females than males worry that they will get poor grades in mathematics, 17.7% more females than males worry that they will experience difficulties in mathematics class, and 15.8% more males identify as being able to learn mathematics quickly. These findings are mirrored in PISA 2012 results, which found anxiety levels of Irish students to be higher than the OECD average (OECD, 2013b). Research has shown that self-efficacy is strongly associated with performance and students with high levels of self-efficacy record significantly higher levels of achievement than those who reported low levels of self-efficacy (Close & Shiel, 2009). There is a significant difference in performance between students reporting high levels of anxiety and students reporting low levels of anxiety (Close & Shiel, 2009). Students who report high levels of anxiety are more likely to record low achievement, and girls who completed PISA in 2012 showed significantly higher levels of anxiety than their male counterparts (Perkins & Shiel, 2016). The PISA 2012 results on anxiety are mirrored by this study. High levels of anxiety in mathematics have been shown to lead to avoidance of mathematics (Ashcraft, 2002) and compromise the development of higher-level mathematical skills (Maloney, Ansari, & Fugelsang, 2011). Close and Shiel (2009) suggest that stronger performance by male students is related to stronger levels of self-efficacy and lower levels of anxiety. In addition, PISA 2012 found a moderate to strong correlation between mathematics self-beliefs and performance (Perkins et al., 2013).

Fishbein and Ajzen (1977) have shown that high levels of subjective norms increase motivation towards a desired behaviour and the prospect of that behaviour being exhibited. Given the positive emotional disposition students have displayed towards mathematics in this, the openness to learning suggests that approaches to learning other than memorisation may be embraced by students. This study further highlights a gender disparity in mathematics self-beliefs, particularly in relation to self-efficacy and anxiety. This has implications for future female participation in STEM disciplines.

Finally, it is important to consider the findings on student interest and willingness to engage with mathematics within the context of the larger study of academic performance between the end of primary school and the end of the first year of secondary school. The larger study shows student failure to successfully negotiate transition in mathematics. On average, out of the 119 questions on the test, students scored eight marks less than they had scored a year previously, despite covering a very similar curriculum in sixth class and first year. The losses incurred in mathematics in first year found in this study were far more pronounced than either national or international comparable studies (Cox & Kennedy, 2008; Galton et al., 1999; Smyth et al., 2004). This is a critical finding because, despite student performance dis-improving, this study has shown that students are still interested in mathematics and eager to succeed in the subject. Given the positive emotional disposition students have displayed towards mathematics, this research establishes that first year in post-primary school represents and offers a huge opportunity for educators to develop students' mathematical skills, understanding, interest in and appreciation of the subject. The questionnaire results show that students are engaged and motivated to learn mathematics so it is vital that students are not allowed to regress and ultimately disengage from the subject. More directed attention to students' academic performance in mathematics in the first year of transition has the potential to secure bigger gains based on better early performance in post-primary education.

6. Recommendations and conclusion

The role of the teacher in the learning of mathematics is of paramount importance (Attard, 2010; Feldlaufer, Midgley, & Eccles, 1988; Galton, Morrison, & Pell, 2000; Midgley, Feldlaufer, & Eccles, 1989) and the transition from primary education to post-primary education in particular is a critical time for our young people (Akos, Shoffner, & Ellis, 2007; Anderson, Jacobs, Schramm, & Splittgerber, 2000; Eccles et al., 1991; Smyth et al., 2004). Academic self-image becomes more negative over the transition to post-primary school for both male and female students, but gender differences increase between the ages of nine and 13 in relation to academic self-image and anxiety measures. Smyth (2016) found poor self-image arising in students who had difficulty negotiating the transition to post-primary school and reported that student self-image is significantly associated with the relationships student have with their teachers. Students who experience praise and positive feedback tend to have positive self-image and similarly, students who are chastised by their teachers tend to have poorer self-image. Thus it is vital that all teachers are made aware of the difficulties students experience in making the transition and the need for increased praise and positive feedback in their interactions with first-year students. This research echoes the recommendations of Smyth (2017), who advised the promotion of positive teacher–student interactions to form part of school development plans and initial and continuous teacher training. While teacher training should be designed to improve outcomes for all students, there needs to be a special focus on recognising the problems that specifically female students face at this significant point in their education. The transition is a pivotal point for female students and it is important that the stereotype of mathematics as a male domain is challenged while students are making the transition. Further research into this area, with a larger sample over an extended period of time, is warranted.

References

Ajzen, I. (1991). The theory of planned behaviour. *Organizational behavior and human decision processes, 50*(2), 509-526.

Akos, P., Shoffner, D. M., & Ellis, D. M. (2007). Mathematics Placement and the Transition to Middle School. *Professional School Counseling, 10*(3), 238-244. doi:10.5330/prsc.10.3.r6666472n013v086

Al-Mutawah, M. A., & Fateel, M. J. (2018). Students' Achievement in Math and Science: How Grit and Attitudes Influence? *International Education Studies, 11*(2), 97-105.

Anderson, L. W., Jacobs, J., Schramm, S., & Splittgerber, F. (2000). School transitions: beginning of the end or a new beginning? *International Journal of Educational Research, 33*(4), 325-339. doi:10.1016/s0883-0355(00)00020-3

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current directions in psychological science, 11*(5), 181-185.

Ashcraft, M. H., & Faust, M. W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. *Cognition & Emotion, 8*(2), 97-125.

Attard, C. (2010). *Students' experiences of mathematics during the transition from primary to secondary school*. Paper presented at the Mathematics Education Research Group of Australasia, Fremantle, Perth.

Baloglu, M., & Kocak, R. (2006). A multivariate investigation of the differences in mathematics anxiety. *Personality and Individual Differences, 40*(7), 1325-1335.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review, 84*(2), 191.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American psychologist, 37*(2), 122.

Bandura, A. (1986). *Social foundations of thought and action*. Englewood Cliffs, NJ: Prentice Hall.

Blumenfeld, P. C., Pintrich, P. R., Meece, J., & Wessels, K. (1982). The formation and role of self perceptions of ability in elementary classrooms. *The Elementary School Journal, 82*(5), 401-420. doi:10.1086/461278

Brassell, A., Petry, S., & Brooks, D. M. (1980). Ability grouping, mathematics achievement, and pupil attitudes toward mathematics. *Journal for Research in Mathematics Education, 11*(1), 22-28.

Casey, A., & Fernandez-Rio, J. (2019). Cooperative learning and the affective domain. *Journal of Physical Education, Recreation & Dance, 90*(3), 12-17.

Close, S., & Shiel, G. (2009). Gender and PISA Mathematics: Irish results in context. *European Educational Research Journal, 8*(1), 20-33.

Cox, S., & Kennedy, S. (2008). Students' achievement as they transition from primary to secondary schooling: Report no. 1 on the students' transition from primary to secondary schooling study (0478137982). Retrieved from Wellington: https://www.educationcounts.govt.nz/publications/schooling/31857

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin, 52*(4), 281-302. doi:10.1037/h0040957

Czocher, J. A., Melhuish, K., & Kandasamy, S. S. (2020). Building mathematics self-efficacy of STEM undergraduates through mathematical modelling. *International Journal of Mathematical Education in Science and Technology, 51*(6), 807-834.

Degol, J. L., Wang, M. T., Zhang, Y., & Allerton, J. (2018). Do Growth Mindsets in Math Benefit Females? Identifying Pathways between Gender, Mindset, and Motivation. *Journal of youth and adolescence, 47*(5), 976-990. doi:10.1007/s10964-017-0739-8

Deieso, D., & Fraser, B. J. (2019). Learning environment, attitudes and anxiety across the transition from primary to secondary school mathematics. *Learning Environments Research, 22*(1), 133-152.

Eccles, J., Midgley, C., Wigfield, A., Reuman, D., Mac Iver, D., & Feldlaufer, H. (1991). Are junior high schools undermining the academic motivation of early adolescents. *Elementary School Journal,* 1-48.

Evans, C. A., Chen, R., & Hudes, R. P. (2020). Understanding Determinants for STEM Major Choice Among Students Beginning Community College. *Community College Review, 48*(3), 227-251.

Feldlaufer, H., Midgley, C., & Eccles, J. S. (1988). Student, teacher, and observer perceptions of the classroom environment before and after the transition to junior high school. *The Journal of Early Adolescence, 8*(2), 133-156. doi:10.1177/0272431688082003

Fennema, E., & Hart, L. (1994). Gender and the JRME. *Journal for Research in Mathematics Education, 25*(6), 648-659.

Fennema, E., & Sherman, J. (1976). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. . *Journal for Research in Mathematics Education, 7*(5), 324-326.

Fischer, C., Malycha, C. P., & Schafmann, E. (2019). The influence of intrinsic motivation and synergistic extrinsic motivators on creativity and innovation. *Frontiers in psychology, 10*, 137.

Fishbein, M., & Ajzen, I. (1977). Belief, attitude, intention, and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley.

Fleener, M. J. (1996). Scientific world building on the edge of chaos: High school students' beliefs about mathematics and science. *School Science and Mathematics, 96*(6), 312-320. doi:10.1111/j.1949-8594.1996.tb15841.x

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59-109.

Galton, M., Gray, J., & Ruddick, J. (1999). The impact of school transitions and transfers on pupil progress and attainment. London: DfEE.

Galton, M., Morrison, I., & Pell, T. (2000). Transfer and transition in English schools: reviewing the evidence. *International Journal of Educational Research, 33*(4), 341-363. doi:10.1016/s0883-0355(00)00021-5

Gladstone, J. R., Häfner, I., Turci, L., Kneißler, H., & Muenks, K. (2018). Associations between parents and students' motivational beliefs in mathematics and mathematical performance: The role of gender. *Contemporary educational psychology, 54*, 221-234.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*(3), 261-273.

Haladyna, T., Shaughnessy, J., & Shaughnessy, J. M. (1983). A causal analysis of attitude toward mathematics. *Journal for Research in Mathematics Education, 14*(1), 19. doi:10.2307/748794

Ho, H.-Z., Senturk, D., Lam, A. G., Zimmer, J. M., Hong, S., Okamoto, Y., ... Wang, C.-P. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in*

Mathematics Education, 362-379.

Huang, C. (2013). Gender differences in academic self-efficacy: a meta-analysis. *European Journal of Psychology of Education, 28*(1), 1-35.

Ivowi, U. (2001). Role of Teachers in Motivating Students' Interest in Science and Mathematics. *IICBA Newsletter, 3*(1).

Karakolidis, A., Pitsia, V., & Emvalotis, A. (2016). Examining students' achievement in mathematics: A multilevel analysis of the Programme for International Student Assessment (PISA) 2012 data for Greece. *International Journal of Educational Research, 79*, 106-115.

Kenney-Benson, G. A., Pomerantz, E. M., Ryan, A. M., & Patrick, H. (2006). Sex differences in math performance: The role of children's approach to schoolwork. *Developmental psychology, 42*(1), 11.

Khasawneh, E., Gosling, C., & Williams, B. (2021). The effect of self-efficacy on maths anxiety among paramedic students. *Australasian Journal of Paramedicine, 18.*

Khine, M. S., Fraser, B. J., & Afari, E. (2020). Structural relationships between learning environments and students' non-cognitive outcomes: secondary analysis of PISA data. *Learning Environments Research, 23*, 395-412.

Kloosterman, P., & Gorman, J. (1990). Building motivation in the elementary mathematics classroom. *School Science and Mathematics, 90*(5), 375-382. doi:10.1111/j.1949-8594.1990.tb17226.x

Kong, Q.-P., Wong, N.-Y., & Lam, C.-C. (2003). Student engagement in mathematics: Development of instrument and validation of construct. *Mathematics Education Research Journal, 15*(1), 4-21.

Kul, Ü., & Çelik, S. (2018). Investigating Changes in Mathematics Teachers' Intentions Regarding Web 2.0 Technology *Integration. Acta Didactica Napocensia, 11*(2), 89-104.

Lapan, R. T., Shaughnessy, P., & Boggs, K. (1996). Efficacy expectations and vocational interests as mediators between sex and choice of math/science college majors: A longitudinal study. *Journal of Vocational Behavior, 49*(3), 277-291.

Larson, L. M., Pesch, K. M., Surapaneni, S., Bonitz, V. S., Wu, T.-F., & Werbel, J. D. (2015). Predicting graduation: the role of mathematics/science self-efficacy. *Journal of Career Assessment, 23*(3), 399-409.

Lazarides, R., Buchholz, J., & Rubach, C. (2018). Teacher enthusiasm and self-efficacy, student-perceived mastery goal orientation, and student motivation in mathematics classrooms. *Teaching and Teacher Education, 69*, 1-10.

Maloney, E. A., Ansari, D., & Fugelsang, J. A. (2011). The effect of mathematics anxiety on the processing of numerical magnitude. *The Quarterly Journal of Experimental Psychology, 64*(1), 10-16.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. *Handbook of research on mathematics teaching and learning, 1*, 575-596.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*(1), 60.

Middleton, J. A., & Spanias, P. A. (1999). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the research. *Journal for Research in Mathematics Education, 30*(1), 65. doi:10.2307/749630

Midgley, C., Feldlaufer, H., & Eccles, J. S. (1989). Student/teacher relations and attitudes toward mathematics before and after the transition to junior high school. *Child Development, 60*(4), 981. doi:10.2307/1131038

O'Brien, T. (1999). Parrot math. *Phi Delta Kappan, 80*(6), 434.

O'Brien, V., Martinez-Pons, M., & Kopala, M. (1999). Mathematics self-efficacy, ethnic identity, gender, and career interests related to mathematics and science. *The Journal of Educational Research, 92*(4), 231-235.

OECD. (2013a). *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*. Retrieved from Paris: https://www.oecd.org/pisa/pisaproducts/PISA%202012%20framework%20e-book_final.pdf

OECD. (2013b). *PISA 2012 Results: Ready to Learn: Students' Engagement, Drive and Self-Beliefs* (9264201149). Retrieved from Paris: https://www.oecd.org/pisa/keyfindings/pisa-2012-results-volume-IV.pdf

OECD. (2014). *PISA 2012 Technical Report*. Retrieved from Paris: https://www.oecd.org/pisa/pisaproducts/PISA-2012-technical-report-final.pdf

Pajares, F. (1996). Self-efficacy beliefs and mathematical problem-solving of gifted students. *Contemporary educational psychology, 21*(4), 325-344.

Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs. In A. Gallagher & J. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach*, 294-315. New York: Cambridge University Press.

Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology, 86*(2), 193-203. doi:10.1037//0022-0663.86.2.193

Parker, P. D., Marsh, H. W., Ciarrochi, J., Marshall, S., & Abduljabbar, A. S. (2014). Juxtaposing math self-efficacy and self-concept as predictors of long-term achievement outcomes. *Educational Psychology, 34*(1), 29-48.

Parsons, J. E., Adler, T. F., & Kaczala, C. M. (1982). Socialization of achievement attitudes and beliefs: Parental influences. *Child Development, 53*(2), 310. doi:10.2307/1128973

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

Perkins, R., Shiel, G., Merriman, B., Cosgrove, J., & Moran, G. (2013). *Learning for life: The achievements of 15-year-olds in Ireland on mathematics, reading literacy and science in PISA 2012* (0900440422). Retrieved from Dublin: https://www.education.ie/en/Publications/Education-Reports/Programme-for-International-Student-Assessment-PISA-2012-Learning-for-Life-The-Achievements-of-15-year-olds-in-Ireland-on-Mathematics-Reading-Literacy-and-Science.pdf

Pitsia, V., Biggart, A., & Karakolidis, A. (2017). The role of students' self-beliefs, motivation and attitudes in predicting mathematics achievement: A multilevel analysis of the Programme for International Student Assessment data. *Learning and Individual Differences, 55*, 163-173.

Putwain, D. W., Symes, W., Nicholson, L. J., & Becker, S. (2018). Achievement goals, behavioural engagement, and mathematics achievement: A mediational analysis. *Learning and Individual Differences, 68*, 12-19.

Ryan, V. (2018). Making the transition: A student's mathematical journey from primary to post-primary school in Ireland [Unpublished doctoral dissertation].

University of Limerick.

Schoenfeld, A. (2009). Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics. *Colección Digital Eudoxus, 25*(6).

Sherman, H. J., & Catapano, S. (2011). After-school elementary school mathematics club: Enhancing achievement and encouraging future teachers. *Educational Research Quarterly, 35*(1), 3.

Smyth, E. (2016). Wellbeing and school experiences among 9-and 13-year-olds: Insights from the growing up in Ireland study. Retrieved from Dublin: https://www.esri.ie/pubs/BKMNEXT291.pdf

Smyth, E. (2017). Off to a good start? Primary school experience and the transition to second-level education. Retrieved from Dublin: http://www.esri.ie/pubs/BKMNEXT343.pdf

Smyth, E., McCoy, S., & Darmody, M. (2004). *Moving up: The experiences of first-year students in post-primary education* (1904148514). Retrieved from Dublin: https://www.esri.ie/pubs/BKMNEXT36.pdf

Spangler, D. A. (1992). Assessing students' beliefs about mathematics. *The Mathematics Educator, 3*(1), 19-23.

Stankov, L., Morony, S., & Lee, Y. P. (2014). Confidence: the best non-cognitive predictor of academic achievement? *Educational Psychology, 34*(1), 9-28.

Surgenor, P., Millar, D., Close, S., & Shiel, G. (2006). *Counting on success: Mathematics achievement in Irish primary schools* (0755773195). Retrieved from Dublin: https://www.education.ie/en/Publications/Education-Reports/Counting-on-Success-Mathematics-Achievement-in-Irish-Primary-Schools.pdf

Thomson, S., Hillman, K., & De Bortoli, L. (2013). *A teacher's guide to PISA mathematical literacy*. Victoria: ACER Press.

Valås, H., & Søvik, N. (1994). Variables affecting students' intrinsic motivation for school mathematics: Two empirical studies based on Deci and Ryan's theory on motivation. *Learning and Instruction, 3*(4), 281-298.

Vorderman, C., Porkess, R., Budd, C., Dunne, R., & Rahman-Hart, P. (2011). *A world-class mathematics education for all our young people*. Retrieved from London: http://www.tsm-resources.com/pdf/VordermanMathsReport.pdf

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary educational psychology, 25*(1), 82-91.

SUMMARY OF FINDINGS, DISCUSSION AND RECOMMENDATIONS

Findings

This is the first Irish study to undertake a detailed examination of the effect of the transition from primary to post-primary on mathematical achievement. It comes in the aftermath of major educational reform in mathematics in Ireland at both primary and post-primary level. A comprehensive treatment of the study and its findings can be found in Ryan 2018, and in cognate segments visited in the peer-reviewed papers included in this report. The report concludes below with a brief summary of findings, some discussion and selected recommendations.
Progress in mathematics was measured over the transition by comparing two test results for 249 students. On average, students' raw scores decreased by 7% from sixth class (final year of primary school) to the end of first year of secondary education despite an additional year of instruction and extensive overlap of both syllabi. The results showed statistically significant losses in each strand area and in each process skill.

A detailed item analysis gives a more comprehensive picture and insight into the mathematical profile of students at this stage of their mathematical journey. On average, out of the 119 questions on the test, students scored eight fewer correct answers than they had scored a year previously, despite covering a very similar curriculum in sixth class and first year. The losses incurred in mathematics in first year found in this study were more pronounced than both national and international comparable studies (Smyth, McCoy, & Darmody, 2004; Galton, Morrison, & Pell, 2000; Cox & Kennedy, 2008). Statistically significant decreases were recorded in all strand areas (Number, Measures, Shape and Space, Algebra, and Data) and in each process skill (Concepts and Facts, Computation, and Word Problems). In addition, this data shows statistically significant differences between male and female students with male students, on average, answering eight more questions correct than female students. Male students outperformed female students in each of the five strand areas and in the three process skills.

The affective element of this study showed students had a positive emotional disposition towards mathematics. However, high levels of mathematics anxiety were recorded. The findings also showed a gender disparity in relation to mathematics self-beliefs, particularly in relation to self-efficacy and anxiety. The strongest correlations existed between response and academic performance on questions relating to anxiety on the attitude questionnaire. Students with high levels of self-efficacy and low levels of anxiety tended to have high STEN scores.
The evidence in this study shows that students in first year have an exceptionally positive emotional disposition towards mathematics. They want to learn mathematics and they enjoy mathematics. The importance their friends and parents attribute to mathematics is at a very high level and almost seven in 10 first-year students plan to pursue a career involving a lot of mathematics. On the negative side, the gender disparity in student self-belief is very evident in first-year students and in particular in relation to female self-efficacy and anxiety levels.

Discussion

Given the positive emotional disposition students have displayed towards mathematics, this research establishes that first year in post-primary school represents and offers a great opportunity for educators to develop in students' mathematical skills, understanding, interest and appreciation of the subject. However, it is clear that this opportunity is not fully acknowledged nor exploited in the Irish context. The opportunity cost for students is that they are failing to reach their full potential in mathematics in first year. This in turn leads to students trying to make up lost ground in their subsequent two years of Junior Cycle mathematics and has a knock-on effect on their preparedness for Senior Cycle mathematics.

While the focus of the study was measuring academic achievement in mathematics at this stage of students' mathematical journey, the authors identified a number of obstacles to progress and discussed them in order to develop a more rounded perspective. A number of factors, such as the quantum of instruction time, the Common Introductory Course, and collaboration of stakeholders, are important considerations in understanding how best to improve the transition process in mathematics. However, improving performance is not simply about increasing the amount of instruction time available but about maximising instruction time to ensure students are engaged in tasks which provide a challenge and yet allow them to experience success (Aronson, Zimmerman, & Carlos, 1999).

The academic results of this study question the effectiveness of the Common Introductory Course followed by first-year students. In its present form, the Common Introductory Course undervalues the importance of building on student prior knowledge because a student's prior knowledge is not accessed, as this course effectively promotes (unintentionally) a 'fresh start' approach where students are re-taught the material from sixth class. The 'fresh start' approach of first year which disregards prior learning has been shown to have negative consequences for student engagement and learning (Galton, Hargreaves, & Pell, 2003; Bicknell & Hunter, 2012). Diezmann and Watters (2002) posit that challenge is fundamental to progress in mathematics education and, as others have found, is absent in the 'fresh start' approach.

Meaningful collaboration is needed between sixth-class and first-year teachers. A greater awareness is needed of the curricula and teaching methodologies employed by each other. Awareness of the respective curricula and teaching methodologies needs to be part of teacher training courses in primary and post-primary education. Parents too must be included in a wider collaborative effort involving their children in school and given the tools to play a greater role in the mathematics education of their children in the first year of post-primary education. This is important because there is a statistically significant positive correlation between parents' attitudes towards mathematics and their children's attitude towards mathematics (Mohr-Schroeder et al., 2017). It is also the case that parents' interest in the school and parents' level of satisfaction in mathematics are linked to students' belief in their own ability (Surgenor et al., 2006).

Recommendations

- To ensure continuity, it would be prudent to re-visit the issue of instruction time and whether more time should be allocated to mathematics in the first year of post-primary school,
- Re-visit the Common Introductory Course with a view to introducing a significant and appropriate level of challenge in its implementation,
- Promote awareness of the respective curricula and teaching methodologies as part of teacher training courses in primary and secondary education,
- Promote meaningful collaboration between sixth-class and first-year mathematics teachers,
- Encourage and make it possible for parents to play a greater role in the mathematics education of their children in primary and post-primary education.

Report References

Akos, P., Shoffner, D. M., & Ellis, D. M. (2007). Mathematics Placement and the Transition to Middle School. *Professional School Counseling, 10*(3), 238-244. doi:10.5330/prsc.10.3.r6666472n013v086

Anderson, L. W., Jacobs, J., Schramm, S., & Splittgerber, F. (2000). School transitions: beginning of the end or a new beginning? *International Journal of Educational Research, 33*(4), 325-339. doi:10.1016/s0883-0355(00)00020-3

Aronson, J., Zimmerman, J., & Carlos, L. (1999). Improving Student Achievement by Extending School: Is It Just a Matter of Time? San Francisco: WestEd.

Attard, C. (2010). *Students' experiences of mathematics during the transition from primary to secondary school.* Paper presented at the Mathematics Education Research Group of Australasia, Fremantle, Perth.

Barbeau, E. J., & Taylor, P. J. (Eds.). (2009). Challenging mathematics in and beyond the classroom: the 16th ICMI study. New York: Springer.

Benner, A. D. & Graham, S. (2009). The transition to high school as a developmental process among multiethnic urban youth, *Child Development, 80*(2), 356-376.

Bicknell, B., & Hunter, R. (2012). School Transition from Year 6 to Year 7: A Focus on Mathematics. *International Journal for Mathematics Teaching & Learning.*

Carmichael, C. (2015). Transitioning to secondary school: The case of mathematics. *Australian Journal of Educational & Developmental Psychology, 15.*

Casillas, A., Robbins, S., Allen, J., Kuo, Y.-L., Hanson, M. A., & Schmeiser, C. (2012). Predicting early academic failure in high school from prior academic achievement, psychosocial characteristics, and behavior. *Journal of Educational Psychology, 104*(2), 407.

Clerkin, A., Perkins, R., & Cunningham, R. (2016). *TIMSS 2015 in Ireland: Mathematics and science in primary and post-primary schools.* Retrieved from Dublin: http://www.erc.ie/wp-content/uploads/2016/11/TIMSS-initial-report-FINAL.pdf

Cohen, L., Manion, L. & Morrison, K., (2007). *Research Methods in Education*, 6th edition. Oxon: Routledge.

Cosgrove, J., Perkins, R., Shiel, G., Fish, R., & McGuinness, L. (2012). *Teaching and Learning in Project Maths: Insights from Teachers who Participated in PISA 2012*. Retrieved from Dublin: http://www.erc.ie/documents/p12teachingandlearningprojectmaths.pdf

Cox, S., & Kennedy, S. (2008). Students' achievement as they transition from primary to secondary schooling: Report no. 1 on the students' transition from primary to secondary schooling study (0478137982). Retrieved from Wellington: https://www.educationcounts.govt.nz/publications/schooling/31857

Denvir, B., & Brown, M. (1987). The feasibility of class administered diagnostic assessment in primary mathematics. *Educational Research, 29*(2), 95-107.

Department of Education and Skills. (2015). Framework for Junior Cycle 2015 [press release], available: https://www.education.ie/en/Publications/Policy-Reports/Framework-for-Junior-Cycle-2015.pdf

Diezmann, C. M., & Watters, J. J. (2002). The importance of challenging tasks for mathematically gifted students. *Gifted and Talented International, 17*(2), 76-84.

Eccles, J., Midgley, C., Wigfield, A., Reuman, D., Mac Iver, D., & Feldlaufer, H. (1991). Are junior high schools undermining the academic motivation of early adolescents. *Elementary School Journal*, 1-48.

Eccles, J. S., Wigfield, A., Midgley, C., Reuman, D., Mac Iver, D., & Feldlaufer, H. (1993). Negative effects of traditional middle schools on students' motivation. *The Elementary School Journal 93*(5), 553-574. doi:10.1086/461740.

Eivers, E., Shiel, G. & Cunningham, R. (2007). Ready for Tomorrow's World?: The Competencies of Ireland's 15-year-olds in PISA 2006: Summary Report, Dublin: Department of Education and Science, available: http://www.erc.ie/documents/tomorrows_world.pdf [accessed 1 Jul 2016].

Galton, M., Gray, J., & Ruddick, J. (1999). The impact of school transitions and transfers on pupil progress and attainment. London: DfEE.

Galton, M., Hargreaves, L., & Pell, T. (2003). Progress in the middle years of schooling: Continuities and discontinuities at transfer. *Education 3-13*, 31(2), 9-18. doi:10.1080/03004270385200161

Galton, M., Morrison, I., & Pell, T. (2000). Transfer and transition in English schools: reviewing the evidence. *International Journal of Educational Research, 33*(4), 341-363. doi:10.1016/s0883-0355(00)00021-5

Jeffes, J., Jones, E., Wilson, M., Lamont, E., Straw, S., Wheater, R., & Dawson, A. (2013). *Research into the impact of Project Maths on student achievement, learning and motivation*. Slough: National Foundation for Educational Research.

Lubienski, S. (2011). Mathematics education and reform in Ireland: An outsider's analysis of Project Maths. *Bulletin of the Irish Mathematical Society, 67*, 27-55.

Mohr-Schroeder, M. J., Jackson, C., Cavalcanti, M., Jong, C., Schroeder, D. C., & Speler, L. G. (2017). Parents' attitudes toward mathematics and the influence on their students' attitudes toward mathematics: A quantitative study. *School Science and Mathematics, 117*(5), 214-222.

NCCA. (2005). *Review of mathematics in post-primary education: Discussion paper.* Retrieved from Dublin: https://www.maths.tcd.ie/pub/ims/bull57/riancca1.pdf

Neild, R. C., Stoner-Eby, S., & Furstenberg, F. (2008). Connecting entrance and departure: The transition to ninth grade and high school dropout. *Education and Urban Society, 40*(5), 543-569.

O'Brien, M. (2001). A study of student transfer from primary to second level schooling: pupils', parents' and teachers' perspectives. Dublin: Department of Education and Science.

OECD. (2013b). *PISA 2012 Results: Ready to Learn: Students' Engagement, Drive and Self-Beliefs* (9264201149). Retrieved from Paris: https://www.oecd.org/pisa/keyfindings/pisa-2012-results-volume-IV.pdf

Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology, 86*(2), 193-203. doi:10.1037//0022-0663.86.2.193

Perkins, R., Shiel, G., Merriman, B., Cosgrove, J., & Moran, G. (2013). *Learning for life: The achievements of 15-year-olds in Ireland on mathematics, reading literacy and science in PISA 2012* (0900440422). Retrieved from Dublin: https://www.education.ie/en/Publications/Education-Reports/Programme-for-International-Student-Assessment-PISA-2012-Learning-for-Life-The-Achievements-of-15-year-olds-in-Ireland-on-Mathematics-Reading-Literacy-and-Science.pdf

Prendergast, M., O'Meara, N., Harbison, L., & O'Hara, C. (2016). A Difficult Crossing: The Transition from Primary to Secondary School Mathematics. *Education Matters Yearbook 2016–2017* (pp. 339-343). Dublin.

Prendergast, M., O'Meara, N., O'Hara, C., Harbison, L., & Cantley, I. (2019). Bridging the primary to secondary school mathematics divide: Teachers' perspectives. *Issues in educational research, 29*(1), 243-260.

Ryan, V. (2018). Making the transition: A student's mathematical journey from primary to post-primary school in Ireland [Unpublished doctoral dissertation]. University of Limerick.

Serbin, L. A., Stack, D. M., & Kingdon, D. (2013). Academic success across the transition from primary to secondary schooling among lower-income adolescents: Understanding the effects of family resources and gender. *Journal of youth and adolescence, 42*(9), 1331-1347.

Shiel, G., Kavanagh, L., & Millar, D. (2014) The 2014 national assessments of English reading and mathematics volume 1: Performance report. Dublin: Educational Research Centre.

Shiel, G., & Kelleher, C. (2017). An evaluation of the impact of Project Maths on the performance of students in Junior Cycle mathematics. Dublin: Education Research Centre.

Smyth, E., McCoy, S., & Darmody, M. (2004). *Moving up: The experiences of first-year students in post-primary education* (1904148514). Retrieved from Dublin: https://www.esri.ie/pubs/BKMNEXT36.pdf

State Examinations Commission. (2015). *Leaving Certificate Examination 2015 Mathematics Chief Examiner's Report*. Available: https://www.examinations.ie/misc-doc/EN-EN-53913274.pdf

Surgenor, P., Millar, D., Close, S., & Shiel, G. (2006). *Counting on success: Mathematics achievement in Irish primary schools* (0755773195). Retrieved from Dublin: https://www.education.ie/en/Publications/Education-Reports/Counting-on-Success-Mathematics-Achievement-in-Irish-Primary-Schools.pdf

Torgerson, C., Wiggins, A., Torgerson, D., Ainsworth, H., Barmby, H., Hewitt, C., Jones, K., Hendry, V., Askew, M., & Bland, M. (2011). *Every child counts: The independent evaluation*. London: Department for Education, available: https://www.gov.uk/government/uploads/

system/uploads/attachment_data/file/182404/DFE-RR091A.pdf [accessed 02 May 2015].

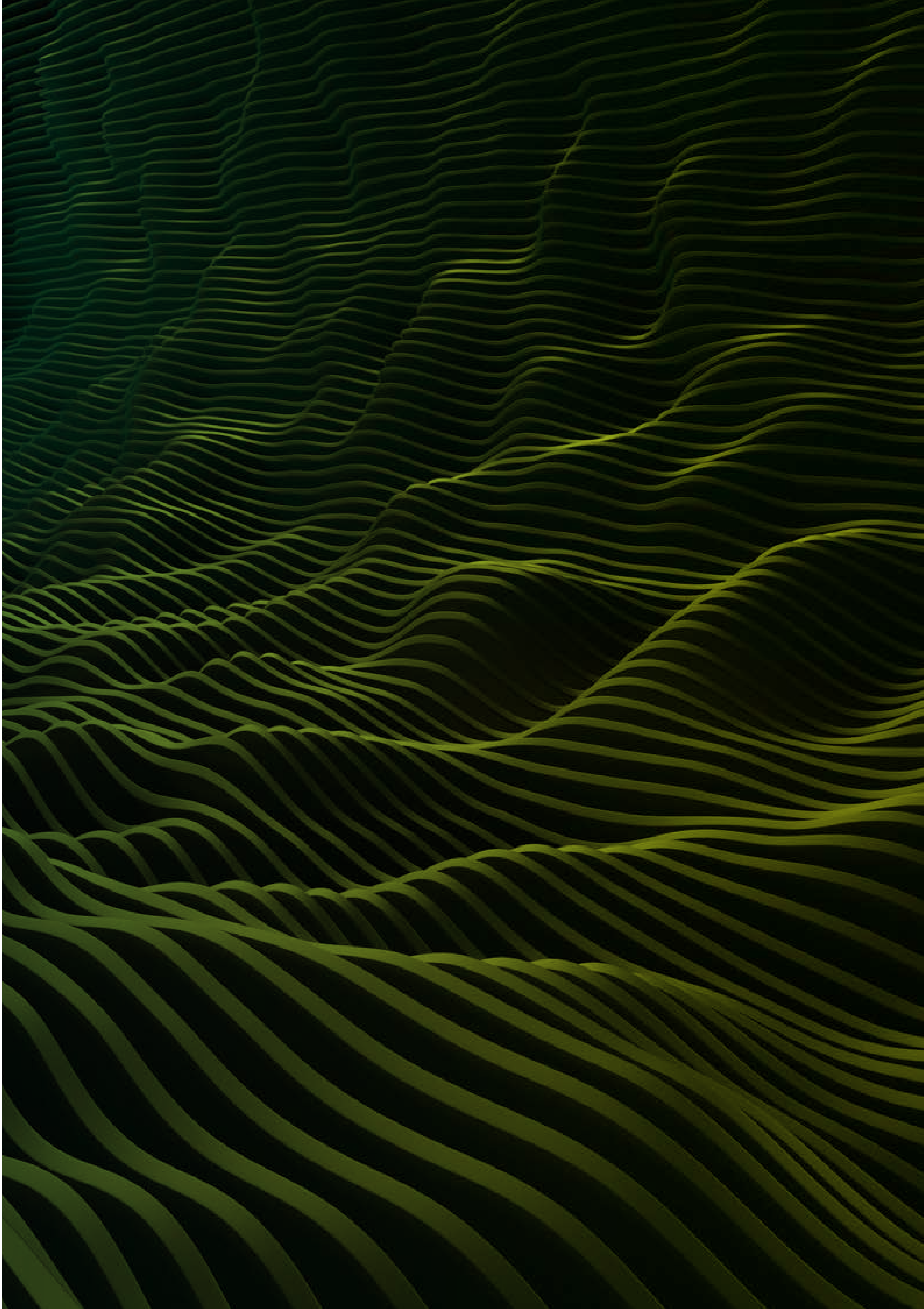
Turner, J. C., & Meyer, D. K. (2004). A classroom perspective on the principle of moderate challenge in mathematics. *The Journal of Educational Research, 97*(6), 311-318.

van Rens, M., Haelermans, C., Groot, W., & van den Brink, H. M. (2018). Facilitating a Successful Transition to Secondary School:(How) Does it Work? A Systematic Literature Review. *Adolescent Research Review, 3*(1), 43-56.

Vorderman, C., Porkess, R., Budd, C., Dunne, R., & Rahman-Hart, P. (2011). *A world-class mathematics education for all our young people.* Retrieved from London: http://www.tsm-resources.com/pdf/VordermanMathsReport.pdf

West, P., Sweeting, H., & Young, R. (2010). Transition matters: pupils’ experiences of the primary-secondary school transition in the West of Scotland and consequences for well-being and attainment. *Research Papers in Education, 25*(1), 21-50.

Zaiontz, C. (2018). *Cohen’s h Effect Size.* Available: https://real-statistics.com/binomial-and-related-distributions/proportion-distribution/cohens-h-effect-size/ [accessed 02 March 2023]



National Centre for STEM Education

ISBN: 9781911620624