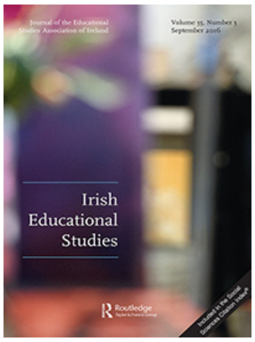

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The effect of a pre-university mathematics bridging course on adult learners' self-efficacy and retention rates in STEM subjects

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In August 2008, the Mathematics Learning Centre at the University of Limerick initiated a mathematics bridging course, entitled 'Head Start Maths', to provide mathematics revision for adult learners about to embark on science or technology degree programmes. The aim of Head Start Maths was to revise mathematics fundamentals before the commencement of third-level education so as to lessen the anxiety levels of adult learners towards mathematics. Negative preconceptions have been noted as being of major concern with adult learners, both preconceptions of mathematics in general and also of their own abilities. In addition to this, it was hoped that Head Start Maths might lead to increased retention rates among adult learners and lead to less dropouts within the first semester. Results found that there were statistically significant increases in self-efficacy scores across some, but not all, of the mathematical topic areas and that there was an increase in the retention rates of adult learners who participated in Head Start Maths compared to those who did not.

Keywords: mathematics bridging programme; self-efficacy; retention; adult learners; STEM

Introduction

In recent years, a considerable focus of mathematics education research has been on what Howson et al. (1995) termed the 'Mathematics Problem'. This 'problem' encapsulates a key concern for third-level educators, which is the under-preparedness of students to tackle the mathematical/statistical requirements of their courses. In 2008, the EGFSN[1] (and more recently in 2012) (2008) highlighted the need for increased mathematical competency among graduates which is further supported by Engineers Ireland (2010) who have committed themselves to supporting mathematics education at secondary and tertiary levels in Ireland due to a growing concern over the mathematical aptitude of graduating students.

In addition to this problem, Hardin (2008) highlights that in recent years, the 'face of higher education' has changed, with a more diverse range of leaners now entering third-level education. Hardin (2008) notes that in 1987, the number of adult learners[2] in College or University in the U.S. had increased to 4.9 million and the 2010 projections were set at 6.8 million. In the Irish context, the National Adult Learning Organisation (Aontas) identified that in 2012, adult learners accounted for 15% of all third-level

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full-time students and 96% of all part-time students. According to Aontas (2012), these percentages equate to circa 6000 full-time and 1500 part-time adult learners each year. Murtaugh, Burns, and Schuster (1999) point out that increases in the number of adult learners can cause additional retention worries for university policy-makers, as research shows that attrition rates have been found to increase with age. Further to this statistic, studies such as those conducted by House (2000) and Tsui (2007) indicate that significant numbers of students dropout of STEM degree programmes within the first two years, which highlights the importance of addressing this retention issue as early as possible in a student's career. One approach that has proven effective in addressing this issue is to encourage students to engage with mathematics learner support provisions. Lee et al. (2008) advocate that appropriate engagement with mathematics learner support can have a positive impact on student retention and progression.

In response to the changing profile of students, the Mathematics Learning Centre (MLC) at the University of Limerick has adapted its services to meet the altered needs of the students. Such changes are outlined by O'Keeffe, O'Donoghue, and Gill (2011) and include a move away from 'fire-fighting' measures to provide more front end, preventive support measures. Such measures include the provision of a mathematics bridging programme entitled 'Head Start Maths' in conjunction with diagnostic testing of first-year science and technology mathematics students.

According to Postle, Clarke, and Bull (1995), bridging programmes usually come in two forms; longer programmes designed as pre-university programmes or shorter programmes tailored specifically to meet the needs of a particular group. While Cobbin and Gotstlelow (1993) note that the number and type of such programmes are varied, Benn and Burton (1994) believe that mathematics should be an essential element of all such programmes. The nature of a short bridging programme is elaborated on by Taylor and Galligan (2005) who explain that specific tailored bridging programmes can also be broken down into two categories, those which are pre-degree 'stand-alone' courses or those which offer on-going support. The Head Start Maths programme can therefore be classified as a short 'stand-alone' pre-university programme tailored specifically to meet the needs of adult learners returning to or beginning tertiary education.

In addition to Head Start Maths, diagnostic testing of first-year science and technology students was introduced by the MLC in 1997 (Gill 2006; O'Donoghue 1999). The intention of the diagnostic test is to identify and inform 'at-risk' students[3] and follow up with suitably tailored mathematics support. The breakdown of the diagnostic test results is recorded annually; these data include a question by question breakdown and a profile of the students. According to Faulkner, Hannigan, and Gill (2011), these data highlight that the majority of adult learners are deemed to be 'at-risk' of failing their end-of-term examinations and given the findings of Murtaugh, Burns, and Schuster (1999), this may have an impact on overall retention rates.

This paper broadens and extends a previous evaluation of the Head Start Maths programme (Gill 2010) by discussing the impact of the programme on self-efficacy, identifying any connections with diagnostic test scores, end-of-term mathematics module scores and end-of-year retention rates. This paper aims to answer the following research questions:

(1) To what extent does attendance of a pre-university mathematics bridging programme improve adult learners' mathematical self-efficacy?

(2) Does a pre-university mathematics bridging programme have an effect on the retention rates of adult learners' in STEM-related subject areas?

Literature review

O'Donoghue (2004) summarised the key issues of the 'Mathematics Problem' in the Irish context and found that foremost among these issues were students' mathematical shortcomings and deficiencies. Prior to commencing third-level education, some students may not have had adequate opportunity to develop the pre-requisite skills needed and so it is up to the institutions to provide additional assistance to help these students survive, progress and succeed. The additional assistance needed as a consequence of the students' lack of preparedness places added financial costs on the institutions as well as affecting student self-efficacy, retention and progression rates within the institutes.

This problem though is not restricted solely to Ireland with Cuthbert and MacGillivray (2003) discussing the lack of mathematical confidence among first-year engineering students and Rylands and Coady (2009) highlighting the lack of appropriate mathematical background among students at their respective institutes in Australia. In Canada, Kajander and Lovric (2005) highlighted what they termed the 'transition gap' between secondary- and tertiary-level mathematics and in the UK the decline in numeracy skills among first-year biosciences undergraduate students has been highlighted by Tariq (2002). These papers are only a sample of the research conducted on this topic but they do present a worrying international trend for students enrolled in STEM degree programmes.

Astin and Oseguera (2005) and Croft, Harrison, and Robinson (2009) agree that the mathematics skill level at entry of students undertaking STEM degrees is one of the primary factors which impacts on student retention. Robinson (2003) suggests that more advanced mathematics and science programmes in second-level education will minimise such attrition. Further to this, Kitchen (1999) previously highlighted that some mathematics departments within universities have already felt a need to introduce remedial mathematics into the first-year teaching programmes. Moses et al. (2011) suggest advanced and targeted preparatory programmes (outside of the normal university preparation) better prepare students for third level and they suggest that those without such preparation may be more likely to dropout.

As outlined by Hardin (2008), the profile of higher education has changed and this needs to be considered by universities and programme providers. In the Irish context, this changing profile of students studying mathematics at the University of Limerick is documented by Faulkner, Gill, and Hannigan (2010) who noted that between 1998 and 2008, there has been a 20–25% reduction in students attending their first service[4] mathematics lecture, a 12–16% reduction in the number of students entering service mathematics modules with higher level[5] mathematics and an 8–12% increase in the number of non-standard students.[6] Such changes place additional pressure on support services like MLCs whose primary function is to provide the necessary and appropriate support to all university students.

Focusing on adult learners, who constitute the largest cohort of non-standard students at the University of Limerick, Burton (1987) and Klinger (2006, 2011) indicate that negative preconceptions are of major concern, both preconceptions of mathematics, in general, and also of their own abilities. Bandura (1997, 391) defines self-efficacy as 'people's judgement of their capabilities to organize and execute courses of action required to attain designated types of performance'. Self-efficacy is vital among all students but particularly among adult learners as an individual's beliefs of self-capability has been shown to affect motivation, performance, achievement, effort, willingness to persist with a task, as well as the anxiety they experience (Bandura 1997; Pajares and Miller 1994, 1997; Pajares 1996; Pajares and Graham 1999). Woodley (1987) (cited in McGivney 1996) noted that the main personal factors that contribute to dropout are: self-perception, being disorganised, not having sufficient study skills and lacking in self-confidence. This suggests that an individual's self-efficacy plays a role in their decision with regard to dropping out.

Hackett and Betz (1989) and Pajares and Miller (1994, 1995) also found that self-efficacy can have an impact on career choice. In these studies, it was found that mathematical self-efficacy is a stronger predictor of students' mathematical interest and choice of degree programmes than either prior mathematical achievement or mathematical outcome expectations. Self-efficacy also influences how often mathematics is used, as well as an individual's willingness to pursue advanced work in mathematics, and even the choice of prospective occupations (Dutton and Dutton 1991). Engineers Ireland (2010) highlight that this avoidance of mathematics, and mathematics-related courses, at university will eventually prove detrimental when attempting to build a knowledge economy. This point was also stressed decades before by Hembree (1990, 34) when he stated that 'when otherwise capable students avoid the study of mathematics, their options regarding careers are reduced, eroding the country's resource base in science and technology'.

Further highlighting the importance of mathematics, Volmink (1994) and Noyes (2007) both stressed its essential role with Noyes (2007, 1) stating that '[mathematic's] sacred position as the gatekeeper to many education, employment and life opportunities is now firmly established'. This gatekeeping function was also emphasised by Russel (2005) who stated that a student's leaving certificate mathematics grade was a key determinant in that student successfully progressing through an engineering programme. Therefore, in the case of adult learners, who can enter degree programmes through non-standard application avenues and bypass the leaving certificate examinations, it is essential that appropriate mathematical support provisions be put in place to lessen the difficulties associated with commencing third-level education.

Methodology

Programme design and structure

Since 2008, the MLC has rolled out a mathematics bridging programme called Head Start Maths which has proved to be very popular and appreciated among University of Limerick adult learners (Gill 2010). This programme not only helps to prepare adult learners for the mathematical demands of their degree programmes but also familiarises them with the MLC supports and staff prior to commencing university education. Anecdotal evidence has suggested that Head Start Maths plays a role in keeping some adult learners in third-level education. However, due to the complex nature of available intervention and support, the type of student who might avail of such a support and the varying classroom climates, it has proved difficult to validate and quantify the effectiveness of such a programme. Hence, this study looks at evaluating the Head Start Maths programme through two main lenses – adult learner self-efficacy levels and adult learner retention rates.

The Head Start Maths programme was developed in 2007 in the University of Limerick and run for the first time in the weeks prior to the commencement of the academic year 2008/2009. The purpose of the course was to help returning adult learners make a successful transition to third-level mathematics by improving the basic mathematical skills that they would need for their selected degree programme. Funding towards the creation of the material was provided by Sigma, the UK-based Centre for Excellence in Teaching and Learning (CETL) through its secondment programme. The week long course was designed to reintroduce the adult learners to some basic mathematical knowledge that they may have forgotten (e.g. number systems, fractions and decimals) but also to extend and apply their knowledge to more advanced topics (e.g. logs, indices and problem-solving).

In 2010, due to the increasing numbers of adult learners entering into engineering degree programmes, it was decided to expand Head Start Maths into a two-week programme. The level of mathematics required for traditional students to gain entry to an engineering degree at the University of Limerick is higher level mathematics. As adult learners do not apply through traditional entry routes, it is possible for an adult learner without higher level mathematics to be accepted onto such degree programmes. This perceived deficit in adult learner knowledge, in addition to increasing demand for support by such students in the MLC, prompted the expansion of Head Start Maths. The second week of the course was designed to introduce and revise some of the higher level leaving certificate mathematics concepts (e.g. advanced algebra, functions, differentiation, vectors and complex numbers).

Research instrument

As highlighted previously, self-efficacy is important in terms of personal motivation, performance and willingness to persevere. It is anticipated that the adult learners' mathematical self-efficacy level would typically be low prior to commencing University and their self-efficacy is at risk of being further reduced in the first few weeks of large group service mathematics lectures. For this study, the research instrument used was *The Mathematics Self-efficacy Scale* (Betz and Hackett 1993). According to Betz and Hackett (1993), the Mathematics Self-efficacy Scale is intended to measure beliefs regarding one's ability to perform various mathematics-related activities. It is based on three distinct areas of math-related self-efficacy expectations which are divided into two parts.

Part 1: Comprises questions relating to the *solving of math* problems and *mathematics behaviours used in everyday life* such as balancing a cheque book. Betz and Hackett (1993) state that the problems presented are similar to those found on standardised tests of mathematical aptitude and achievement (i.e. Dowling's (1978) *Mathematics Confidence Scale*) and the everyday life activities are similar to those included in the *Math Anxiety Rating Scale* (MARS; Richardson and Suinn 1972) (Figure 1)

Part 2: Capability of satisfactory performance in college courses requiring various degrees of mathematics knowledge and mastery.

How much confidence do you have that you could successfully:

6. Compute your cars petrol/diesel mileage

0 1 2 3 4 5 6 7 8 9

13. Understand a graph accompanying an article on business profits.

0 1 2 3 4 5 6 7 8 9

Figure 1. Sample questions from self-efficacy part 1.

For the purpose of this study, Part 2, relating to the college courses, was adapted to correspond specifically with the mathematical topics covered in the Head Start Maths course. Part 2 of the original survey comprises 16 statements, whereas Part 2 of the adapted survey comprises 13 statements. Hence, in line with the original intention of the test instrument, self-efficacy expectations with regard to mathematics are still 'defined to include perceptions of performance capability in relationship to math problems, everyday math tasks and mathematics-related college coursework' as identified by Betz and Hackett (1993). For example, participants were asked how confident they would be in completing a course in various mathematics topics with a final grade of 'A' or 'B' (Figure 2).

The adapted Mathematics Self-efficacy Scale is composed of a total of 31 statements; each statement has an associated scale that ranges from 0 to 9 with 0 representing no confidence and 9 representing complete confidence in your ability to successfully accomplish the task in question. Cronbach's alpha was computed for the adapted Mathematics Self-efficacy Scale and returned a value of 0.963, which indicates a high level of internal consistency for the scale.

Data collection and analysis

Each year attendance at the Head Start Maths programme is recorded. In August 2012, a total of 40 adult learners attended the first week of the programme and 37 attended the second week. The adapted Mathematics Self-efficacy Scale was distributed prior to commencing week 1, at the end of week 1, prior to commencing week 2 and at the end of week 2, allowing for pre and post data to be collected and

Please rate the following mathematics topics according to how much confidence you have that you could complete the course with a final grade of "A" or "B". Circle your answer on the 10-point scale.

20. Rational Numbers/ Fractions/Decimals

0 1 2 3 4 5 6 7 8 9

25. Graphing Quadratics & Special Functions

0 1 2 3 4 5 6 7 8 9

Figure 2. Sample questions from self-efficacy part 2.

matched up for each specific group. From those who completed the survey, a total of 29 adult learners only attended week 1, 17 attended week 2 only and 7 adult learners attended both week 1 and week 2. The collected data were entered into IBM SPSS Statistics and then a one-way analysis of variance (ANOVA) and Tukey *post hoc* tests were used to test differences among the three groups. Additionally, the pre- and post-test average means[7] and standard deviations were computed for all three cohorts (week 1 only, week 2 only, weeks 1 and 2).

In conjunction with the Self-efficacy Scale, the authors also reviewed existing data in relation to diagnostic test scores, end-of-term module examination grades and retention data in an attempt to further quantify the impact that Head Start Maths may be having on the adult learners. These data were tracked over a period of three years, starting from 2010 when the Head Start Maths programme was extended to be a two-week programme.

Results

This section comprises three distinct elements; the first of which presents the findings from the self-efficacy questionnaires which were gathered during Head Start Maths 2012. The second element focuses on diagnostic test results for adult learners who participated in Head Start Maths between 2010 and 2012 and the final element presents data on adult learner retention rates over the same three-year period.

Head Start Maths self-efficacy analysis

Preliminary analysis of the pre- and post-test results from the Mathematics Self-efficacy Scale looked at the average mean and standard deviation scores for the three cohorts (week 1, week 2, weeks 1 and 2). From Table 1, it can be seen that not only there was an increase in the average score over time for all three cohorts but that there was an increase in the average score over time in each part of the test instrument (recall that part 1 tested basic mathematical tasks, whereas part 2 tested mathematical topics).

Table 1. Pre- and post-test average means and standard deviations for mathematics self-efficacy scores.

		HS week 1 only ($N = 29$)		HS week 2 only ($N = 17$)		HS weeks 1 and 2 ($N = 7$)	
		Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
Pre	Maths tasks (1–18)	6.20	1.96	6.95	1.43	6.70	1.31
	Maths topics (19–31)	4.50	1.89	6.01	1.70	5.45	1.60
	Average total score	5.35	1.925	6.48	1.565	6.075	1.455
Post	Maths tasks (1–18)	6.99	1.62	7.37	1.32	7.76	0.89
	Maths topics (19–31)	5.89	1.67	6.97	1.29	7.20	1.22
	Average total score	6.44	1.645	7.17	1.305	7.48	1.055

The Head Start Maths 'week 1' cohort has the lowest overall average level of self-efficacy. These students only signed up for the one week of Head Start Maths as they have typically selected degree programmes which have a minimal amount of mathematics. For this reason, these students may feel that they only need to refresh their basic mathematical knowledge as mathematics will not play a key role in their degree programme. The Head Start Maths 'week 2' only cohort typically consists of students who have signed up to degrees in Engineering, Science or some other Mathematics intensive programme. These students tend to be more confident in their ability to carry out mathematical tasks and hence only sign up for the second, more advanced, week of Head Start Maths. The smallest cohort of students is those who signed up for both week 1 and week 2 of Head Start. This cohort displayed the largest overall increase between pre- and post-testing but due to the size of the cohort ($n = 7$) it is difficult to draw any substantial conclusions from this result. This finding does, however, suggest that the longer the students engage with a bridging programme, the more return they will see in terms of self-efficacy but more research would need to be conducted with a larger cohort before this result could be consolidated.

Further to this preliminary analysis, a one-way analysis of variance (ANOVA) test was used to check for differences among the three cohorts of students. A Tukey *post hoc* comparison test was then used to test difference among the three cohorts on each question. Statistically significant differences existed between the groups in 7 of the 31 questions at the $p < .05$ level; 4 questions related to mathematical tasks (Questions 1, 4, 6 and 13) and 3 related to mathematical topics (Questions 25, 30 and 31).

Table 2 shows the comparison of the mean scores within each group. Subscripts are used to highlight differences within the means of the groups. Group means with different subscripts are significantly different at the $p < .05$ level, for example, in Question 1 there is a statistically significant difference between the Head Start Maths week 1 group and the Head Start Maths weeks 1 and 2 group. Group means sharing the same subscript are not significantly different.

Focusing on the maths tasks questions (Q1–Q18), it is evident that in three of the four questions there was a statistically significant difference in means scores between the week 1 and the week 2 group, with the week 1 cohort showing statistically

Table 2. Comparison among adult learner mean scores, highlighting statistically significant differences within the groups.

	Head Start week 1 ($N = 29$)	Head Start week 2 ($N = 17$)	Head Start weeks 1 and 2 ($N = 7$)	p-Value
Question 1	0.00_{a}	$1.06_{a,b}$	2.29_{b}	.033
Question 4	1.10_{a}	-0.06_{b}	$1.29_{a,b}$	.023
Question 6	1.17_{a}	0.12_{b}	1.57_{a}	.010
Question 13	1.45_{a}	0.29_{b}	$1.29_{a,b}$	.037
Question 25	2.17_{a}	0.47_{b}	$2.00_{a,b}$	.011
Question 30	0.41_{a}	$1.29_{a,b}$	2.14_{b}	.015
Question 31	0.59_{a}	$1.00_{a,b}$	2.43_{b}	.022

Note: Group means sharing the same subscript are not significantly different at $p < .05$.

significant improvements in self-efficacy scores. The three mathematical tasks in question were determining interest on a loan, computing car diesel/petrol mileage and understanding a graph accompanying an article on business profits. In fact, the week 2 cohort showed a slight decrease in self-efficacy relating to the task of determining the interest on a loan over the course of the week.

In the mathematical topics section (Q19–Q31), one significant result was found in the mean difference between the Head Start Maths week 1 and the Head Start Maths week 2 cohort regarding question 25, which related to the graphing of quadratic functions and special functions (logarithms and exponentials) – a topic covered during the first week of the course. For this topic, the week 1 cohort showed a statistically significant improvement in self-efficacy as compared to the week 2 cohort. This would suggest that the graphing of quadratic, logarithmic and exponential functions is a topic that needs to be covered during mathematics bridging courses as the self-efficacy scores of the week 2 participants suggest that they are not comfortable with their prior knowledge of this topic. There were no other statistically significant differences between the week 1 and week 2 cohorts in any other topic area that was covered during the first week of Head Start Maths.

The statistically significant difference between the week 1 and the weeks 1 and 2 cohort in questions 30 and 31 (vectors and complex numbers) are not surprising as these topics were only covered in week 2 of the course in the case of the group being analysed within this research. It is, however, noteworthy that it was the weeks 1 and 2 cohort that showed the statistically significant improvement over the week 1 cohort and that the week 2 only cohort did not display a statistically significant improvement over the week 1 cohort in these topics. This result would again imply, as expected, that the longer the students participate in a bridging course, the higher a self-efficacy level they attain.

Diagnostic test analysis

While diagnostic testing has been carried out on students pursuing science and technology-based degree programmes by the MLC since September 1997, data on student type[8] were not recorded until 2008. Diagnostic test data indicate that adult learners have consistently been at risk of failing their first end-of-term mathematics examinations (diagnostic test scores of less than 20) and consistently score below the class average (see Tables 3 and 4).

Table 3 shows a breakdown of the diagnostic test scores for Technological Mathematics 1 students and Table 4 shows the corresponding breakdown for Science Mathematics 1 students – two of the first year, first semester service mathematics modules offered at the University of Limerick. These data represent the mean diagnostic test scores for the adult learners who attended Head Start Maths in comparison to those who did not attend. The 2010 Technological Mathematics 1 scores are the only results where there was a statistically significant difference between the diagnostic scores for the adult learners who attended Head Start Maths and those who did not ($p = .0053$). Even though there is no statistically significant difference for all the other cohorts, with the exception of the 2011 Science Mathematics 1 scores, the mean diagnostic score for adult learners who attended Head Start Maths exceeded that of those who did not attend. Also, it should be

Table 3. Comparison of adult learner against class average for diagnostic scores (out of 40) for Technological Mathematics 1.

	MA4701 Technological Mathematics 1					
	Adult learners				Technological Mathematics 1 students who took the diagnostic test[a]	
	Adult learners who attended Head Start		Adult learners who did not attend Head Start			
	Mean μ	SD	Mean μ	SD	Mean μ	SD
2010	$n = 8$ $\mu = 16.63$	4.57	$n = 28$ $\mu = 10.43$	5.31	$n = 367$ $\mu = 18.84$	6.92
2011	$n = 4$ $\mu = 16$	6.03	$n = 20$ $\mu = 14.65$	5.94	$n = 322$ $\mu = 19.36$	6.62
2012	$n = 6$ $\mu = 11.83$	4.58	$n = 28$ $\mu = 9.82$	4.66	$n = 349$ $\mu = 17.84$	6.41

[a]These data exclude all 0 scores assuming them to be no-shows.

noted that the adult learner diagnostic test scores, for both attendees and non-attendees of Head Start Maths, are consistently lower than the overall class average.

Impact on end-of-term results and dropout rates

Table 5 presents the average end-of-term examination raw marks for both Technological Mathematics 1 students and Science Mathematics 1 students from 2010 to 2012.

Table 4. Comparison of adult learner against class average for diagnostic scores (out of 40) for Science Mathematics 1.

	MA4601 Science Mathematics 1					
	Adult learners				Science Mathematics 1 students who took the diagnostic test[a]	
	Adult learners who attended Head Start		Adult learners who did not attend Head Start			
	Mean μ	SD	Mean μ	SD	Mean μ	SD
2010	$n = 11$ $\mu = 15.45$	5.2	$n = 17$ $\mu = 13.24$	5.6	$n = 405$ $\mu = 20.43$	7.4
2011	$n = 14$ $\mu = 12.71$	5.7	$n = 13$ $\mu = 13.31$	8.94	$n = 364$ $\mu = 20.27$	7.24
2012	$n = 12$ $\mu = 12.25$	5.6	$n = 21$ $\mu = 10.43$	6.4	$n = 390$ $\mu = 18.76$	6.51

[a]These data exclude all 0 scores assuming them to be no-shows.

The table presents the overall class averages, the average mark obtained by the adult learners who attended Head Start Maths and the average mark of those adult learners who did not attend Head Start Maths. The numbers in brackets under the averages represent the total number of students in this group and the range of the scores achieved by these students. Along with this, Table 5 also presents the number of drop-outs each year and whether or not these students were adult learners and if they had attended Head Start Maths.

From this table, it is evident that by the end-of-term examinations the difference in adult learners' average marks and the overall class average mark is reduced when compared to the differences in their diagnostic test results. The average end-of-term examination mark for Head Start Maths adult learners only exceeded that of non-Head Start Maths adult learners in 50% of the cases which is not a very significant result. However, the number of non-Head Start Maths adult learners who dropped out during their first semester equalled (1) or exceeded (5) those of the Head Start Maths adult learners in both modules across all three years.

The overall student 'dropout' results are the most significant findings from the analysis. As evident in Table 6, all of the adult learners taking Technological Mathematics 1 who attended Head Start Maths in 2011 and 2012 remained in their respective programme. There was one dropout in 2010 which was a mid-semester dropout. In contrast, there were a number of Non-Head Start Maths adult learners (taking Technological Mathematics) who dropped out each year. The reasons for these dropouts range from deciding to drop mathematics (mathematics was an elective within their degree programme and they choose to switch electives), students dropped out of their studies completely or they changed to a different degree programme.

Table 5. Adult learner end-of-semester examination results (out of 100).

	Average raw mark (μ)					
	All students (n, range of scores)	No. of dropouts	Adult learner Head Start ✓	No. of dropouts	Adult learner Head Start ✗	No. of dropouts
2010						
Technological Mathematics 1	53.26 (399, 7–100)	30	69 (8, 55–83)	1	53.17 (28, 23–87)	9
Science Mathematics 1	47.75 (353, 9–98)	26	43.5 (11, 16–68)	3	49.94 (17, 30.5–70)	8
2011						
Technological Mathematics 1	54.06 (362, 2–99)	17	59.5 (4, 37–98)	0	67.2 (20, 23–96)	5
Science Mathematics 1	29.54 (361, 2.45–75.65)	23	21.66 (11, 2.8–43.4)	6	12.2 (13, 3.5–18.55)	6
2012						
Technological Mathematics 1	56.69 (401, 1–100)	24	51.5 (6, 2–85)	0	53.04 (28, 4–88)	3
Science Mathematics 1	42.98 (410, 4–97.5)	15	42.04 (12,17.5–73)	0	37.42 (19, 10–72.5)	3

Table 6. Proportions of adult learner dropouts.

	Technological Mathematics 1		Science Mathematics 1	
Year	Head Start	Non-Head Start	Head Start	Non-Head Start
2010	1/8	10/28	3/11	8/17
2011	0	5/20	6/14	6/13
2012	0	3/28	0	3/21

The data for Science Mathematics 1 depict greater numbers of Head Start Maths adult learners having dropped out, six in 2011 and three in 2010. A total of 17 of the Science Mathematics 1 adult learners who had not attended Head Start Maths are recorded as having dropped out over the three year period. The records indicate that again the reasons for these dropouts range from straightforward dropouts prior to end of the first term, passing their end-of-term examinations but dropping out at a later stage, dropped mathematics as an elective or changing to a degree programme which has a higher mathematics element or no mathematics.

Traditionally, you would expect adult learners who partake of a bridging course to be individuals who would categorise themselves as less ready to commence third-level education. These would be the cohort of adult learners who might be considered to be most at-risk of dropping out in their first semester. The results here revealed that a larger proportion of non-Head Start Maths adult learner dropped out every year when compared to students who participated in Head Start Maths. When we additionally consider that zero adult learners who commenced the bridging course failed to finish it, and that every adult then proceeded to commence their chosen university degree programme, this is an additional positive result in terms of retention.

Summary and conclusions

With the rising numbers of adult learners returning to third-level education, and the gatekeeping function of mathematics, which remains as an entry requirement into many third-level STEM courses, it is essential that adult learners are sufficiently prepared and supported in their studies. The first research question of this study focused on adult learners enrolled in STEM programmes and sought to measure the effect of a mathematics bridging programme on their mathematical self-efficacy. The adult learners who participated in the full two weeks of the bridging course exhibited the largest overall increase in self-efficacy although all cohorts did display an increase in self-efficacy over time. Statistically significant differences exist between the groups for certain mathematical tasks and topics although with regard to the mathematical topics there does not appear to be any consistent significant difference between any two cohorts of students who covered the same topics. The small sample size analysed as part of this research could be a factor in this result and so the need for more research on adult learner self-efficacy post involvement in a mathematics bridging programme is needed. Even with this inconclusive result since most of the content covered in the Head Start Maths course is pre-requisite knowledge in the mathematics modules these students will be undertaking in their degree programmes, one can assume that improved self-efficacy overall will be of benefit to each adult learner.

Diagnostic test results for the science and technology students also indicate that while adult learners are consistently performing below the class average and being identified as 'at-risk' of failing their end-of-term mathematics examinations, in every case except one, the adult learners who attend the bridging programme are scoring higher diagnostic scores than those who do not attend. This result again supports the universally held belief that a bridging course of this nature can provide adult learners with a better start when commencing third-level education (Moses et al. 2011). Also noteworthy from these data is how the gap between adult learners and traditional students, exposed in the diagnostic test data, is closed throughout the duration of the first semester. This might possibly be due to the adult learners' uptake of additional support offered by the MLC and their overall work ethic throughout the semester but this is impossible to say exactly due to the large number of factors which affect performance in examinations.

In terms of end-of-semester average marks, adult learners' marks are also more in-line with the overall class average, with minor differences between the adult learners who did and did not attend Head Start Maths. However, what is noteworthy from this end-of-term data is the information regarding retention rates. For every year analysed, the proportion of dropouts among adult learners who did not attend the bridging course exceeded those adult learners who did attend. This is an encouraging result which answered the second of the research questions outlined in this paper. The results seem to suggest that a bridging course of this nature will aid in increasing retention rates among adult learners, which is of primary concern for higher education worldwide in this current economic climate. Although this is a positive result, caution should be displayed when interpreting this finding as in general it is very difficult to claim that mathematics learner support is responsible for increases in retention or student success rates in mathematics (Lawson, Croft, and Halpin 2003).

While the data on self-efficacy and diagnostic scores all suggest that a bridging course, like Head Start Maths, could be of benefit to adult learners, the results regarding the number of dropouts in the first semester provide the strongest evidence for the impact of such a bridging course. The authors recognise that there are many factors which influence an adult learner's decision to remain in education; personal, academic, financial, etc., nevertheless, we believe that providing sufficient front-end support to adult learners prior to commencing their degree programme may well be a contributing factor in supporting them to continue with their studies and lead to an overall increase in retention rates.

Notes

1. EGFSN – Expert Group on Future Skills Needs (Irish Government advisory board).
2. The University of Limerick defines an adult learner as any individual who is aged 23 or over at the time of registration at the University.
3. Students who answer less than 20 of the 40 questions correctly are identified as being 'at-risk', that is, statistically they are likely to fail their end-of-term examination and not proceed onto the second year of their degree programme.
4. Service mathematics refers to degree courses where mathematics is present, but is not the main focus of the degree. The two service mathematics strands that are referred to throughout this paper are Technology and Science mathematics.
5. Leaving Certificate Mathematics can be sat at three levels – Foundation, Ordinary and Higher, where Higher Level is the most challenging in terms of depth and breadth of material covered.

6. Non-standard students include all students who did not apply to their degree programme via traditional routes. Adult learners would be considered non-standard students.
7. According to Jamieson (2004) it is common practice to assume that a Likert scale is an interval scale (where the distance between values is assumed equal) hence validating the process of averaging means. This process of averaging means was originally intended and employed by Betz and Hackett (1993).
8. The student type classification records whether the student is an adult learner or not.

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