Has the introduction of "Project Maths" at post-primary level affected the attitudes of first-year higher education engineering students in Ireland?

Noha Nahari[1], Eabhnat Ní Fhloinn[2] and Bryan MacDonald[1]
[1]School of Mechanical and Manufacturing Engineering,[2]School of Mathematical Sciences
Dublin City University, Dublin, Ireland

Abstract

Since 2008, the National Council for Curriculum and Assessment have led a reform of the mathematics curriculum in post primary education in Ireland, known as "Project Maths". It aims to support students through a new teaching/learning style to enhance their thinking and mathematical skills. In this paper, we report upon an attitudinal survey on students attitudes and beliefs towards mathematics, as part of a broader study underway to investigate the impact of Project Maths on first year engineering students.

1 Introduction

Mathematics is increasingly a focus of educational studies nationally and internationally, due to the growing need of mathematical skills in today's technological, economical, and industrial world (European Commission 2011, Conway and Sloane 2005). It is widely known that mathematics is a core subject for science and engineering disciplines. As Project Maths was implemented on a phased basis over a four-year period, our study is directed upon testing the mathematical skills and investigating first year engineering students' attitudes towards mathematics over the course of the implementation.

In this paper, we give a detailed overview of the results of a pilot attitudinal survey conducted in 2012 on a cohort of students who studied phase one of Project Maths. Overall, the results show quite a negative attitude towards mathematics, a fact that is naturally of concern among a cohort of engineering students who will rely heavily upon mathematics for the duration of their studies and beyond. Possible reasons for these attitudes will be further investigated in the following years, along with comparisons as to whether there are any improvements in students' mathematical skills and attitudes evident in the data we collect.

2 Background

2.1 The Irish Education System

Post primary education in Ireland is called secondary level (Department of Education and Science 2004). Students spend five or six years in secondary level, depending on whether they take an optional transition year after their third year or not. Two major state examinations are taken by second level students; the Junior Certificate (JC) upon completing their third year, and the Leaving Certificate (LC) upon finishing secondary school. Even though taking mathematics at LC is not mandatory, most of the students who take LC study mathematics (Breen, Cleary and O'Shea 2009) as it is a core requirement for entry into higher education. Mathematics at LC is offered in three levels: foundation level, ordinary level, and higher level.

2.2 Project Maths

Project Maths is a reform of mathematics teaching and assessing in second level in the Irish education system, set by the NCCA. *"It involves changes to what students learn in mathematics, how they learn it and how they will be assessed."* (Project Maths Development Team 2014). Project Maths began as a result of educational concerns about mathematics education in Ireland. Conway and Sloane (2005), for example, addressed many concerns regarding mathematics education nationally and internationally. In particular, they emphasised the lack of students' capacity to apply mathematics in practical 'real world' contexts. In addition, a report by the NCCA (2011) declared that a significant number of students in post-primary level are lacking the skills needed in their academic and professional lives. Moreover, Scanlan (2010) stated other concerns including: students' performance levels in PISA tests; the small number of students taking mathematics at higher level in LC exams; the difficulties with mathematics illustrated by third level students; the lack of problem solving skills highlighted by employers of Irish students; and the general need for qualified mathematical and scientific graduates for the knowledge economy.

Project Maths was first implemented on a pilot basis in 24 schools (who volunteered to participate) from September 2008. These schools were chosen to run the project over three years, along with the associated changes to the examinations which commenced in 2010 for LC and 2011 for JC. The overall feedback from the participating pilot schools resulted in adjustments to the syllabus subsequently rolled out on a nationwide basis. The rollout was then applied in three main phases: in September 2010, phase one began nationwide, with phases two and three following in subsequent years. The first national LC examination to contain Project Maths material took place in June

2012, with the JC following in June 2013. The fully revised examinations containing only Project Maths-type questions will be in place from June 2014 and June 2015 respectively.

3 Attitudinal Survey

The attitudinal survey used in this study is based largely upon the work of Breen, Cleary and O'Shea (2009). However, in our case, two open-ended questions were added following each part of the survey in order to better explore any further opinions or ideas expressed by the students.

3.1 Survey Design and Administration

The questionnaire used collected personal information (including gender, year of birth, level of mathematics at LC) from the participants as well as recording responses to sets of rating scale items relating to Confidence, Anxiety, Theory of Intelligence, Goal Orientation (Learning/Mastery and Performance) and Persistence (Breen, Cleary and O'Shea 2009). In addition, two other scales were included in the study, known as Approach and Prior experience. All rating scale items were presented using a five-point Likert scale where (1) represented 'Strongly agree, (2) 'Agree', (3) 'Not sure', (4) 'Disagree' and (5) 'Strongly disagree.

3.2 Survey Analysis:

In 2012, 34 students were included in the pilot study. The pilot survey included 44 Likert-scale questions (referred to as Q1…). After a preliminary analysis, eight questions were dropped from the main survey. In this paper, only the questions used in the main study are explained in detail.

3.2.1 Confidence Scale:

The survey started with six questions examining students' confidence regarding mathematics, all of which are adopted from the study of (Breen, Cleary and O'Shea 2009). While the first three questions (Q1-Q3) in the confidence scale address positive statements regarding confidence in mathematics, the following three questions (Q4-Q6) address negative confidence statements about mathematics. Students' responses regarding confidence in mathematics were mainly negative. The responses show that most of the students, more than 64%, "strongly disagree" with Q1*: "I can learn mathematics quickly"* and Q2 *"I feel confident in approaching mathematics"*. On the other hand, about 20% of the students are "not sure" whether they could get *"good marks"* in mathematics or not, but 50% of the students strongly disagreed with that. The

main survey is run at the beginning and the end of first year, which will allow us to take a closer look at their attitudes to compare whether their uncertainty about getting good marks in mathematics will be changed in any way after taking mathematics exams during that year in higher education. Furthermore, the majority of students, more than 82%, "agree" or "strongly agree" on Q6 which stated: *"I am just not good at mathematics*". What is more, when students were confronted with the statement: *"Q5. Mathematics is one of my worst subjects.",* strikingly, students only responded negatively, with more than 61% agreeing with that statement, and more than 35% strongly agreeing with that. It is particularly concerning that engineering students would respond thus.

3.2.2 Anxiety Scale:

Since the anxiety scale is also adopted from (Breen, Cleary and O'Shea 2009), and giving that (Q11) was dropped off their scale due to Rasch analysis results, we excluded the same question from the main study, even though it was included in the pilot survey, and for that reason Q11 does not appear on the anxiety results in this paper. Unlike the confidence scale, the most common responses to anxiety questions were "not sure". However, a considerable number of students (more than 26%) felt helpless, uneasy or worried about mathematics shown in the responses to Q9: *"I often feel helpless when doing a maths problem"*; Q10 *"Mathematics makes me feel uneasy and confused"*; and Q12 *"I usually feel at ease doing mathematics problems"* respectively. In our main study, we will take a closer look at the anxiety levels of the students compared with the individual's maths test results in order to determine whether their mathematical level affected their anxiety towards mathematics or not, with particular focus upon the very few students who showed no worries about mathematics.

3.2.3 Theory of Intelligence:

There are seven items in the theory of intelligence scale, which showed a variety of responses regarding students' beliefs in intelligence in general, and in terms of mathematics in particular. What is significant here is that the majority of the responses (79% of the students) disagreed or strongly disagreed with: *"Q16.You can succeed at anything if you put your mind to it."*. Again 44% of the students strongly disagreed with the statement: *"Q17.You can succeed at maths if you put your mind to it."* and with *"Q18.It is possible to improve your mathematical skills."*. Moreover, more than 55% of the students strongly disagreed with the last question on the scale which was: *"Q19.Everyone can do well in maths if they work at it."*. However, a considerable number of students did not respond to many of the theory of intelligence related questions and possible reasons for that will be examined and discussed later on the study.

3.2.4 Persistence Scale:

There are seven persistence questions in the survey. In terms of persistence attitudes towards mathematics, the responses varied from agreement and uncertainty to strong

disagreement with persistence in mathematics-related statements, with the exception of Q25: *"When presented with a mathematical task I cannot immediately complete, I give up"* which got a striking level of agreement in student responses, with percentages of 64% agreed and an extra 23% who strongly agreed with that statement . Also, more than 58% of the students strongly disagreed with Q23 which stated: *"When presented with a mathematical task I cannot immediately complete, I increase my efforts"*. It is also worth mentioning that a couple of questions received fewer responses than the total number of students. In general, responses to the persistence-in-mathematics questions gives an overall impression of consistent failure to persist when encourtering a mathematical challenge, great or small, again a worrying trait in engineering students.

3.2.5 Learning Goals Scale:

The learning goals scale consists of five questions investigating students' goals in learning mathematics. Unfortunately, the questions of learning goals scales are missing a considerable number of students responses (over than 58% on each question), ending up with only 20 responses or slightly more, which hopefully will be avoided in the following surveys. Nonetheless, the majority of students who responded to those questions reflected a negative point of view regarding their mathematical learning goals. The majority of responses maintained that the goal of working at mathematics is not necessarily for the possibility of learning, figuring things out, or finding new methods or ideas. The most interesting points from the learning goals scale were that almost all the responses to Q29 were strongly disagreeing with the statement: *" I work at mathematics because I like figuring things out"*. Again almost all the responses to Q31 were strongly disagreeing with the statement: *" I work at maths because it is important for me that I understand the ideas."*.

3.2.6 Approach Scale:

The approach scale attempts to investigate students' approaches to learning mathematics and determine whether it is by memorizing mathematics rules or understanding the principles of mathematics. Students' responses to the scale showed an overall negative response to both questions. Looking at the first item on the scale, which stated: *"I learn mathematics by understanding the underlying logical principles, not by memorizing the rules."*, the majority of responses showed uncertainty along with a definite negative approach to learning mathematics. Specifically, 26% were not sure and 32% strongly disagreed with the statement. However, it is worth mentioning that more than 35% of the students did not answer that question. The second question on the scale illustrates a absolute negative student views to approaching mathematics, with more than 64% of the students strongly disagreeing with the statement: "*If I cannot solve a mathematical problem, at least I know a general method of attacking it"*.

3.2.7 Prior Experience Scale:

There are four items questioning mathematical prior experience. They are specially designed to investigate students' experiences with mathematics in school and specifically in second level, in order to determine whether the phased implementation of Project Maths over the period of the study is making any difference to students' experiences and feelings in relation to post-primary level mathematics. Question one on this scale obtained a variety of responses with only 2% strongly agreeing that mathematics was always "enjoyable" in school; continuing with comparable responses (around 14%) who either agree, not sure or disagree; but ending with a majority of 44%, who strongly disagree with that statement: *"Q41:Mathematics is a course in school which I have always enjoyed studying"*. Furthermore, when focusing on mathematical enjoyment in secondary school on the fourth question on the scale, comparable results were shown with 38% strongly disagreeing. The second question on this scale also resulted in variable responses; on the one hand, 40% of the responses agreed about forgetting mathematical concepts learnt in secondary level, while on the other hand 26% of students strongly did not agree with that statement. These responses will be looked at in comparison with the following years of the implementation of Project Maths, exploring the long-term recall memory of mathematics. What is significant in Question four on this scale is that 50% of the responses strongly disagreed with having a good background in mathematics, and 17% are not sure, so an overall negative response to the question: *"I have a good background in mathematics"*.

4 Conclusion

By investigating students' attitudes towards mathematics in this pilot survey, an overall negative response to the subject was strongly shown by the first-year engineering students who responded. The confidence scale showed low levels of students' confidence in mathematics, which was also seen in the mathematics test results which are currently being analysed. Furthermore, the persistence scale showed a significant lack of persistence in learning mathematics. Many of the responses given are particularly concerning the case of engineering students. However, it must be remembered that these students had only experienced two years of the first phase of Project Maths (so two out of five topic "strands" had been changed, but only for their final two years in secondary school). In the coming years, it will be of interest to compare whether students with greater exposure to Project Maths display more positive attitudes towards the subject, and to find out whether Project Maths has made any improvements to students' beliefs in mathematics and their abilities to learn and achieve high goals and scores in mathematics.

5 References

Breen, S., Cleary, J. and O'Shea, A. 2009. Constructing and validating an instrument to measure students' attitudes and beliefs about learning mathematics. *IN:* Corcoran, D., Dooley, T., Close, S. and Ward, R. (eds.) *Proceedings of the Third National Conference on Research in Mathematics Education.*pp.332-342.

Breen, S., Cleary, J. and O'Shea, A. 2009. An investigation of the mathematical literacy of first year third-level students in the republic of Ireland. *International Journal of Mathematical Education in Science & Technology,* 40(2), pp.229-246.

Conway, P.F. and Sloane, F.C. 2005. *International trends in post-primary mathematics education.* National Council for Curriculum and Assessment.

Department of Education and Science. 2004. *A Brief Description of the Irish Education System.* Report ed. online: Communications Unit Department of Education and Science.

European Commission 2011. *Mathematics education in Europe: Common challenges and national policies.* Brussels: Education, Audiovisual and Culture Executive Agency.

National Council for Curriculum and Assessment 2011. *Project Maths: Reviewing the project in the initial group of 24 schools - report on schools visits.* Dublin: NCCA.

Project Maths Development Team 2009. *Overview of Project Maths* [Online]. Available from: http://www.projectmaths.ie/overview/ [Accessed 05/05 2014].