COMPUTER-AIDED SELF-ASSESSMENT AND INDEPENDENT LEARNING IN HIGHER EDUCATION

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Abstract: This paper outlines the process and evaluates the effectiveness of introducing software for self-assessment and independent learning in a Mathematics module. Many students identify mathematics as a problem area, and lecturers must maintain standards and meet learning outcomes for their modules. With limited resources, difficulties arise from increasing student numbers and a more diverse cohort. The aim of this study was to enable students to learn independently, reduce mathematical anxiety, and improve self-efficacy and competencies in mathematics, through the use of technology. Software, consisting of visual tutorials and online assessments, was introduced to a Mathematics module on a first year undergraduate degree programme. Students could take and retake online assessments given within supervised technology-led sessions, with their best result recorded. The advantages of this include improved accessibility, alternative teaching styles, self-paced tutorials, timely automated feedback and self-assessment for learning. The problems encountered are highlighted and solutions suggested which may have relevance to mathematics lecturers and learning support units. Our research findings show that the aims of the initiative were broadly met. Notably, the initiative enabled most students to bridge the gap between their expected and actual level of mathematical competency, and improved mathematical self-efficacy for identified groups of students.

1 PROJECT OUTLINE AND AIMS

In a diverse student cohort, there is a mixed level of competency in fundamental subject areas such as in mathematics. The level of mathematical competency expected by the lecturer is not always met by the students. Lecturers must maintain standards and meet the learning outcomes for the modules they teach leaving little time to raise students' competencies in these fundamentals.

The majority of students entering 1st year of the computing degree programmes in this study have come directly from secondary school. Mixed with these are mature students (many of whom have not studied mathematics for many years), international students (many of whom have language difficulties) and students entering from further education.

Pajares (1996a) lists many variables that contribute to achievement in mathematics including mathematics self-efficacy and mathematics anxiety.

Self-efficacy refers to the student's self-belief in their ability to solve mathematical problems. One investigation "revealed that there is a strong positive relationship between mathematics self-efficacy and achievement in mathematics" (Ayotola and Adedeji, 2009, p. 956), a finding supported by Lent and Hackett (1987), Hackett (1985) and Pajares (1996b).

Negative past experiences in mathematics can lead to emotional responses to mathematical problems, known as mathematical anxiety, which can reduce the student's future mathematical achievement. According to Hoffman (2010) mathematics anxiety "may impede mathematics performance irrespective of true ability". This is supported by Aiken (1970) and Ashcraft (2002, 2005).

The central question for this inquiry was whether we could improve the knowledge of mathematical fundamentals, for a diverse 1st year student cohort, through the introduction of software that incorporates self-directed online tutorials and assessments for learning. To achieve this aim, the following objectives were outlined:

a. Inform the incoming students of their own understanding of mathematical fundamentals

b. Enable students who have already achieved a

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proficiency to be assessed quickly

c. Build students' confidence in maths, improve self-efficacy and reduce mathematical anxiety

d. Improve engagement in mathematics

e. Promote independent learning

f. Offer flexible timing of assessments to students, enabling students to dedicate more time to the topics they find most difficult

g. Analyse the effect of initiative on students

2 METHODOLOGY

Understanding Mathematics, software by *Matrix Multimedia*, which includes self-assessment for learning, was introduced to the students. This enabled them to learn some mathematical fundamentals, in their own time, independently of the lecturer, through visual tutorials and cumulative assessments.

The approach used by the software is in line with the suggested methodologies for learning through multimedia as proposed by Alessi & Trollip (2001, p. 89). It also adheres to the *Contiguity Principle* and *Multiple Representation Principle* as proposed by Mayer and Moreno (1998). Demir and Kiliç (2009) found that using a computer had a positive effect on maths achievement for some students.

The students had access to the software in a computer lab, whenever the room was available, and also during optional weekly 2-hour supervised sessions. The researchers supervised these sessions for the purpose of monitoring and recording of assessments but not to teach the topics. Students took assessments as often as they wished with only their best mark used. 20% of a module's overall mark was dedicated to the completion of three cumulative assessments (6% each), and a final diagnostic test (worth 2%).

To facilitate self-study and self-evaluation, the students chose the pace at which they learned, when they completed the assessment and the assessment duration. Assessment for learning was facilitated as students could also practise the assessments before being formally assessed. Also, assessments could be taken many times, and feedback following an assessment was delivered in private, by the computer, with no need for results to be revealed to their peers or their lecturer.

Topics all included an animated introduction, visual tutorials, worksheets and a final assessment. Students could jump ahead to any tutorial within the topic, or to take the final assessment, at any time. The assessment was based on that topic's tutorials and results were presented on screen immediately.

When student's declared that they wished to take formal assessments, they were supervised taking final assessments in a formal examination setting.

The students completed a diagnostic test (Test 1) before the software was introduced, the result of which informed them of their level of ability in the topics covered by the software. A second diagnostic test (Test 2) was administered in the last week of the semester and the two tests were compared to evaluate any change that occurred in their competency.

Two surveys were used in the initiative. The first survey was to gauge the students' feelings about their results in the first diagnostic test and to act as a motivator for students to engage with the initiative. The second survey was taken during the final three weeks of the initiative to capture the students' views on the software, the effectiveness of the initiative, and any perceived changes in levels of mathematical self-efficacy and maths anxiety.

Students also completed a personal reflective journal on the initiative. An external independent evaluator anonymously summarised the journals.

3 FINDINGS AND ANALYSIS

Students that spent their time during supervised sessions completing the visual tutorials and practising assessments did not require any supervision. Queries from students mainly related to the software, and whether it was correctly marking their answers. The software provided corrective feedback, engaging the student in independent learning and assessment for learning, as described by Petty (2006) and Hattie (1999). As the feedback was delivered personally to the individual student it should be of particular benefit to the "weakest learners", as detailed by Black & William (1998) and Bennett (1999). As students repeatedly practice the assessments independently, with feedback provided, computer-aided self-assessment is facilitated. As a result, students should become "realistic judges of their own performance" (Boud, 1995, p. 13).

Some issues, including browser compatibility and on-campus only licensing agreements, impacted negatively on the software's accessibility and the objective of promoting independent learning.

3.1 Survey 1: Response to Test 1

Survey 1 encouraged students to reflect on their first Diagnostic Test (Test 1) result and gauged their motivation to engage with independent learning.

47% of responding students were “surprised with their result”, with about half of these expecting to have performed better, and half worse. This result may indicate levels of mathematical self-efficacy.

Students subsequently rated their placement within the class. Over half of the students felt they were “about average”, 30% felt they were “above average” and less than 20% felt “below average”.

Students were then asked to gauge if they valued mathematics fundamentals. In a 5-part rating scale from 1 “very important” to 5 “not at all important”, 31 of 40 students valued mathematics as 1 or 2.

Finally students’ rated their motivation for learning independently. No-one stated that their result did “not act as an incentive”. 15 of 40 respondents stated it acted “as a big incentive”.

The researchers feel that the combination of diagnostic test and survey informed students of their initial mathematics competency and motivated them to engage in the rest of the initiative.

3.2 Comparison of Diagnostic Tests

The results from Diagnostic Tests 1 and 2 were analysed. For the 48 students who sat both tests:

1. The average mark changed from 20.1 (out of 36) to 24.52 marks (approx. 12% increase).

2. The hypothesis that “the change is due to chance” was rejected at the 95% level. The 95% confidence interval for the *mean of the differences* is: (2.05, 4.78).

The achievement of the 48 students is broken down into 4 groups A, B, C and D (figure 1).

Group A’s (22 students) “difference in marks” was approximately normally distributed with an average of 1 mark and a standard deviation of 1.604 marks. A paired t-test was used to test whether “this improvement was due to chance” but was rejected at the 95% level. So, we conclude there was an improvement for these students but it is only small.

Of the students who got less than or equal to 20 marks in Test 1, 16 of these (61.5%), Group B, obtained 20 or more marks in Test 2. While there is still room for improvement, we might consider this group to have improved to a competent level.

There were 10 students who got less than or equal to 20 marks in both tests. However, 6 of these (Group C) improved by at least 5 marks (out of 36), which might be considered a reasonable improvement in spite of the fact that they did not reach the competency levels of those in group B.

This leaves 4 students, Group D, who do not belong in Groups A, B or C. Three of these actually did worse in Test 2. The initiative did not appear to help these students.

We note that 38 of the 48 students (Groups A and B) achieved 20 or more marks in Test 2. So, by the end of the initiative, nearly 80% of the students might now be considered competent. Groups A, B and C constitute nearly 92% of the students.

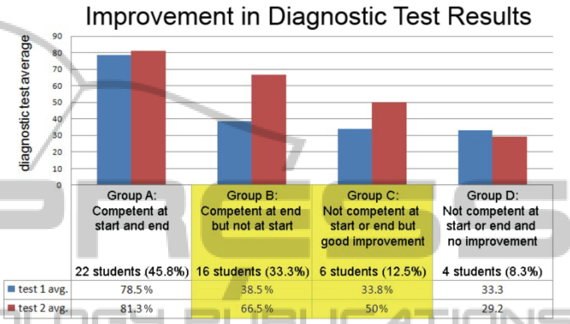

Figure 1: Summary of improvements.

3.3 Student Feedback

40 students completed an online survey during the last three weeks of the initiative to provide feedback on the effectiveness of the initiative. Asked if their understanding of the mathematics topics improved, nearly 50% responded that the software helped them “a small amount”. 38% were more positive. Only 13% stated that they did not improve, or were “not sure” of any improvement.

63% felt that using the software did result in them being less fearful. 15% (6) stated the software “helped a lot”, and 28% (11) that “it has helped” them become less fearful of mathematics. 34% of responses (14) were negative, which might indicate that these students either did not reduce their anxiety or that they may never have suffered from anxiety.

In response to a question regarding maths self-efficacy, 29% (12) found that their confidence in doing maths problems improved “a small amount”. 41% (16) felt that the software “helped”, or “helped a lot” but 25% saw no improvement.

Use of the software outside the scheduled supervised classes was limited, with 28 students, or 70% of respondents, having used it only once, or never, outside of class time. Half of respondents (20) felt they did not have enough access to the software.

In a 5-part rating scale, with 1 as “very easy” and 5 as “very difficult”, 45% of respondents (18) found the software easy to use, rating 1 or 2, just 17.5% of respondents (7) found it difficult, rating 4 or 5.

An anonymous reflective journal on the initiative was completed by the students and independently evaluated. One student stated “I liked the fact you could re-do the test as many times as you like...also the fact that you could practise on your own time… My mathematical ability was not good but has improved a lot as the semester progressed.”

3.4 Summary of Findings

From our evaluation, we concluded that there was an improvement in the mathematical competency of the students, and particular improvements for some of the weaker students (Groups B and C).

The use of assessment for learning ensured that the assessments were not being performed “under timed, high-stakes conditions” (Ashcraft & Moore, 2009). This should have helped to reduce maths anxiety. Survey 2 found that students benefited both by reducing mathematical anxiety and improving self-efficacy, with an improvement in mathematical achievement, as supported by Pajares (1996a).

4 ACTION IMPLICATIONS

During and following the initiative, the researchers recorded their reflections on challenges overcome. The decoupling of the sessions from the module was considered to be beneficial to the delivery of the module. There was a positive effect on the students' feelings towards the module and the degree. There was a strong positive effect on mature students with low maths self-efficacy. The attendance in supervised sessions was low at times. Some students completed assessments for all three topics in the one session allowing those who were proficient to proceed quickly.

Several recommendations can be drawn from the initiative with regards the software including ensuring early installation, student access from home within a virtual learning environment and using video tutorials to introduce the software. Future considerations include embedding the initiative within the module, or delivering it through a Mathematics Learning Centre, and expanding to any 1st year programme with a Mathematics module and to outreach and life-long learning programmes.

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