**Using self-explanation training to improve nursing students’ mathematical understanding**

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Abstract

Mathematics is an essential part of many degree subjects. Despite this, many students come to university ill-prepared for, and struggle with, the mathematical concepts on their course. One particular course where these issues are often prevalent is nursing. Indeed, a lack of numerical ability has been shown to be the main factor in predicting drug calculation ability (McMullan, Jones, and Lea, 2012); a skill that is vital for a safe and successful nursing career (Choudhary and Malthus, 2017). A method that could improve students’ understanding of the mathematics on their course is called “*self-explanation training”*. Self-explanation training has previously been shown to be successful in improving students’ understanding in various subjects including mathematics and, in particular, mathematical proofs (Hodds, Alcock, and Inglis, 2014). There has, however, been little research on the use of self-explanation training to improve the understanding of mathematics for non-mathematicians. This paper describes a small-scale study (N = 26) that investigated the use of self-explanation training in two forms (a booklet and a video) designed to improve nursing students’ mathematical understanding. Although performance in the tests was still far from ideal, the results suggest that self-explanation training has the potential to improve nursing students’ understanding of the mathematics on their course and, in particular, significantly improve their ability to solve more complex questions that require greater conceptual understanding.

1. Introduction and Motivation

The use of mathematics and mathematical skills is central to almost any career path chosen by an individual. However, when an individual chooses to complete a particular degree programme, they are often unaware of the amount of mathematical content in their chosen course. As a result, students come to university unprepared, and those students who struggle to manage their mathematical understanding are usually more prone to dropping out. Indeed, many of these students suffer from maths anxiety due to their previous bad experiences with mathematics (Warwick, 2017).

Many universities have now established Mathematics Support Centres (MSCs) in order to provide support for such students and help them achieve the level of mathematical understanding required to succeed in their chosen course. The initial emergence of MSCs was indeed motivated by a decline in mathematical skills of undergraduate students (Lawson, Croft, and Halpin, 2003) but more recently it has been shown that MSCs are being used more frequently by the mathematically able students, seeking further understanding and excellence, rather than the less mathematically able students who are on the brink of failure (Pell and Croft, 2008). A natural question to ask is, therefore, whether alternative support could be provided for students who do not use MSCs but clearly need support for the mathematics on their course.

1.1. Nursing students

One such course that suffers greatly from students’ lack of mathematical ability is nursing. Nursing students are required to have good mathematical skills in order to practice safely and to have a successful career (Choudhary and Malthus, 2017). Indeed, a lack of numerical ability has been shown to be the main factor in predicting drug calculation ability of a particular student (McMullan, Jones, and Lea, 2012). Furthermore, students are required to achieve 100% on certain mathematics tests in their course, just in order to pass. Such a high threshold is set because one small mathematical error at work could clearly prove to be fatal to a patient.

Despite mathematics being such an important component of any nursing degree, researchers consistently find that teachers of nursing students bemoan a lack of numeracy skills, confidence, and maths anxiety in their students, leading to many errors in drug calculations in particular (Choudhary and Malthus, 2017). These students also often fail to utilize the support offered to them, as described previously.

1.2. Self-explanation Training

An alternative method of support that has previously been shown to be effective in improving understanding is *“self-explanation training”.* A self-explanation is the process of explaining text to oneself either orally or in writing. Self-explanation training can be provided to students in many forms, such as a booklet or a video, and guides the user on how to break down information contained within a set piece of text to help them understand it clearly and to connect it with other knowledge they have.

Self-explanation training has been shown to be successful in improving students’ understanding in several subjects outside of mathematics and initially the training was designed to help with text coherence and understanding of regular passages of text (McNamara, 2001). Clearly, mathematics is written in a different way to a regular passage of text and, therefore, requires the reader to use different skills in order to read and process the information contained. It is, therefore, unclear whether self-explanation training would have the same positive effects on mathematical understanding that has previously been seen due to the difference in style of text.

Indeed, little research has been conducted into the use of self-explanation training in the field of mathematics, and even less on the use of self-explanation training to aid non-mathematicians. However, the research that has been conducted has shown some promising results. Self-explanation training has been shown to improve students’ understanding of high school geometry (Wong, Lawson, and Keeves, 2002) and, more recently, has been shown to improve proof comprehension of university mathematicians (Hodds, Alcock, and Inglis, 2014). Furthermore, “Self-explanations can help students improve their conceptual and procedural knowledge of mathematics by integrating knowledge of the problem solving process and knowledge of the underlying principles in the learner’s mental mode” (Durkin, 2011, p.1). Conceptual knowledge requires the student to interpret concepts and understand the relationship between them whereas procedural knowledge requires students to follow rules or sequences in order to solve problems. Nursing mathematics requires students to have both procedural and conceptual knowledge, therefore, suggesting that self-explanation training may be a method that improves nursing students’ mathematical understanding.

2. Methodology

2.1. Measures

The main focus of this study was to determine if self-explanation training improves the mathematical understanding of nursing students at Coventry University. In order to demonstrate this, a simple 20 question, multiple choice test was created based upon the questions nursing students receive during one of their exams. Each question had three possible answers with two distractors and one correct answer. The 20 questions could also be split based upon whether they required procedural knowledge (9 questions), such as “What is 7.265 divided by 100?”, or more conceptual knowledge (11 questions), such as drug calculation questions. By having a combination of questions, it allowed the consideration of whether self-explanation training improved students’ mathematical understanding as a whole but also whether it improved their procedural and conceptual understanding individually, as suggested by Durkin (2011).

A secondary focus of this study was to determine whether one form of self-explanation training provided better support for nursing students than another. Previous studies have used spoken instructions or used a booklet to provide the training. However, since nursing students often suffer from maths anxiety, providing the training in a booklet using formal mathematical terminology and layout may not be the approach. Therefore, this study considered a second approach to self-explanation training in the form of a “YouTube” style video. The video contained the same information as the booklet but was designed to be a lighter, more informal approach, with music and pictures rather than just text. By considering the two approaches, this study investigated not only whether self-explanation training provides nursing students with a greater understanding, but also whether one form of self-explanation training is more effective than the other.

A final focus was to determine students’ opinions on self-explanation training and whether they believed it improved their confidence and understanding of mathematics. A criticism of previous self-explanation training research is that it often did not take into account the opinions of the participants in the studies. This study considered that criticism and asked the students to complete a short questionnaire on completion of the study. The questionnaire asked students to rate, on a seven-point Likert scale, their confidence with the mathematics on their course, both before and after receiving the training. The questionnaire also asked students their opinions on self-explanation training, again on a seven-point Likert scale, and to rank different methods of support available to them, such as video tutorials, using the MSC, and self-explanation training of various forms.

2.2. Participants and research design

26 students on various nursing degree courses and at different stages of their degree at Coventry University took part in return for a £5 Amazon gift voucher and were randomly assigned to one of three groups based on their individual identification card numbers. Group one (7 participants) received self-explanation training through a video, group two (6 participants) received self-explanation training through a booklet, and group three (13 participants) received a control activity containing questions on their study habits, based on that reported in experiment three of Hodds et al. (2014). The two self-explanation groups had 15 minutes to watch or read the self-explanation training and attempt three practice questions. The control group also had 15 minutes to read and answer questions on their study habits and attempt the same three practice questions as the self-explanation groups. Doing so ensured that all three groups had some practice with mathematical material before they undertook the test questions. All participants then had 35 minutes to answer the 20 multiple-choice questions. Once this was completed, the self-explanation groups completed the control activity whilst the control group watched the self-explanation training video or read the self-explanation training booklet. Finally, all participants completed the questionnaire on their mathematical confidence and understanding, opinions on the self-explanation training they had received, and their preferred form of support.

3. Results

All results reported use a significance level of 5% and have been calculated using SPSS.

3.1. The effect of self-explanation training on mathematical understanding

To investigate the effect of self-explanation training on nursing students’ mathematical understanding, a simple independent samples t-test with two conditions (self-explanation training of either form or control) was conducted on participants’ test scores. The analysis revealed participants who received self-explanation training (M = 12.46, s.d. = 2.76) scored significantly higher on average than those who did not receive self-explanation training (M = 10.31, s.d. = 2.53), t(24) = 2.075, p = 0.049, as shown in Figure 1. A secondary independent samples t-test with two conditions (self-explanation training video and self-explanation training booklet) conducted on participants’ test scores revealed that the video group (M = 12.71, s.d. = 2.81) scored higher on average than the booklet group (M = 12.17, s.d. 2.93), as shown in Figure 2, but this did not reach significance, t(11) = -0.344, p = 0.738.

Figure 1

Figure 2

However, the above analysis does not consider any external factors that could account for the difference between the groups, such as prior knowledge. For most nursing students, the highest mathematics qualification they have is a GCSE or equivalent. Unsurprisingly, participants’ GCSE Mathematics grade (or equivalent) correlated with their test score when subjected to a Spearman rank correlation test, rs = 0.527, p = 0.006, and could, therefore, provide an alternative influence on the significant differences between the groups in the previous analysis.

Therefore, in order to obtain a better reflection of the effect that self-explanation training has on mathematical understanding, participants’ test scores were also subjected to a 3 (year of study) x 2 (condition: self-explanation of either type, control) ANCOVA with GCSE Mathematics grade (or equivalent) as a covariate. By considering the year of study, the results of this ANCOVA provides an indication of whether self-explanation training can be used effectively with all students, regardless of what stage they are at with their degree. The analysis revealed that there was no significant effect of condition, F(1,19) = 4.081, p = 0.058. Furthermore, there was no significant year by condition interaction on test score, F(2,19) = 7.458, p = 0.296. Hence, when combined with the previous analysis, these results suggest that although self-explanation training did appear to improve students’ mathematical understanding, the difference in average test scores can perhaps be explained by the students’ prior knowledge rather than the intervention itself.

3.2. The effect of self-explanation training on conceptual understanding

As stated earlier, Durkin (2011) suggested that self-explanation training can improve both procedural and conceptual understanding in mathematics. Since the majority of mathematical problems faced by nurses in their jobs would require more conceptual understanding, an analysis on participants’ scores for the 11 questions in the test that could be considered conceptual was conducted. A 3 (year of study) x 2 (condition) ANCOVA, with GCSE Mathematics grade (or equivalent) as a covariate revealed that the self-explanation groups combined (M = 7.77, s.d. = 1.42) performed significantly better than the control group (M = 5.46, s.d. = 1.90) on the conceptual questions, F(1,19) = 15.476, p = 0.001, ηp2 = 0.449, but there was no significant condition by year interaction, F(2,19) = 1.014, p = 0.382. Figure 3 shows the mean scores for the more conceptual questions separated by condition and year of study. Since GCSE Mathematics grade (or equivalent) was used as a covariate in this analysis, the difference in the scores for the more conceptual questions cannot be accounted for by students’ prior knowledge, unlike with the analysis in section 3.1. The results of this analysis, therefore, suggest that self-explanation training does indeed appear to improve the understanding of more conceptual questions for nursing students and this improvement is seen in all years of study. Furthermore, a 3 (year of study) x 2 (Self-explanation training type: video, booklet) ANCOVA, with GCSE Mathematics grade (or equivalent) as a covariate, revealed no significant difference between the video group (M = 7.71, s.d. = 1.60) and the booklet group (M = 7.83, s.d. = 1.33), F(1,13) = 0.252, p = 0.631, suggesting the improvement in understanding is made regardless of the type of training they receive.

Figure 3

3.3. Student beliefs on self-explanation training

To determine whether students felt they were more confident with the mathematics on their course after receiving the training, a Wilcoxon Signed-Ranks test was conducted on the median ranks of confidence levels before and after receiving the training. The data for this test were collected using a seven point Likert scale ranging from not at all confident (1) to extremely confident (7). A Wilcoxon Signed-Ranks test was conducted due to the data being ordinal and paired for each participant. The analysis revealed that the median ranks after the training for the booklet group (N = 6, Mdn = 4) were statistically significantly higher than the median ranks before the training (Mdn = 3), Z = -2.332, p = 0.02, whereas the median ranks after the training for the video group (N = 7, Mdn = 3) did not change significantly from the median ranks before the training (Mdn = 3), Z = -0.06, p = 0.952, shown graphically in Figure 4. These results suggest that participants feel that the booklet is perhaps the best method to provide the self-explanation training in order to increase their confidence. However it should also be noted that the participants who received the booklet training were less confident on average to begin with.

Figure 4

Further descriptive analysis was conducted on the data from all participants regarding their general opinions of self-explanation training. The data from these questions were based on a Likert scale ranging from strongly disagree (1) to strongly agree (7) using a seven point scale. Participants generally agreed that the method of self-explanation training they were shown suited their learning style (Mdn = 5), slightly agreed that they would prefer the training in a different format (Mdn = 4), agreed that self-explanation training improved their confidence and understanding (Mdn = 5), agreed that self-explanation training was easy to understand (Mdn = 5), and agreed they would use the training in the future (Mdn = 5). These results are encouraging, suggesting students like the self-explanation training method and find it beneficial for their mathematical understanding.

Finally, students were asked to rank the following methods of receiving support in order of preference: self-explanation training booklet, self-explanation training video, self-explanation training podcast, help from the MSC, “YouTube” tutorial videos, and traditional methods (seeing the lecturer/tutorials). The median ranks of the students were analysed and this showed the students preferred order of support was as follows:

1. Self-explanation podcast (Mdn = 5)
2. Traditional methods, Self-explanation booklet, and “YouTube” tutorial videos (Mdn = 4)
3. Self-explanation video (Mdn = 3)
4. Mathematics Support Centre (Mdn = 2).

These results are surprising given that participants did not receive a podcast version of the training and that the booklet version of the training appeared to improve their confidence the most. Furthermore, it is disappointing to see that the MSC was ranked the lowest of the support methods. However, the questionnaire also asked the participants how many times they had visited the MSC during the academic year and this revealed the mean number of visits by the participants in the study was 0.2. The main reasons given for why participants had not visited the MSC were because they were either not aware that the MSC was available to all students, and not just mathematicians, or participants thought their questions were too simple to be asked in the MSC setting. These reasons, along with the very low number of visits from the participants, perhaps explain why the MSC was ranked the lowest method of preferred support.

4. Conclusions

The small-scale study reported here set out to determine whether self-explanation training can be used to improve nursing students’ understanding of the mathematics on their course. The findings from this research are consistent with previous studies involving the use of self-explanation training since there appear to be immediate short-term effects on understanding. However, the training appears to be more effective at helping students answer the more conceptual questions rather than the procedural questions. This finding may contradict the suggestion by Durkin (2011) that self-explanation training improves both conceptual and procedural understanding in mathematics, however, it should be noted that the definition of questions in this research as procedural or conceptual differ slightly to that in Durkin (2011). Nevertheless, an important conclusion can still be drawn from these findings regarding the use of self-explanation training to improve mathematical understanding. The results of this research suggest that students who receive self-explanation training in any form can use it to unpick the mathematics behind a more conceptual question, so long as they have the procedural knowledge to do so. For example, if a student does not understand the procedure to divide a particular number by 1000, they will clearly be unable to answer a more complex question requiring the conversions of units. Self-explanation training for non-mathematicians is, therefore, not a solution to help students at the lowest level of understanding. Students will need a basic understanding of the mathematical concepts before self-explanation training will be effective in supporting their more conceptual understanding. Hence, it can be suggested that self-explanation training should be used alongside other methods of mathematics support in order to improve overall understanding. However, future studies should perhaps consider asking only conceptual questions to confirm whether or not self-explanation training has a significant effect on the understanding of these particular types of questions.

The analysis also showed that there was no significant difference in the test scores for the video group when compared to the scores of the booklet group, contradicting the suggestion that non-mathematicians may prefer a less formal approach to mathematics support. The data provide evidence to the contrary since the booklet appeared to provide the students with a statistically significant increase in mathematical confidence. It is perhaps that students are used to receiving instructions through books and various other forms of text during the course of their studies so they are more comfortable and familiar with that particular method. This may, therefore, give them a false perception of their mathematical confidence. Indeed, it has been suggested that students are not particularly good at recognising what is best for them in terms of their learning (Poropat, 2014) and since there was no statistically significant difference in the test scores between the two types of self-explanation training, the training should perhaps be offered in various forms to allow the students the choice of their preferred method.

Finally, the research reported in this study was small-scale and only considered 26 participants. Although the results appear to be promising, more data need to be collected and analysed before firm conclusions on the benefits of self-explanation training for non-mathematicians can be drawn. Indeed, this study only reported the immediate effects of the training and a major issue with current self-explanation research is that very little of it has explored the longer term effects. Clearly, for self-explanation training to be beneficial, it needs to have long lasting effects to allow students to progress their mathematical knowledge.

Overall this study has provided some promising insight into the use of self-explanation training to improve the mathematical understanding of non-mathematicians, specifically nursing students. The work in this study can be adapted and used to provide support for other non-mathematicians, complementing the traditional support mechanisms that are already in place. Self-explanation training, therefore, has the potential to be a beneficial method of support for any student studying any degree containing mathematical content.

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