# The Five Question Approach: Disrupting the Linear Approach to Mathematics Teaching

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Student disengagement is influenced by the degree of success that is experienced in the mathematics classroom. In turn, success is often determined by the depth of understanding that students gain during predetermined time frames. This paper reports on the Five Question Approach to teaching mathematics which provides teachers with greater flexibility in content delivery, pacing and consolidation of content. This qualitative case study draws on data collected in three Australian secondary classrooms. Findings indicate that the Five Question Approach led to increased student engagement, academic improvement and a significant decrease in examination anxiety.

## Introduction

Student engagement with mathematics in the middle years (Years 5 – 8) is a significant issue and has been the focus of considerable research. The level of students' engagement typically declines from the end of primary through to the first two years of secondary schooling (Martin, Way, Bobis, & Anderson, 2015; Plenty & Heubeck, 2013). Arguably such disengagement could have contributed to a decline in the performance of Australian students in mathematics in Programme for International Student Assessment, PISA, testing from 2000 to 2012 (Masters 2016). One aspect that may influence student engagement is the 'traditional' mathematics teaching approach. In this approach students follow step-by-step teacher led procedures, set out in worked examples, and complete copious, repetitive questions with a focus on finding one correct answer.

All schools in NSW are required to have a scope and sequence document outlining the order and duration of syllabus topics for each year. The linear, fixed time approach to the teaching of mathematics may also be related to a lack of success for some students. Many teachers follow the scope and sequence document prescriptively, moving from one topic to the next according to the time allocated and irrespective of student competence. The Five Question Approach (FQA) may provide a solution to this problem. This paper introduces the FQA and provides details of its application in two Australian secondary schools. While the FQA has been used in classrooms over many years, no empirical evidence is available on its efficacy for improving student learning and engagement.

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## Literature Review

### *Traditional approach to teaching*

In the typical Australian classroom, mathematics content is taught according to a scope and sequence document that provides a plan of the order of topics and the duration of time spent on each topic across the school year. Each school develops its scope and sequence document from the syllabus documents and the class teacher follows this plan in their teaching program. The teaching and learning structure is therefore linear with a fixed time allocated for each topic and little linking between topic areas (Rhorer, 2015). In the week preceding the half yearly or yearly examinations there is usually a period of dense and rushed revision where all topics areas are revisited. This intensive revision can lead to a high level of examination stress (Plenty & Heubeck, 2013).

In most mathematics textbooks questions on each topic are grouped together and students generally work on sets of similar questions before moving on to the next topic. This massed, as opposed to spaced practice promotes ‘overlearning’, which is the belief that the longer the practice directly following the new learning, the longer the material will be retained (Rohrer & Taylor, 2007). An alternative approach, ‘mixed review’, which is based on a combination of mixing questions on multiple topic areas (interleaving), and then spacing the questions over time, has been shown to result in a significant improvement in test results (Rohrer, 2015, Rohrer, 2009). The spacing and mixing of questions using repetition with variation, where questions are similar but different, may allow students to deepen their understanding of the concepts over time (Kapler, Weston, & Wiseheart, 2015, Handa 2012).

According to Steffe (2010), Anthony and Walshaw (2009); and Anderson, White, and Sullivan (2005), mathematical learning takes place when students are engaged in the solution of problem style tasks involving open ended, investigative style questions where various solution paths are discussed. Ideally these tasks need to be engaging and specifically selected by the teacher to achieve the desired educational goals. This contrasts with the traditional teaching approach in which the students follow step-by-step teacher led procedures where students are provided with examples, and repetitive, similar exercises are completed in class and usually finished for homework. Often when marking the exercise, the answer is given without any discussion and there is no concluding summary of the concepts from the lesson. It is this traditional method of teaching that is the most common practice currently used in Australia and this is generally considered to have contributed to a decrease in engagement (Sullivan 2011, Stacey 2010, Ball, Sleep, Boerst, & Bass 2009).

### *Student engagement*

Engagement is associated with the depth to which the students relate to their classroom work and can be conceptualised as including three dimensions (Attard, 2014). Behavioural, cognitive and affective dimensions are manifested in active participation, valuing of learning and the willingness to be involved (Attard, 2014). Engagement with mathematics is an issue in Australia and internationally resulting in a general decline in participation in mathematics at higher levels and a decline in performance internationally over the past 20 years (Kennedy, Lyons, & Quinn 2014, Plenty, & Heubeck, 2013). While there are many factors that influence student engagement in the classroom one aspect contributing to the decrease in engagement may be a result of the restricted time allocated by the linear scope and sequence which influences the pace of lessons (Ollerton 2009).

### *FQA approach*

The Five Question Approach (FQA) involves the presentation of five questions from different content areas at the start of every lesson. Students are required to complete the questions in order, from one to five, to ensure that they do not omit the questions that they are less confident in or do not want to do. While the first four questions focus on procedural fluency, the fifth question is conceptual, often open-ended, and enables students to deepen their knowledge. Students who have completed the first four questions quickly spend more time and delve more deeply into the concepts involved. The FQA provides opportunities for students, over a longer variable time period, to consolidate procedural knowledge and develop conceptual knowledge of content areas that they may not have previously understood due to the fixed amount of time allocated to that topic. The FQA may address the shortcomings of the linear fixed-time approach by allowing teachers to take small steps towards a change in practice without completely changing their entire approach to teaching.

This research aimed to provide some direction for improvement in the teaching and learning of mathematics and mathematics pedagogy in general. The central research questions were:

1. What influence does the FQA have on perceived and actual academic performance of students in mathematics?
2. What influence does the FQA have on student engagement in mathematics?

## Methodology

To evaluate the efficacy of the FQA in practice both qualitative and quantitative data were collected from two schools over the course of one school year. Quantitative academic achievement data was collected from the half year and end of year examinations held at both schools. This data was used to answer part of the first research question. The data on student engagement and the perceptions of their academic improvement were collected through student focus group discussions, teacher interviews and classroom observations. Participants were provided with pseudonyms to protect their privacy. This qualitative data was collected at the start of the year, and at the end of Terms 1, 2 and 4.

### *Contexts*

Data was collected from three classes across two Catholic secondary schools. Each year group, Years 7 to 10, had approximately 180 students spread across seven classes. Both schools graded their mathematics classes in all years, based on the end of year examinations, and followed a linear scope and sequence document. All four teachers (one class was taught by two teachers in a job share) commented on the pressure they felt in having to complete the scope and sequence in the required time, describing it as very content heavy and stating that in previous years some topics were omitted due to time constraints.

Two classes were selected from the first school, one Year 9 and one Year 10, and were both the fifth graded classes out of seven. Participants were trained mathematics teachers with more than 10 years of teaching experience. The school's 2015 National Assessment Program – Literacy and Numeracy, NAPLAN, year 9 numeracy results were below average when compared to similar schools. One Year 8 class was selected from the second school, which was the second highest graded class out of seven. The teachers worked in a job share arrangement. Both teachers were trained mathematics teachers but with less than five years of teaching experience. The school’s 2015 NAPLAN year 9 numeracy results were close to those of similar schools.

### *Data*

For each participating class the teacher(s) selected a sample of six students to participate in focus group discussions. The sample was stratified by selecting female and male students across a broad range of academic performance levels within each class. Based on the teachers' knowledge of the students the selected student's engagement levels in year 8 ranged from disengaged to highly engaged while the year 9 and 10 classes ranged from disengaged to a moderate level of engagement. The qualitative data on engagement and perceived academic performance was collected from classroom observations, teacher interviews and focus group discussions all of which occurred four times, at the start and end of term 1 and the end of terms 2 and 4. Each source of data was analysed for emerging themes prior to a cross-case analysis to seek new or common themes (Flick 2009).

## Findings and Discussion

Time to learn was the strongest theme. The students discussed how under the traditional structure there was not enough time to understand each topic. According to Gina, a Year 9 student, "Last year I didn't understand most of the topics. We have a week or two to finish a topic but really you need more time." The students made it clear that they required additional time to understand the material. The FQA provided the opportunity for the teacher to focus on areas of concern until the students developed their understanding. With the amount of time per lesson spent on the FQA varying from ten minutes to most of the lesson there was concern about completing the scope and sequence. However, by year's end all classes had completed the scope and sequence within the required time frame, albeit by following a different, non-linear route using the FQA.

### *Teacher Perceptions*

Prior to using the FQA each of the four teachers taught in a similar manner and all described themselves as 'traditional' teachers. The first classroom observations clearly indicated that the teachers followed the same traditional structure as previously described. The lessons did not revise any previous material and the teachers continued with the next aspect of the current topic, whether or not the students were ready, so that the topic would be completed within the set time.

This practice appeared to change with the teachers using the FQA to focus on the areas that were causing the students' difficulties. For example, the changes to Jenny's teaching centred around her organisation and thinking. She intended to focus on students' understanding of the concept rather than spending the allotted time and moving on to the next topic whether or not the students understood: "…and I am guided by how we're not all there yet, let's keep going. Let's get this, we will get this and then we will move on" (Jenny, Year 9 teacher). By teaching that way she felt that the students achieved success and that they felt positive about themselves and became more engaged. Jenny found the FQA gave her much greater freedom in the classroom as the time restrictions were removed: "…if it goes somewhere you just let it because that's okay …you just pick up in the next lesson… I've really enjoyed getting that understanding" (Jenny, Year 9 teacher).

### *Student Perceptions*

The students stated that they liked the topic areas that they understood and in which they performed well. Ella, a year 8 student, didn't like or understand the algebra topic when studied in the previous year. She commented that she did not have sufficient time to develop an understanding of algebra as the teacher moved too quickly through that topic area. By the end of the year her level of cognitive and affective engagement had changed from low to high. Other students made similar comments about the fast pace of the lesson and insufficient time to learn, reflecting findings from Ediger (2012). When thinking back to the previous year Allie said: "we do algebra at the start for a week and wouldn't understand it and then we'd have a test at the end of the term and we didn't know it because we only did it at the start" (Year 9 student). The other students in the focus group agreed and felt that the repetition of the FQA allowed better understanding and built their confidence.

Rather than having a topic started and finished over two or three weeks the students preferred to continually revisit the topic area which gave them time to understand and they retained that knowledge for a longer time period aligning with the findings from research by Rohrer (2015), Dunlosky, Rawson, Marsh, Nathan, & Willingham (2013); and Bird (2011). The focus group students preferred and enjoyed the flexibility and the variety of the FQA. Brenda represented the opinions of the group and she said "…if it's just the same question all the way down, you get lost and think about other things. But with FQA you must focus, it makes you think a lot harder and engage in the lesson" (Year 8 student), indicating an increase in cognitive and affective engagement. The teachers agreed that the students enjoyed the challenge and variety of the different topics of the FQA which enabled them to deeply investigate the concepts and the subsequent discussion promoted even greater understanding.

### *Engagement*

All teachers raised the point that, in general, engagement was higher in mathematics classes that contained more capable mathematics students. The students commented that they enjoyed the topics in which they were confident which aligns with the teacher statement on engagement. The first Year 8 classroom observation showed a compliant class but there was little evidence of deep engagement. The students appeared to be able to easily answer the questions given but displayed little enthusiasm and the activities did not have any cognitive challenge. Over the course of the year the questions increased in cognitive challenge and the level of engagement increased. The initial Year 9 and 10 classroom observations showed classes that were not engaged with significant class time was used to manage behaviour and the attention level of the students. Over the course of the year the level of engagement in those classes increased and the need for classroom management decreased. Harriette, the year 10 teacher, felt the students were more engaged and confident due to the extra time spent on problem areas in the FQA. She noticed that the students' level of engagement with the FQA was much greater than during the traditional part of the lesson and felt that this was due to the repetitive nature of the work they were required to complete.

All the participating teachers used tests to ascertain the students' level of understanding but the time restrictions prior to implementing the FQA prevented any remediation. The teachers stated that the analysis of the results was supposed to influence teaching to remedy the issues identified. "We're supposed to do assessment for learning, but time restrictions make it impossible – you do the task and you go, this is what mark you got and move on" (Karen, Year 8 teacher). In this case the tests could have contributed to the students' lack of engagement because of a lack of remediation caused by time limits.

The FQA provided an opportunity to address the problem areas indicated in the test. The teacher included poorly answered test questions in the FQA which allowed the students opportunities to develop their conceptual understanding that they lacked. Although the students all stated that the FQA took time from the textbook theory work, Brenda made this comment that provides some evidence that the combination of cognitive, operative and affective engagement results in deep engagement (Attard 2014):

> I think the five questions is better than theory because we're attempting questions, and you remember sitting there and working out things, and attempting them. And I think that the best lessons are if you remember working it out in your head, and if you get it wrong, sort of talking about it and discussing it is really good (Year 8 student).

### *Academic Improvements*

The focus group students commented that the FQA with its revision, repetition with variation, consolidation and interleaving had helped in the reduction of examination stress. The students had developed an understanding of concepts over time which provided the opportunity for them to develop a more complicated map or network in their memory rather than a simple linear progression (Ollerton, 2009). Allie said: "…when you have an exam it's like, oh I know how to do this because like I do it in five questions, but you don't actually realise that in class". Gina went further when she said "… everyone in the year should (do the FQA), because it really does help when you get to exams, you actually have a better understanding of what you have to do and how to do it" (Year 9 student).

All three classes showed improvement in their half yearly and yearly examination results. The marks were used to rank the students based on their academic performance in that examination. The rankings were used to show the relative movement of the students from the sample classes compared with other students in the year group. As the content in the examination was directly related to the content of the five questions this analysis gave an indication of the influence of the FQA. The rank for each student was compared with the initial rank from the previous year that was used to form the class. These rankings were compared, and the data displayed on a scatter plot.

The scatterplots show the results for the current class comparing the final examination ranking with the final examination ranking from the previous year. The straight line indicates equal rankings so points above the line show an improvement in ranking. There was greater improvement in the Year 9 and 10 classes when compared with the Year 8 class, but this was because there was significantly greater room for improvement. In Year 8 there were nine students from the 8M2 class that were placed above 20th ranking. As a result, students that were nine places or less below the line may have improved or performed at the same level. Therefore, twenty of the students improved and eight did not when compared against their Year 7 performance.

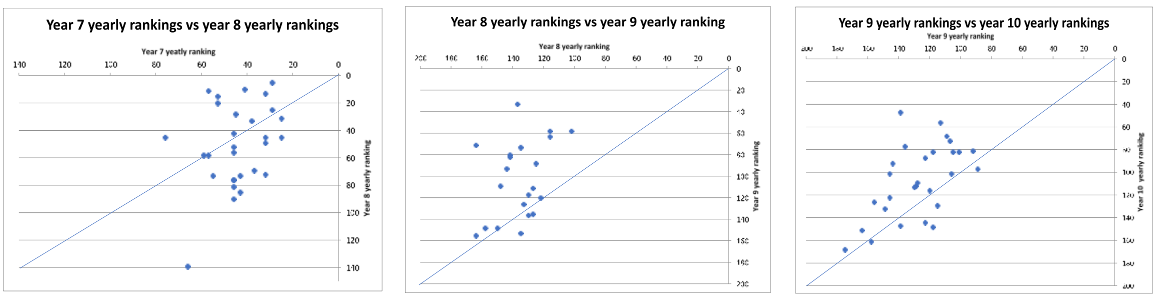


*Figure 1*: Comparison of yearly examination rankings

Importantly, all the students felt that they were better at answering questions due to the repeated practice over time and would be more likely to attempt questions because of the

FQA. The teachers said that the student enjoyment of mathematics class and as a result their behavioural engagement, was enhanced by the FQA. The positive attitude through success in the FQA increased students' perceptions that their academic performance was improving and as the results showed, academic performance did improve for most of the students.

## Conclusion

The FQA positively influenced the level of engagement and academic performance in all three classes. The students and teachers found the repetition of questions over time provided the opportunity for students to develop understanding and confidence. The increased confidence helped to reduce examination anxiety for many of the students and as a result their examination performance improved. The greater discussion around mathematical concepts, and explanation of multiple solution pathways, showed an increase in engagement. All teachers and students indicated that they would like to continue with the FQA in the next year with one school adopting the practice across the entire faculty.

The success of the FQA in improving engagement and academic performance through multiple exposure to content areas over extended time periods has implications for all 'traditional' teachers. The emphasis on textbook exercises and worksheets that replicate the worked example are not as effective as spreading the questions over time. Strict adhesion to the time allocated in the scope and sequence may not allow all students to develop sufficient understanding and consequently the lack of understanding and success is disengagement. The study showed that the 'traditional' classroom structure did not provide many opportunities for students to deeply engage with the mathematical content and concepts. The FQA provided multiple opportunities for understanding and hence success from meaningful conversations about mathematical concepts which was borne out through the study as engagement increased in all classes.

This study had some limitations which should be recognised. Firstly, only secondary schools were used in the study and both schools were secondary Catholic schools. Both schools graded their classes and as a result the students had a strong focus on their examination performance as that determined their class allocation. It would be difficult to predict the results of the FQA in schools where students are grouped heterogeneously. Such a context might provide challenges for the teacher in determining the optimal set of five questions for each class. The design of the five questions requires teachers to have a strong pedagogical content knowledge and as a result, out of field teachers may find the writing of the questions difficult.

This research has the potential to be expanded by involving more school systems, both secondary and primary schools, teachers, and students, in particular, non-denominational schools and schools using a mixed ability approach to mathematics classes. The collection of data from two schools and three different year levels provided some insight into the value of the FQA. Extension of the study into more schools may provide a deeper understanding of the potential of the FQA to alleviate some of the issues involved with a 'traditional' teaching environment with fixed time linear approach to teaching mathematics.

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