The use of Socratic Method to improve problem solving skills among Further Education students.

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Students who come into English Further Education (FE) and haven't previously achieved a grade 4+ in GCSE (General Certificate of Secondary Education) Mathematics are now required to continue studying mathematics. Many of those students come into FE with negative predispositions towards mathematics and frequently a cycle of examination failure follows them. The emphasis on improving learners' problem-solving skills is very clear in the recent development of the mathematics curriculum in the UK and the Socratic Method was used to enhance those skills. The method involves the use of a series of questions that guide students to understand the mathematical problem. The main aim is to encourage learners to be less dependent on the teacher and develop problem solving and reasoning skills. To achieve the latter, we conducted lesson studies for two academic years. The findings suggest small improvements in the students' ability to approach problems and some development of independence.

Further Education; GCSE mathematics re-sits; problem solving; Socratic Method

Introduction

We introduce this paper with a scenario that the authors as practitioners in Further Education (FE) claim we face every year. It is almost the end of the academic year and we believe we have taught our students everything they need to know in order to have a successful outcome in their GCSE maths examination. GCSE examination is the General Certificate of Secondary Education that students are required to sit at the age of 16 and mathematics is one of the compulsory subjects. We have given them advice on how to approach complex questions, tricks on how to identify key words and we are confident that our students have developed those problem-solving skills they need to productively handle examination questions. Therefore, we draw a close to our formal teaching and begin with revision sessions. And there comes an important realisation! The majority of our students lack what we believed we had armed them with and that is problem-solving skills.

Although we have been through similar questions before, our students seem to still lack the ability to work towards a mathematical solution by examining and analysing the problem in order to find connections between what is previously known, what is given and what is sought. So, we asked why, though we believe we repeatedly improve our teaching strategy and approaches to learning, our students keep failing. We concluded that we tend to teach for the mathematics examinations and not for mathematical understanding. This realisation coincides with Swan's (2006) findings that a large proportion of teaching in GCSE mathematics re-sit is concentrated on examination practice that favours transmission teaching and memorisation of rules and procedures.

The heart of our teaching was so focused on exams that we forgot that we believe the aim of mathematics education should be to develop a person's ability to share and evaluate ideas, examine and analyse evidence, explore implications and consequences, and reason sufficiently. This ultimately led us to explore the ideas and philosophy of the Socratic Method and how it could be used to improve performance in our GCSE Mathematics re-sit cohorts and foster an environment of independent problem-solving.

GCSE Mathematics in Further Education

Since September 2013, in an attempt to improve mathematical literacy among young UK citizens, the Department for Education has made the study of GCSE mathematics compulsory for students who enter Further Education (Swan, 2000; Schulz, 2013; Bellamy, 2017). Further Education in the UK is additional education to that received in Secondary school and it is a means to obtain an intermediate, advanced or follow-up qualification, useful if one wishes to enter Higher Education or begin a specific career path. Students tend to choose FE mainly because of its vocational rather than its academic character. Thus, every student who enrols in an FE course and has not previously achieved a GCSE grade 4+ for mathematics is now also enrolled in a mathematics course.

Recently, a number of reforms concerning the improvement of mathematical literacy in post-16 education have been put in place and various projects have been implemented (Smith, 2017; Swan, 2000). These reforms made their appearance after a significant link was found between low levels of numeracy and unemployment (Parsons & Bynner, 2005). However, we do not believe that simply raising numeracy levels among young UK citizens, is sufficient to foster mathematical understanding, at least as important for future employment.

Many students who enter FE present low levels of motivation, confidence and understanding towards mathematics which eventually lead to great disengagement (Hough, Solomon, Dickinson and Gough, 2017). Further, a large number of these students have already experienced failure in previous mathematics examinations probably more than once (Dalby, 2013; Hannula, 2002). Moreover, there is the idea among students that GCSE mathematics is irrelevant and boring (Smith, 2014).

So, what can a teacher do to encourage a classroom environment where students can productively engage with the subject, minimise any negative predispositions, and improve their problem-solving skills? A report made by Hough, Solomon, Dickinson, and Gough (2017, p.7) suggests that:

> courses need to focus on changing classroom cultures towards new norms of discussion involving questioning, sharing and evaluating ideas in order to support new understandings of mathematics and encourage students to take ownership of the subject. Courses also need to work on enhancing students' learning skills by encouraging them to question their own and others' strategies.

We posited that adding the above elements to our everyday teaching in FE might help our students to both improve their problem-solving skills and achieve better examination performance.

GCSE Mathematics and Problem Solving

Recently much emphasis has been given to the development of problem-solving skills through mathematics and its importance can be seen from the changes in the new GCSE mathematics, first examined in 2017. From our experience, problem solving was an underdeveloped skill within mathematics. However, it is now a theme under discussion which teachers are trying to improve and cultivate in order to align with the new reform (Bradshaw & Hazell, 2017).

According to Marcut (2005), problem solving skills help learners pay attention to ideas and sense making instead of simply memorising facts. Problem solving increases the learner's belief that they can do mathematics and it can be used as a way to assess their understanding or make instructional decisions and ultimately, help students succeed.

Teaching problem solving in FE is challenging for both the learners and the teachers. Pre-existing negativity towards the subject makes a teacher's job challenging as more emphasis needs to be given on engaging the learners with mathematics rather than teaching them mathematics. For this reason, we made it our focus to create a classroom environment in which students will have the opportunity to discuss mathematical concepts and seek solutions based on problem examination and reasoning. We hypothesised that the ideas and philosophy behind the Socratic method could help us build that kind of classroom environment.

The Socratic Method

Through a series of questions the Greek philosopher Plato uses *Socrates* to expose the thoughts of his interlocutor by rephrasing, reconstructing or developing them further. Socratic method is characterised by a rigorous analysis of the arguments under examination (Chesters, 2012). Dialogue is the heart of this process. In his dialogues, Socrates feigns ignorance about a given subject in order to acquire another person's fullest possible knowledge of the topic. Through the logic of reasoning, he tries to reveal any misconceptions and uncover flaws and contradictions in his interlocutor's position (Chesters, 2012). He is not the expert in the dialogue; he wants to help the students detect their own faulty reasoning.

We decided to include Socratic questioning in our everyday teaching because we wished to engage students with the learning, assess what has been learned, and check that what has been learnt is understood and applied, initiate individual and collaborative thinking in response to new information, provide an opportunity for learners to share their views, foster speculation, hypothesis and the forming of opinions, challenge the level of thinking and possibly make a change to a higher order of thinking.

To achieve the above aims we try to implement the six following types of Socratic questioning (Wagner, 2018):

1. Questions that clarify.
2. Questions that challenge assumptions.
3. Questions that examine evidence or reasons.
4. Questions about viewpoints and perspectives.
5. Questions that explore implications and consequences.
6. Questions about the question.

Methodology

One of the authors had started to implement Socratic questioning in his teaching the academic year 2016/2017 whereas the other author joined the lesson study in 2017/2018. Hence, the method was used for two academic years. Two mathematics teachers took part in the study each academic year (teacher A and B for 16/17, teacher B and C for 17/18) with a learning coach co-ordinating the whole process and giving advice when appropriate. The students used for the study were two groups of a total of 30 students in parallel ability GCSE re-sit sets each academic year. From each group a sample of three students were selected for feedback after every completed lesson study cycle.

A lesson study consists of three stages: *plan, observe,* and *reflect & plan*. It is a form of collaborative research that is used to support professional development. It has been used in Japan since 1870 to help teachers act as researchers and work together in order to improve and develop areas in their students' learning. The participants research, plan, teach and observe a series of lessons, using continuous discussion, reflection and expert advice to further develop and refine their interventions (Lewis, Perry, & Friedkin, 2009).

Firstly, both teachers collaborate in the lesson planning to address each activity to the enquiry question, predict learners' reaction and discuss how they would assess this. Then they pick three learners that will be observed during the study (that is a random choice).

Secondly, one of the teachers (teacher 1) delivers the lesson and the other (teacher 2), along with the learning coach, observes the lesson with a focus on the reactions of the three selected learners. During the observation, the learning coach and teacher 2 keep notes based on what was previously planned, discussed and expected to be seen. At the end of the observation, the three chosen students are briefly interviewed to identify if they noticed any changes during the lesson. The first academic year, responses from the interviews were kept as written notes. In the second academic year, we decided to record students' responses as it would make our analysis much more efficient.

In the last stage, we reflect on what has been observed during the lesson and on what the three students have stated at the interview. Based on that information we plan for the next lesson. Each of the teachers/participants is observed three times during the academic year.

The first year of the lesson study was informal and focused mainly on types of questions that clarify. Teachers had observed that one important issue students faced with, was language. For that reason, they were asking specific questions to help learners understand the terminology and the words used in the mathematical problems. It was hoped that through that type of questioning students would be able to comprehend the information given to them and what was required.

The focus of the second year was a mixture of all the six types of questioning as we wanted to enhance not only clarification of the mathematical problem but also students' attention to evidence, reasons, implications and consequences. We believe that it is one thing to be able to understand the problem situation and what is asked for you to do and another to be able to find a solution by making connections, finding evidence and reasoning. This is an important skill that our students in FE greatly lack.

The questions asked during the interviews were the following: 1. Did you notice anything different in your teacher's teaching today? 2. How do you feel when instead of answers the teacher responds to you with a question? 3. Do you find it

helpful when you are asked a lot of questions? 4. How do you think this impacted your learning?

Findings

The data that have been examined and analysed come mainly from the second year of the lesson study. From the interviews, we saw that there was a mixture of feelings towards the Socratic questioning.

In response to the first question, all the students said they did not notice anything different in their teachers' teaching; some of them stated that "my teacher always asks a lot of questions". We hypothesise that because we have been researching the Socratic questioning rigorously our everyday teaching had been greatly influenced. Once we began to conduct the lesson observations, our students had already got used to our Socratic style.

As far as the second question is concerned, two thirds of the students enjoyed being asked questions instead of being given the answers. For instance, one student said "that helps because it kind of tests you to see what you know and what you don't know, [the teacher] knows that you know the answer and makes me see that I also know it, I just need to think…". However, a third of them thought that they were on the spotlight during the questioning; something that made them feel slightly uncomfortable. We concluded that the fear of giving the wrong answer enhanced those feelings.

In response to the third question, half of the students found the questioning process helpful and the other half thought it was a bit confusing sometimes. One student stated that "sometimes when you read the problem, I feel I miss important information but when [my teacher] says it aloud and asks questions is like, oh! I missed that…". However, another student said that "other students' methods sometimes confuses me because if they are wrong and you think they are right, then it is confusing and then [my teacher] might give another method, and I prefer [my teacher's] method…".

Finally, regarding the fourth question, half of the students felt that they were learning more mathematics than before as they started to approach the mathematical problems differently by breaking them down in simpler questions that made more sense. The other half of the students, however, still thought that mathematics is difficult and complex to learn and understand.

Conclusions

So far, we have seen partially positive reactions towards the Socratic method but we realise that our learners need to be given the time to trust us and then let themselves engage with the learning of mathematics. We need to think further on how we can receive more information through the interviews and how we can escape students' bias towards their teachers. Finally, we need to see if there is another way to "measure" the impact that the Socratic method has on our students' learning and problem solving skills as until now we only see it through observations during revision sessions.

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