A week with secondary mathematics through history and culture

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This paper is about the mathematics lessons I delivered during the last week of the previous school year at a secondary school, years seven to ten. The lessons involved history of mathematics as well as sociocultural elements. The material chosen are described and briefly examined. The students' reactions to the idea and whether they engaged with the lesson is also looked at. The kind of questions students asked in class and what these revealed is discussed. Another area of discussion is students' answers as well as their interpretations of the issues raised in class. As each of the four classes was of different achievement (from bottom to top sets), I comment on whether achievement seemed to have any effect on students' reactions. Finally, some teaching issues I encountered when attempting to teach with this approach are raised.

Introduction

The series of lessons described in this paper is *the last cycle* of an one-year action research project I started in 2007-08. Three years ago, I had worked with a group of 12 academically challenged students teaching them mathematics through history and culture. The one-year course I taught was called *Cultural Mathematics* and relevant information can be found in Georgiou (2008). The lessons that are described here were informed by this action research project, as well as by my general experience as a mathematics teacher and an action researcher.

What does mathematics through history and culture mean?

It has been extensively identified that mathematics curricula are more often than not disconnected from real life situations thus making it harder for the students to make sense of it (Frankenstein 1994). Zaslavsky (1994) pointed out that the students have minimum opportunities to understand the origins of mathematics and the role of the various peoples in its creation. Ascher and D'Ambrosio (1994) indicated that the lack of any emotion in mathematics lead to the dislike of the subject on behalf of the students.

Anderson's (2010) work revealed that using material related to the students' reality may not only introduce connections between mathematics and societal issues, but also help students achieve agency and social empowerment. Bishop (2001) indicated the explicit value teaching that is possible to take place in a mathematics classroom (in contrast to implicit values coming up in the lessons). Acknowledging the values that may emerge can give the mathematics teachers the chance to be mathematics *educators* and not just *trainers.* In this way they may also contribute to the moral and spiritual growth and maturation of their students.

Ethnomathematics was coined by D' Ambrosio (1985) and it is a discipline that encompasses the study of mathematical evolutions from the peoples' and cultures' point of view. This point of view may include ways in which mathematics can be used to help people in their lives, and show how it is or was used by different cultures. Shirley (2006) supports that Ethnomathematics can be used to teach students the mathematics that needs to be covered according to the curricula and at the same time inform the students about the contributions and the practices of the various cultures around the world. Swetz (2000) shows that concrete examples of using mathematics may enable students' learning and understanding.

Katz (1993) pointed out that history of mathematics can help students understand the origin of this science and how it evolved. Furinghetti (2000) discussed the benefits the students received when themselves or their teachers used the journal *Il Pitagora*, a journal about the historical evolution of mathematics. Radford and Puig (2007) support that teachers' awareness and use of historical sources may facilitate the understanding of their students. The work of Lawrence (2006) revealed that using history when teaching mathematics to KS3&4 students may help in the increase of the students' motivation, initiatives for investigations and communication skills. Rogers and Fairchild (2010) worked with students on solving quadratic equations using the Mesopotamian and early Hindu method that later lead to the completion of the square. The students' interest and involvement had increased and Rogers and Fairchild (2010) pointed out that looking at a problem from an historical perspective, reveals aspects such as "conjecture, justification and generalisation".

Background, material and data

The lessons that will be described here took place during the last week of school, with KS3&4 students, years seven to ten. The abilities of the four groups were ranging from top to bottom. Their attitudes were generally positive, although two of the classes displayed a more passive style of learning, and the other two were more active and excited. Again, the setting did not have to do with their willingness to participate and share responses and ideas. The years will be named as N, B, V, C, for anonymity purposes. The discussion will involve the specific year's material, without revealing whether it is a top, middle or bottom set.

The material was chosen according to the syllabus covered in the year that was coming to an end and in relation to the expressed interests of the students, if any. Ideas were taken from a variety of sources like Addison-Wesley (1993), Lumpkin and Strong (1995), Katz (1993), NCTM (1989) and Wright (1999). I prepared booklets with the activities for all the students, which I was collecting at the end of every lesson and also at the end of the week. The booklets were kept for analysis purposes.

For year seven, I chose to use worksheets on Egyptian numerals and Egyptian multiplication. Some further problems using Egyptian numerals were taken from Eagle (1999). I also included an activity from Smile, related to the power of two and how fast a (positive) number grows when doubling it. The booklet concluded with instructions on how to play oware.

For year eight I used an activity about people's right for fair employment and specifically fairly-traded coffee and fluctuation of prices. Wright (1999) proposed a series of activities starting with an article from the declaration of the human rights, followed by the description of a situation. Mathematical tools are then employed to examine whether the specific article was violated in the case described and fairly-traded coffee was one of these activities.

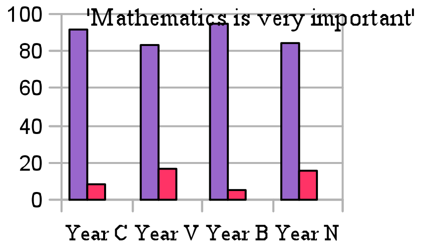
For year nine I chose some texts on Babylonians and the Plimtpon 322 tablet, an early artefact of the use of Pythagoras' theorem, before Pythagoras. Some problems taken from the Chinese *nine chapters* and the Indian *Sulbasutras* were added in the booklet, as well as a text on Hypatia, the first known woman mathematician and some exercises with number patterns related to her work. For the last lesson, I arranged for the students to watch a 20-minute excerpt from the BBC documentary "The story of maths" (2008), that was related to the discussions we had during that week. Musto (2010) also refers to the specific documentary and how he used this, in collaboration with the head of art, to motivate the students become involved in an art-mathematics project of drawing portraits of mathematicians. The students created paintings of a mathematician they chose and added some mathematical elements relevant to the mathematician's work.

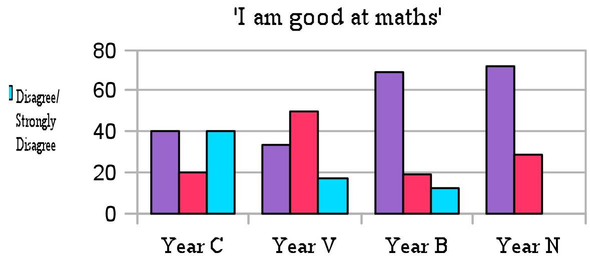
For year ten, I included a text on Al-Khowarizmi and some activities on his geometric method for solving quadratic equations. A second text on Eratosthenes was also included, with some activities explaining how he calculated the circumference of the earth, having very few instruments available. I also presented the students with a form of Euclid's proof on the infinitude of the primes. The week concluded with learning how to play oware.

Before commencing the lessons using historical and sociocultural elements, I gave the students an initial questionnaire to capture their stances towards mathematics. A second significant piece of data is the students' written work from the booklets, as well as some transcriptions of lessons. After completing these “alternative” lessons, I distributed another questionnaire to capture their stances towards the material used in that final week.

First questionnaire

Two of the questions of the first questionnaire will be used here to shed some light on the general attitudes of the students. As it becomes apparent, the majority of the students thought that “mathematics is very important”, rather irrespectively of whether they perceived themselves as “good at maths”. Generally, the students appeared to recognise the utility of mathematics, but their responses regarding “enjoyment” or “difficulty” of the subject, were widely varied. The charts represent percentages of the students in each of the four classes.





Trends in the lessons

In this section, I will be discussing some patterns that emerged while analysing the data. It must be noted that the analysis is still developing and these are only some initial observations.

The students displayed intense reactions when presented with different formats of written text in mathematics. For example, some year eight and year nine students took negative facial expressions, or made comments like “This is English!” when presented with passages. On the contrary, when year seven students skimmed through the booklet and found the Smile activity resembling a comic-book page, displayed exclamation and asked “When are we going to do that?”. As historical and sociocultural issues require some form of written text to be presented, such reactions can be anticipated as the students probably expect numbers and formulae, otherwise it may not be mathematics for them.

Some of the questions the students raised, as well as some of their answers, revealed some misconceptions or mere ignorance of what would maths encompass in the past. For example, when discussing the Babylonian's sexagesimal system with year nine, a student said that sixty would be easier to remember since it was “just a six and a zero”. When I challenged them by asking if the Babylonians actually *had* a six or a zero, another students asked if they wrote sixty in words. Although a picture of the Plimpton 322 tablet was in their booklets and it contained the symbols the Babylonians used for numbers, the students did not make the connection with the symbols. Another case that revealed some misconceptions, emerged when comparing various numerals. The current Hindu-Arabic symbols were described as 'unique' in contrast to the Roman ones, that repeated “I” for example, to show bigger values. The repetitions in the use of 1 and 0 that were used to write ten, did not occur to them as repetitions, perhaps because they were not accustomed in challenging what had became habitual for them.

Another significant incident emerged again when dealing with the Babylonians and the Pythagoras' theorem, that revealed students' confusion between two or more main points covered in the lesson. As the students used their knowledge on Pythagoras' theorem to check the patterns of the numbers on the Plimpton tablet, they had to choose which was the column representing the hypotenuse. Although they were aware of the fact that the hypotenuse is always the longest in any right-angled triangle, they suggested that the number missing from the triple had to be divisible by 60. This was quite unexpected. The discussion on the sexagesimal (base 60) system had probably diverted their attention to new issues and caused the confusion.

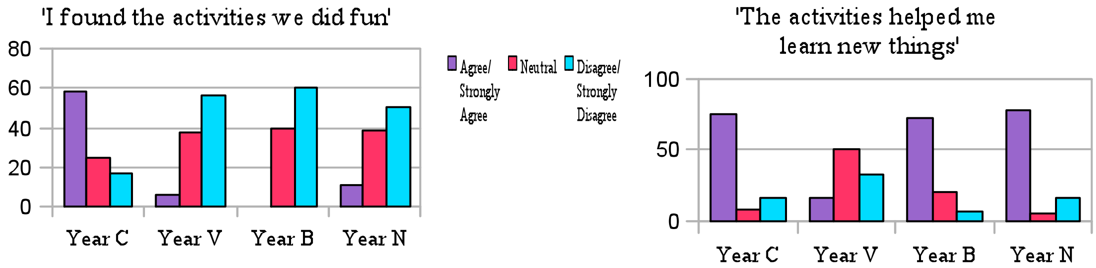
In the written answers to the historical/critical questions after the class discussion, some students demonstrated misunderstandings of what was discussed in the class. For instance, they wrote that a difference between the Hindu-Arabic and the Egyptian numerals was that the latter were *shapes*; it was made clear to them that the current ones can also be described as *shapes.* Although some students insisted that “ours are numbers, theirs are shapes”, I mistakenly thought that the extensive discussion that followed their suggestions should have clarified the issue.

A significant category of incidences is the “teacher brought into a challenging position”. As most maths teachers are not history or sociology experts, using such an approach can easily lead the discussion to unfamiliar areas for the teacher. This occurred when for example, when some students connected the measurement unit “stadium” with the modern meaning of the word (incidentally the length of both is around 200m), while I was not sure if such a connection was historically valid.

The students were not bothered when things I was not aware off came up. But it must be acknowledged that there are challenges the teacher might face while working within an area outside standard mathematics. Pompeu (1992) mentions that while preparing an ethnomathematical approach to mathematics, some of the teachers in the team got discouraged and wanted to abandon this approach and turn to the standard textbook to complete their preparation. In other words, the challenges a teacher may face with such an approach are either related to a tiring and sometimes daunting preparation or some unexpected themes emerging during the lesson.

Second questionnaire

The four classes completed the second questionnaire on their last lesson; not all last lessons occurred on the same day (e.g. some lessons were missed on the last day, and some classes did not have maths lessons every day). The comparisons drawn here are on two of the questions. What the chart shows is that only year C found the activities fun. Nonetheless, only year V found that they did not learn much from these activities. In a sense, one of the aims when using such an approach is to enrich students' mathematical experience and the students acknowledged the fact that they did learn new things. Regarding the *kind* of new things they learnt, there is no universal answer to that; some did agree, that what we did was more like history. At the same time some students agreed that they did learn some more maths during these activities.



Initial conclusions

The above observations allow for some initial conclusions to be drawn. As mentioned before, these conclusions are drawn prior to the completion of the analysis and this is why they should only be used as provisional.

Firstly, ability did not seem to affect how the students enjoyed the new material. Although it was not made clear in this paper which class was of what setting, the responses of the students were varied and both the upper and the lower sets included positive and negative reactions.

What many students seemed to appreciate in their comments was the variety in the approach. Doing something different than what was going on during the whole year seemed to be motivating for most of them. On the other hand, working during the last week of lessons probably affected the results in a negative manner, as some students explicitly said that they did not want to have lessons and that we should do something more relaxing.

Lastly, it appears to be more challenging for the teacher to prepare and deliver an alternative lesson. In a traditional maths lesson, not many surprises are anticipated. On the contrary, in a historical/sociocultural approach, even if the material is ready-made, unexpected issues may arise. Moreover, from my experience, it is far more difficult to prepare this style of lessons. The preparation takes much longer and there is some element of uncertainty on whether the material will be welcomed or not by the students.

The results so far are generally encouraging, in spite of the aforementioned challenges. Further analysis is required. Extension of this research including more students and trialling of more material is to be sought.

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