

Developing Mathematical Knowledge through Social Justice Pedagogy with Young Adult Arab Women

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The study involved a group of Middle Eastern Muslim women learning mathematics through social justice pedagogy. The findings suggest that the involvement of students in social justice issues has not lead into a decline in their opportunity to learn mathematical content as set in the course. However, this approach has helped them to develop significant mathematical knowledge beyond the basic numeracy skills expected of them. In addition, this study demonstrated how a focus on mathematical content can be maintained while students are involved in social issues in mathematics learning.

In many school curricula around the world, mathematics is privileged for its perceived importance both for society and the individual student. The social importance of quality mathematical knowledge is often justified due to its role in technology and science which is seen as essential for the economic development of a society and its standard of living. At the personal level of the student, mathematics is seen as opening the doors to many careers and courses of further study. However, as Atweh and Brady (2009) cautioned, both reasons should not be taken uncritically. Borrowing the terminology from Down, Ditchburn and Lee (2007), Atweh and Brady added that it is possible to conceive the importance of mathematics for the student can be understood at three levels. Mathematics education can contribute to the students' *conforming*, *reforming* or *transforming* society. This understanding of the role of mathematics education is consistent with the critical mathematics movement (Skovsmose, 1994). Using Freire's terminology, Gutstein (2006) argues that developing mathematical knowledge helps students to not only "read the world", i.e., understand it, but it should lay the foundation for their capacity to "write the world", i.e., change it.

This paper discusses how mathematics learning of a group of Arab women was facilitated by using a social justice pedagogy based on Gutstein's model. Gutstein's framework of teaching mathematics for social justice identified two sets of goals: Mathematics goals and social justice goals. The mathematics goals are: To read the mathematical world; to succeed academically in the traditional sense; and to change his or her orientation to mathematics. The social justice goals are: To read the world with mathematics; to write the world with mathematics; and, to develop positive cultural and social identities. This paper addresses only 2 elements of the mathematical goals, namely, "to succeed academically in the traditional sense" and "change ones orientation towards mathematic".

Theoretical Background

The social justice approach adopted here is based on the work of Gutstein and his colleagues (Gutstein, 2001, 2006; Gutstein & Peterson, 2005) in a Chicago school in the

USA which argues that engaging students in mathematics within a social justice context increases students' interest in mathematics and also helps them learn important mathematics. A number of researchers investigating issues similar to the one presented in this paper have documented how students' mathematical knowledge and understanding could be enhanced through social justice teaching. For example, Gutstein (2001) documented how middle school students developed their understanding of the concept of "area" by examining the distortion of the world map projection used in their school (typically, Mercator's) by enlarging Europe and Greenland and shrinking the African continent. Turner (2003) described how urban middle school students developed their understanding of measurement and ratios by investigating the level of crowdedness of their school in comparison to others in the district. More recently, Tracey (2007) documented how students in a Maths Club used mathematics as a tool to fight against a plan to close their school by considering the costs of bussing them to the new school and the subsequent overcrowding and adverse learning conditions that may result at the receiving school.

Researchers have also documented the challenges associated with teaching mathematics for social justice. For example, Taysum and Gunter (2008) said "it is arguably dangerous to attempt to work for social justice in the school when the writers [Leaders] of policy tests are people far removed from the messiness of the day to day realities of the people whose identities they are shaping" (p. 187). Gutstein and Peterson (2005) argued that social justice teaching cannot be easily done when using a rote, procedure-oriented mathematics curriculum. A test-driven, teacher centred approach does not foster the kind of teaching environment necessary for teaching for social justice.

Jacobsen and Mistele (2010), in their investigation of the challenges preservice teacher face with teaching for social justice concluded that the major challenge was what they called the "problem of balancing" (p. 8). In other words, the problem of how to get a balance between the mathematical concepts and the social justice issues addressed in given tasks. They provided 4 possible manifestations of the "problem of balance" (1) the use of mathematics without mathematics instruction by the teacher (2) use of traditional methods of teaching and/or nonchallenging mathematics (3) trivializing of social issues, and (4) disconnect or artificial connections between social issues and the mathematics.

More recently, Atweh (2012) in a response to a chapter by Dowling and Burke (2012) argues that a reading of the world necessarily is subjected to the simplification of the phenomenon being read and the simplification of the mathematics used to read it (based on the level of knowledge and resources available to the student). Hence, a prerequisite for a productive reading of the world through mathematics is an awareness of the limitations and assumptions one makes about the mathematics, the world, and the viewer. Atweh concludes by saying "Under the right conditions, I would like still to hope that one can be to be a good mathematics teacher and political activist at the same time" (p. 110).

The context

This research was carried out in one of 17 HCT colleges around the United Arab Emirates (UAE). At the time of this study, at entry, students with reasonable Common Educational Proficiency Assessment (CEPA) scores in English and Mathematics are admitted into the Higher Diploma Foundation Program (HDF) and the remainder into the Diploma Foundation Program (DF). Upon passing the DF, students can commence their HDF courses. In other words, DF students are perceived, by the system, as mathematically weak, and the course aims to develop rather basic numeracy skills in order to prepare students for higher studies.

Further, contextual information about the College that is relevant to the content of the projects developed by the students in this study, is that more than 50% of the students came from outside the city of Abu Dhabi. The college provides bus services, at a subsidised rate, to students who require the service. Some students are driven, or drive themselves to college. Those who drive themselves are mostly part-time working students. The college has student parking area and staff parking area within its premises.

The mathematics course in which the participants were involved in consists of 8 modules: Whole numbers; time; fractions and decimals; measurement; fractions, decimals and percentage; ratio and proportion; time calculations; and tables, graphs and formulas. The research presented in this paper focused on 3 content areas, namely: Percentage, time calculation and graphs. Experience from previous years shows that these topics remain a particular challenge for many students undergoing a traditional teaching approach. They are also useful topics to deal with many demands of the daily life.

Methodology

This study involved a group of 20 women participants, from the age of 16-36 years in the DF Mathematics Course. The sample was purposefully chosen (Creswell 2005) because they were taught by the first author and, relative to other classes, the majority had a reasonable command of both written and spoken English. Triangulation (Stake, 2003) was achieved through multiple sources of data including (1) student presentations (2) participants' test results from the end of the module (3) participants' reflective questionnaires, and (4) focus groups. Grounded theory approach was used to analyse the data. In particular, the approach discussed by Strauss and Corbin (1998) was utilised to organise and interpret the raw data in this research.

Procedures

At the start of the project, students engaged in a brainstorming session to identify issues related to social justice of concern to them to investigate using mathematics resulting in three projects: Time of Travel, Career Aspirations and Car Parking.

The Time of Travel group was concerned with the issue whether the means of transport provided by the college could be improved to meet the needs of a number of students who lived outside the city. Each student in the class recorded their travel times to and from college for a week. This data formed the basis of learning mathematics as well as investigating the challenges some students faced in their travels to and from College. The Car Parking was concerned with the allocation of parking at the College to see if it was fairly distributed between staff and students. To obtain their data, they measured the dimensions of all car parks and worked out how many cars could park at any given time. The Career Aspirations group used mathematics to investigate needed action to increase the level of information available to students with regards to available career opportunities. They constructed a questionnaire which was completed by 7 classes out of the 9 classes in DF Semester 2 at the college for their data collection.

Five hours every week for the duration of 6 weeks were devoted to working and reporting on the projects. During the early stages of the projects, it was noted that the group discussion tended to focusing less on the mathematics involved and more on the investigated social issues. This is the "problem of balance" identified by Jacobsen and Mistele (2010) above. In seeking to meet this challenge, the first author introduced the Mathematical Enriched Worksheets to focus the students on the mathematics. A separate

sheet was developed to consider the data from each of the 3 projects. All students in the class attempted all 3 worksheets; first, individually in class and at home; then, they discussed their results within their project groups. Finally, the project group working on the topic presented their answers to the relevant Mathematical Enriched Worksheet to the whole class.

Results

Overall performance of the students: One common concern by many teachers about engaging students in project work is that the time “wasted” on project may prohibit “covering the curriculum” and hence disadvantage students’ performance on set tests. Hence, it is useful to compare the performance of these students with other groups also taught by the first author following the traditional pedagogies in the course. At the end of each Module, all the DF students would take the same pen and paper end of module examination. The examination consisted of questions contributed by the teachers who taught the course. Table 1 shows the result of the participating class (Class A) compared to other classes. Sections A, B and C were taught by the first author but only Section A students were exposed to teaching for social justice.

Table 1: Summary of Test Results (Class A followed the Social Justice Pedagogy)

Section	PERCENTAGE				TIME CALCULATIONS				GRAPHS			
	A	B	C	D	A	B	C	D	A	B	C	D
Student Number	20	19	20	18	20	19	20	18	20	19	20	18
Mean	72	76	68	81	70	74	64	74	78	69	62	71
STDEV	8	15	18	12	7	11	13	9	10	12	18	12

Two observations stand out from the Table 1. First, the performance on class A was the highest of all classed on the Graphs test, about average on the Time Calculations test and slightly lower than average on the Percentage test. However, over all, not a single student in Class A has failed the tests compared to 3, 6 and 1 failures from Classes B, C and D respectively. It is also interesting to note that these tests recorded the highest failure rate of all modules, indicating that students in general found this content to be ones of the hardest to master. Also, arguably, these modules required students to demonstrate understanding of the content as against recall of procedures and formulas which constitute the content of the other modules. Hence, overall this approach to teaching mathematics did not disadvantage students on their performance on the set tests. We can only conjecture that had the context of the questions on these tests been related to the context of the projects (thus creating a synergy between pedagogy and assessment) the performance of the students in Class A might even have been higher.

However, the second interesting observation from the above data is that on all tests, Class A demonstrated the lowest standard deviation. This lower variation means that the gaps in knowledge between the top and bottom students are less pronounced in this class. Therefore, rather than learning in this class being individualistic, it was more communal.

However, other observations from the data show that there are significant benefits in students learning as a result of these activities. These will be outlined below.

Deep mathematical knowledge: As discussed above, the course consisted of foundational level skills expected of students to enter the Diploma courses. With this in mind, these projects provided students with activities that were beyond the level of difficulty represented in the workbooks adopted in the course. For example, the students involved in the Car Parking project designed their own sketch of the car parks at the College and successfully calculated their areas (see Figure(1)). Not only have students not studied this content in their class, but it is also much more complex than the simple calculations expected of students. Of additional interest is that the students obtained the necessary formulas on their own. One student asserted that “this project has made us to search for information about area of shapes and drawing that we didn’t know before”.

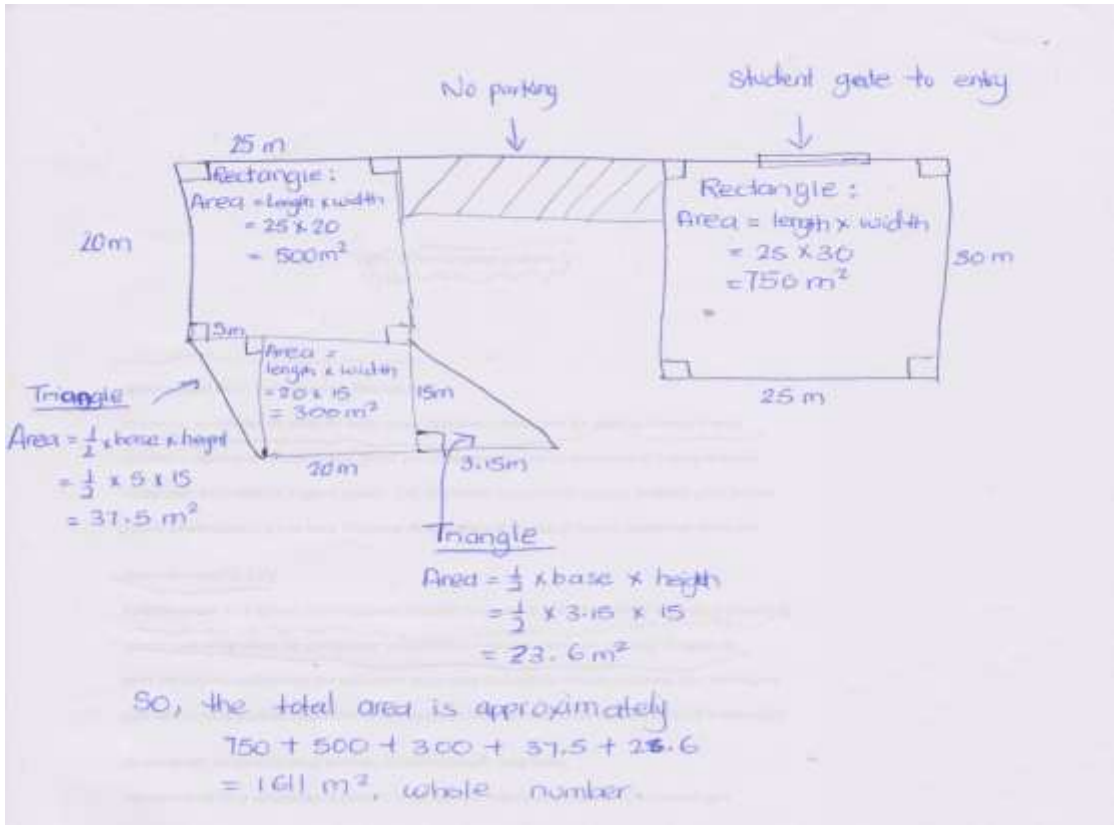


Figure 1: A sketch of the students’ car parking area

The Time of Travel Mathematical Enriched Worksheet contained the following question.

A journey on a bus from city A to city B will normally last for two hours, and every passenger pays Dh15 for this journey. Use this information to calculate how much it would have cost you to travel to college using public bus. From your answer, do you think those of you who travels by bus to college are getting a good deal? Explain your answer fully.

To arrive at the answer, they had to multiply the cost (15) by their total hours per week, and then divide the answer by 120. They then multiplied the answer by the total number of weeks in a semester. The question involved multiple skills and steps; hence, it was more complex than the direct questions that the students are used to in their modular workbooks.

Shaikha spends approximately 2 hours on the bus every week. Below is her response to the question.

$$120n = 15 \times 533$$

$$n = (15 \times 533) \div 120 = \text{Dh } 66.63 \text{ per week}$$

One semester is about 20 weeks, so I multiplied the answer by 20,

$$66.63 \times 20 = \text{Dh } 1332.60, \text{ one semester.}$$

It is cheap[er] for me to travel by public transport, only Dh1332.60 in one semester.

But, I pay Dh1900 to travel in the [school] bus.

However, significantly, Shaikha adds “I still take the college bus because it is better than public because I travel with my friends and is safer and I don’t worry when I am late to college because we are many”.

One very interesting aspect of Shaikha’s work is that it reminds us of one of the limitations of traditional mathematical problems in which the mathematics produces the “correct” answer to real world problems. This is far from authentic problems where mathematics can assist in decision making, but the adopted solution may not be mathematical at all.

However, not all students demonstrated the ability to make sense of the problem in terms of the real world situation that they were investigating. One of the questions on the Time of Travel Worksheet was:

Find out how many students come from outside the city in your class.

For this academic year (2008-2009), there are approximately 2500 students registered at the College. Based on your answer above, calculate the percentage of students you would expect to come from the city.

For many students this is a “trick” question. While the first part involves number of students living outside the city, the second part involved calculations of the number of students from the city itself. Sumaya seems to have fallen into this trap; her solution was:

$$\text{Number of students from outside Abu Dhabi} = 11$$

$$\text{Number of students from Abu Dhabi at ADWC} = (11 \div 20) \times 2500 = 1375 \text{ students}$$

$$\text{So, percentage} = (1375 \div 2500) \times 100 = 55\%$$

Arguably, she did not read the question with much care even though her knowledge and skill in percentages was appropriate. Furthermore, this reasoning was not isolated; a few of the students gave the same answer. Of interest here is to speculate as to why this miss-reading has occurred. While the worksheets used in this study were provided to assure a focus on the mathematical knowledge and skills, for some of the students who were not involved in the Time to Travel group, the exercises in them were not necessarily as meaningful. They did not generate the questions themselves. Hence these questions may not have been different to the usual problems that appear in textbooks – where shallow reading is not uncommon.

Finally, interviews and reflective questionnaires with the students at the conclusion of the study show that the majority of students have gained confidence in their mathematical understanding and skills. One of the questions on the reflective questionnaire was “*what do you like or not like about the mathematics projects you have completed this semester?*” One of the participants Bedour wrote:

I now see math as useful in my life. I didn’t like math before but now I go to class early no late again. I can calculate percentage in fun way also I can add and subtract time. Before is all hard to understand.

Another participant Afra, wrote “I understand math better and I want to do math all the time”.

Discussion and Conclusions

The findings discussed above suggest that the involvement of students in the social justice pedagogy implemented as projects chosen by the students, assured there was no decline in their opportunity to learn mathematical content as set in the course. It has helped them develop significant mathematical knowledge beyond the basic numeracy skills expected of them. However, the findings also show that by developing mathematics within real world contexts that are meaningful to them, mathematics has become meaningful to them, and they have developed confidence in its learning. We conclude this paper by a reflection on its design and findings using the four challenges to a social justice approach to teaching mathematics identified by Jacobsen and Mistele (2010) and discussed above.

Mathematics without mathematics instruction: The use of student selected projects necessarily raises a dilemma for teachers. On one hand, they need to avoid taking the responsibility away from the students for decisions as to what mathematics is needed to investigate the selected social phenomenon; and on the other hand abdicating their accountability as a teacher responsible for meeting the set outcomes of the subject. In this project the students decided what kind of data was needed to investigate the issues they had selected. They may not have been consciously aware of the particular content of mathematics required in the module. However, this was important part of the teachers concern. The lengthy discussion within the groups and in consultation with the teacher and with the use of the mathematics enriched worksheets, it was possible to achieve both challenges above. While the students were completing the worksheets, the teacher partly assumed the traditional role of a teacher in checking students work and scaffolding their mathematical understanding. Hence, scaffolding the students is possible without taking away their sense of agency in their design and implementation of the project. Our suggestion is in line with Gutstein's (2006) dictum that in the absence of concrete direction and guidance in the mathematics content, one does not easily become a "reader" of the world using mathematics.

Non-challenging mathematics: A related dilemma which presents itself for teachers using social justice projects in their teaching is the balance between the mathematics needed to investigate the phenomenon (which may be considered as basic level as far as the curriculum is concerned) and the level of mathematics expected in the formal curriculum. Once again, the teacher in this particular class opted to supplement the mathematics actually used by the students to investigate their phenomena with questions that highlighted the mathematics in the curriculum. However, as we argued above, these worksheets were still based on the actual data that the students have generated, hence, may have contributed to keeping the mathematics meaningful for the students.

Trivializing of social issues: Arguably, some of the social issues investigated in these projects, e.g., parking and cost of travel, may not be seen as significant social justice issues for the students and their society. However, they were selected by the students themselves. They are meaningful to them in their particular context.

Disconnect or artificial connections between the mathematics and the social issues: The last challenge identified by Jacobsen and Mistele is the tendency of teachers raising questions that have marginal connection to social issues in real life - that is using questions that may have some mathematical value but no one really needs to answer in real life. In a real classroom context, perhaps this is inevitable. Particularly when different groups of students are working on social justice issues that they select, a challenge for the teacher is to assure that all students would have a chance to experience all the mathematics content covered in the curriculum. Hence, it may be unavoidable at times to raise some

mathematical questions that may be artificial in that particular context of the social issue. In this particular study, it was decided that all students attempt all worksheets including those based on the data of the other groups.

Finally, we note that this study has made a contribution to the limited, yet expanding empirical literature on a social justice approach to mathematics education by investigating its use in mathematics bridging course in higher education as well as in the context of traditional cultures such as the Middle East.

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