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Using Social Justice Pedagogies to Improve Student Numeracy in Secondary School Education.

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Abstract
This unique Australian paper presents a study involving a Western Victorian District High School year nine mathematics class using social justice pedagogy to learn Mathematics. The class was comprised of gifted students, mainstream students and students who had diagnosed learning disabilities, all key foci in Australian Education research. The learning content of the Mathematics unit required students to make comparisons between their own lifestyles and those of different families from around the world. This was socially and educationally important as Mathematics was used as a tool to investigate social inequality to improve numeracy. One aim of the study was to determine if there are associations between student learning, student engagement and student achievement when teaching mathematics using social justice pedagogies. The findings from this study suggest that when mathematics is taught using Social Justice Pedagogy, student learning and engagement are both improved.
Keywords: social justice mathematics, mathematics education, practical mathematics.

1. Introduction.

Traditionally, Mathematics has been taught by using a combination of formulae, algorithms and abstract exercises from a range of textbooks and worksheets (Wright, 2014). Cefaratti (2014), Osler (2007a) and Gutstein (2003) all hold the view that this method of teaching Mathematics does not allow the students to connect the mathematical concepts being taught with their interests, backgrounds or life experiences. Gutstein (2003, 2006) further argues that if the students are unable to connect the mathematical content with their own lives, they can obtain a false perception of the essence and the power of Mathematics in everyday work and life.

Cefaratti (2014), Wright (2014), Wonnacott (2011), Gay (2010) and Appelbaum (2008) all hold the view that teaching Mathematics using traditional methods in a secondary school environment results in a decrease in student engagement, student participation rates and student achievement. In turn, this decrease produces poor performance results in some external examinations (Wright, 2014). To address this issue, governments and educators have begun to reform the Mathematics curriculum as is evidenced by the National Council of Teachers of Mathematics [NCTM] of America, the Office for Standards in Education of England and the Advisory Committee on Mathematics Education from England who are all shifting the emphasis of Mathematics from basic computational skills, memorisation and repetition to one that emphasises reasoning, problem solving and communication (Lubienski, 2002; Wright, 2014).

In Australia, the Federal Government's new national curriculum model AusVELS follows the status quo taken by other countries by incorporating elements of interdisciplinary learning and active citizenship into student learning tasks (Victorian Department of Education and Early Childhood Development, 2009).

Tanko (2012, 2014), Osler (2007a) and Gutstein (2003, 2006) discuss one framework that supports these government initiatives that involving teaching Mathematics for social justice. The framework firstly focuses on the students beginning to appreciate and investigate social justice issues that are relevant to their own lives and interests, with the aim of creating a general awareness. Secondly, the framework promotes the use of Mathematics to be used as a tool to further investigate, address and potentially to change issues involving social justice for the benefit of the students, their community and also the environment.

In order to effectively combine the teaching of mathematics with activities that allow students to interact with the notion of social difference and disadvantage, where in some cases they may be the disadvantaged ones, a Social Justice Pedagogy model was employed for use in this study. The need to generate solutions to basic mathematical problems it was hoped, would focus student attention on social justice issues and motivate participants to engage with these authentic and real world problems. This allowed them to better understand the costs, for example, of different cultural food groups and associate this with their own perceptions of how well off they may be socially. This study used the framework for teaching Mathematics for social justice as developed by Eric Gutstein (2003) to combine mathematical and social justice goals. The objective was to

determine if student learning, thinking and engagement are all evident when Mathematics for social justice is taught with the intent of making Mathematics education more linked to students' interests' backgrounds and abilities. The study discusses the benefits and challenges of implementing this framework.

2. Theoretical Background and Literature Review.

Teaching using social justice pedagogies has been greatly influenced by the work of Paulo Freire who was a social activist and worked in liberatory education (Corman, 2011; Gonzalez, 2009). Freire believed that troubled people can only be liberated from their rulers through action and reflection upon their world (Bartell, 2005; Gonzalez, 2009).

Teaching Mathematics for social justice has been built upon Freires' work and promotes the use of Mathematics as a tool to enable students to understand social life, people's position in society and how Mathematics can be used to transform injustices (Gonzalez, 2009).

One approach to teaching Mathematics for social justice developed by Eric Gutstein (2006) has been successfully trialed. The framework was made up of two key components that included mathematical and social justice goals (Gonzalez, 2009; Osler, 2007a, 2007b; Tanko 2012, 2014; Ucifferri, 2014). The mathematical goals of the framework encouraged students to read the mathematical world and to succeed academically in the traditional sense. The 'social justice' goals of the framework were for students to be able to write the world in Mathematics and develop positive social and cultural identities (Gutstein, 2006; Tanko 2012).

Burton (2003), Brown (2013), Chapman and Hobbel (2010), de Freitas (2008), Frankenstein (1987), Gonzalez (2009), Gutstein (2003), Gutstein and Peterson (2006) and Sriraman (2008) all mention that to achieve these two goals outlined in Gutsteins' framework it is important for the students to learn important mathematical competencies through the use of a range of different contexts and different subjects. There are a variety of theories that describe how to create a range of learning contexts for teaching Mathematics for social justice (Turner, 2003). One such theory involved enabling students to investigate and appreciate issues that involved politics or social justice issues that affected the students' own lives (Bartell, 2005; Gutstein, 2003). To achieve this it is important that the students themselves are ultimately part of the solution when solving issues involving social injustice (Gutstein, 2003).

To enable students to become part of the solution to injustice, the students themselves need to feel empowered and that they are able to make a difference to an unjust situation (Brown, 2013; Gay, 2000; Gutstein, 2003). Gutstein (2003) states that as students begin to address social justice issues that have meaning in their lives, they begin to understand the forces and institutions that shape their world in which they live and to pose their own questions. Brown (2013) and Leeds (2010) also hold the view that as the students address these issues through challenging injustices and inequities, they develop skills in critical thinking, cooperation and conflict resolution.

Current research indicates that students' opinions of themselves and their abilities become more positive as they learn to address issues involving social justice (British Columbia Teachers' Federation, 2014). Furthermore, Strickland (2011) indicates that student perceptions of Mathematics and their ability to understand and solve traditional Mathematics problems also improves when students critically analyse issues that involve social justice issues. According to Gareth (2013), current literature shows that by incorporating teaching strategies which include social justice pedagogies into today's classroom, student engagement can be enhanced, student motivational levels can be increased, and ultimately the students' academic results can be improved. Gareth's assertions are supported by other research into higher order thinking and the ability to reason (Brown, 2013).

3. The Project

Context of the Research

The Western Victorian District High School involved in the study is approximately four hundred kilometres from the capital city of Melbourne in the state of Victoria, Australia. At the last census, the town had a population of 9601 residents, with forty-nine per cent being male and fifty-one per cent being female (Australian Bureau of Statistics, 2011).

Socioeconomically in 2012, the town rated below the average living wage of $606.40 per week when compared to individuals who work in Melbourne, Victoria, Australia. Employees who work in the town earn a median individual income of $472 per week and a median household income of $898 per week (Fair Work Australia, 2012).

The town's educational facilities consist of four primary schools, one private secondary college, a technical and further education (TAFE) campus and one public government school. The government school participating in this study employs sixty staff and has around 750 students. At the government school there were a total of 114 students undertaking year nine Mathematics. It was negotiated with the high schools administration to use a sample size of forty-five participants from the student population to undertake the study.

Method

The study was made up of twenty nine male and sixteen female participants aged between thirteen and fifteen years of age. The class had a wide range of mixed abilities, interests and backgrounds and also contained four integration students who had learning disabilities, and an integration aide to assist them with learning tasks. The participants were selected using a convenient sampling technique. The Western Victorian District High School assigned the first author as a teacher researcher to teach mathematics to a specific group of year nine students for the year. Triangulation (Creswell, 2012) was achieved by cross-referencing multiple sources of data obtained from (1) a focus group session (2) a folio of students work (3) a summative mathematics test conducted at the end of the unit (4) pre and post unit concept maps (5) a student survey and, (6) observations recorded in the researchers' reflective journal. To analysis the data the researcher used a grounded theory approach as described by Denzin and Lincoln (2011) that incorporated a qualitative based action research methodology. The study excluded traditional mathematics classes taught by other teachers as the participants could not be observed directly by the researcher and therefore risked contaminating the study's findings.

The Western Victorian district high schools Mathematics curriculum is broken up into four major areas that align with the Victorian Essential Learning Standards (VELS) curriculum model that include space, number, structure and working mathematically. The department has had a strong emphasis on teaching Mathematics using traditional methods that include the use of Mathematics textbooks and electronic e-books that are integrated with the occasional computer simulations. At the completion of the unit students are required to undertake a written examination to evaluate their understanding of the subject matter.

At the beginning of the study the students were introduced to a selection of three preselected social justice mathematics units that could be studied. These topics included sweatshop wages, public health care in different countries from around the world and global food and mathematics. The students were given an opportunity to ask questions and brainstorm possible ideas before selecting a single topic which the class would investigate as a whole. After considerable discussion, the students negotiated with the teacher to investigate the global food and mathematics unit.

The unit was conducted over one semester (ten weeks) where the students dedicated three hours every week that included 90 minutes class time and 90 minutes as part of the students' homework program. The students were allocated into individual work groups based on student friendship, each of which contained between four and six participants. Each work group was required to investigate and produce a portfolio of work explaining their understanding of the issues that involve world hunger, poverty and how mathematics can be used to understand this problem.

Students were firstly required to analyse a series of photographs compiled by Lowe (2012) and compare the lifestyles of people in different countries from around the world. Secondly, students were asked obtain a range of supermarket shopping dockets from their family's weekly grocery shop that showed the cost of the food purchased. Thirdly, students were required to compare the findings from their shopping docket investigations against the food purchased by other families shown in Lowes (2012) photographs. Finally, students were asked to recommend a strategy from a range of options that could assist third world countries to minimise global hunger. These strategies included supporting online forums, organising a guest speaker from an appropriate charity and taking part in World Vision's forty-hour famine.

4. Results and Discussions

This section will reflect on the learning tasks adopted for this study against Gutsteins (2003) framework for teaching mathematics for social justice.

Shopping docket exercise. The mathematical goals for this learning task required students to collect shopping dockets showing the cost of groceries purchased by their families. Students were required to use the dockets to complete a range of statistical calculations. The exercise consisted of two components. The first component required students to complete a set of sample statistical calculations from the whiteboard to gain an understanding of the subject matter. The second component required students to use their newfound knowledge and apply these skills to find the average cost of groceries purchased by the classes' families to make further comparisons.

In order to determine the students' initial level of traditional mathematics skills, students were required to complete three calculations in their workbook that included finding the mean, mode and median values of the numbers 2,3,6,3,2,4,1.

Initial observations showed that the majority of the table groups had only a fair understanding of the subject matter. For instance, when the students were asked to calculate the mean value of the numbers, all students were able to add up the numbers (totalling 21) and divide the answer by seven, thus giving an average or mean score of 3. However, when the students were asked to find the modal score of the data many of the students looked confused. In an attempt to complete the exercise the majority of table group members began to ask one another how to solve the problem and the following typical discussions were noted:-

"Isn't the mode number the one that appears most often?"
"But there's two number twos and two number threes, so which one do we use? Or do we use both?"
"Mr. Voss, it is possible to have more than one mode"

The final calculation required the students to calculate the median value of the same set of numbers, and although the majority were able to find the middle number, which they believed was three; they failed to write the numbers in ascending order, thus giving an incorrect answer.

Once the students had completed the initial example in their work books and a mathematically rich worksheet, the students were required to select five different countries from Lowes (2012) photographs. From this selection students were required to find the mean, modal and median values of the amount of money that each family spent on food. Tia's (*all names are pseudonyms*) table group came up with the following calculations that were typical across most table groups.

Table 1. *Students' selection of countries and the money spent on food.*

Country	Money spent on food
Mexico	$189.09
Germany	$500.00
Egypt	$68.53
USA	$159.18
Poland	$151.27

$$\text{Average} = \frac{\$189.09 + \$500 + \$68.53 + \$159.18 + \$151.27}{5}$$

$$= \frac{\$1068.07}{5}$$

$$= \$213.61$$

In order to find the median value of the money that the countries spent on food in table 1, Tia table group wrote, "To find the median I must first write the numbers from smallest to largest."
Median = 68.53,151.27,159.18,189.09,500
After writing the numbers in ascending order, Tia's table group noted, "The number in the middle is 159.18 so the median number must be $159.18 because it is in the middle".
When calculating the modal value, Matt's table group asked, *"Mr Voss… when finding the mode each number only appears once so the mode must be zero."*
The researcher replied, *"Does the number zero appear most often in the data?"*
Matt table group answered, *"ah… no but that means there is no mode,"*
The researcher concluded by saying, *"precisely, so you that's what you have to write.*
The second component of the learning task required students to calculate the average amount spent on groceries for the class. Observations showed that the students were able to complete the basic statistical calculations using the examples in their workbooks to guide them. During the learning task there was also evidence of deeper learning (Gutstein & Peterson, 2006). For instance, when analysing the classes shopping dockets Tia's table group pointed out that to the class that some families shopped every few days, weekly or fortnightly. The table group highlighted the fact that it was important to convert all grocery dockets to weekly amounts before attempting the statistical calculations.
The social justice goals of the learning task of the learning task promoted students to compare their own lifestyles against the families from Lowes (2012) photographs as shown in figure 1. Ben's table group provided one comparison when he queried how some families from other countries can live on as little as three dollars a day.

Figure 1. *Sample of Lowes (2012) photographs used by Ben's table groups during the social justice investigation.*

After some discussion into how the barter system and co-ops work, Ben's table group decided to go to the school canteen to find out how much a can of soft drink could be purchased for and compare the results against supermarket prices. The table groups' investigation revealed that supermarkets can use their buying power to purchase good in bulk cheaper than the school canteen. This conclusion lead to several table groups to pose and discuss the question, 'can families from poorer countries also use the barter system and/or co-ops to purchase food'?

Working with percentages. The mathematical goals for the second learning task involved working with decimals, fractions and percentages. Students were required to use the internet to determine the average living wage from the countries shown in Lowes (2012) photographs. Using these photographs, students were then required to calculate the percentage money from wages spent on food and use Microsoft Excel to graph the results. The learning task was once again broken up into two components. The first component required the students to complete a mathematically rich worksheet to develop the students' mathematical skills. The second component required students to once again apply their newfound knowledge to investigate problems related to the social justice unit.

Observations recorded from the mathematically rich worksheet showed that the majority of students were initially unable to convert decimals to percentages.

Figure 2. *Extract of mathematical worksheet completed by students.*

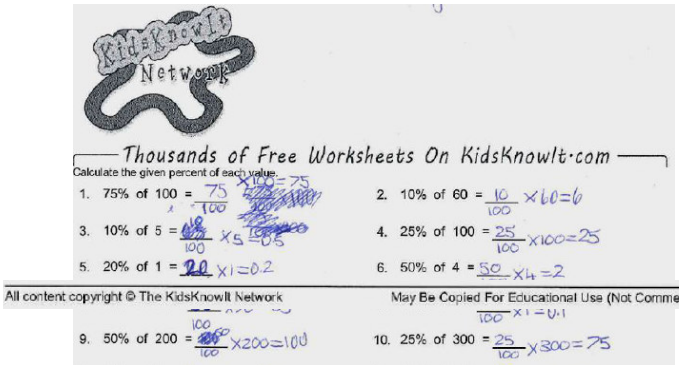
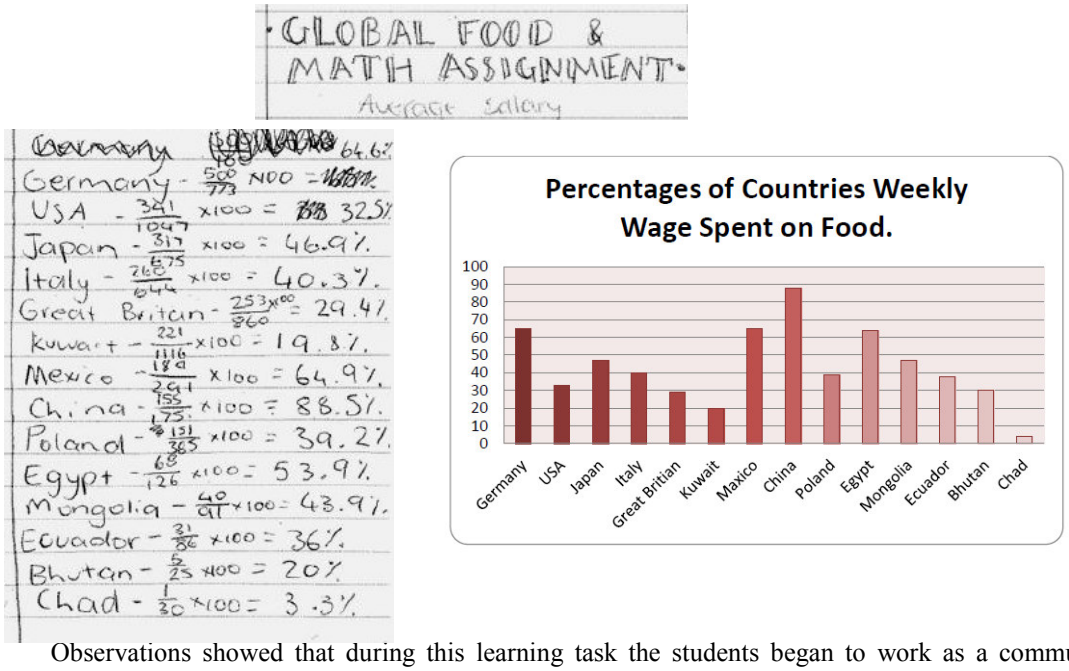


Figure 2 shows a typical worksheet completed by the students. The worksheet shows that as the students were working down the left hand column of the worksheet they were making many fundamental errors and required further explanation. After tuition students were able to complete the remainder of the worksheet with minimum intervention.

The second component of the learning task once again required students to apply the mathematical skills they had learnt into their investigations. Figure 3 shows that although the students made some calculation errors early in their investigation, they were able to use their worksheet to determine where the errors were made and to recalculate the results.

The final part of the investigation required students to use the results in figure 3 and graph the results using Microsoft Excel.

Figure 3. *Extract of global food and mathematics assignment from students workbook showing percentage calculations and an Excel graph showing the results from the investigation.*



Observations showed that during this learning task the students began to work as a community of learners rather than individual table groups as observed in the initial stages of the unit. For instance, during this learning task many inter-table group discussions occurred. Dale's table group who consisted of several students who were competent in using computers and Microsoft Excel took on a teaching role and showed several other students how to create data tables and different types of graphs. It was also noted by the researcher that Dale's table group was also able to assist the integration students to complete the set task showing that higher order thinking and learning were both evident.

A second example that showed deeper learning was also evident occurred at the conclusion of the learning task where two table groups queried the accuracy of the graph that was produced in figure 3. The students posed the question to one another 'if China spent 89% of the money on food, how do they buy a house or pay their bills?' To answer the question one table group decided to redo their calculations in order to check for errors but without avail. The table group concluded that it was possible that the figures obtained from the internet may have been inaccurate.

The social justice goals of the learning task required students to make suggestions into how society can help the countries in poverty. Each table group investigated different relief agencies that assist people in poverty including Care Australia, ADRA and World Vision. As a result of the investigation the students wrote an open letter to the Student Reprehensive Council SRC of the Western Victorian District High School seeking support for World Visions forty hour famine. Furthermore, several students who undertook the study participated or supported the fundraising event by donating time and money.

Summative tests. To determine the level of mathematical achievement students were required to undertake a mathematics test as per the Western Victorian High Schools policies. To determine if this achievement could be attributed to teaching mathematics using social justice pedagogies the students completed a pre and post unit concept maps answering the question 'when I think of mathematics I think of…'.

The summative mathematics test was undertaken by all year nine students and went for duration of fifty minutes. Statistics showed that the average mark for the students studying mathematics using social justice pedagogies was 74% compared to 68% for students studying mathematics using more traditional methods. The range of test marks for the social mathematics class was 31% compared to 37% for their year nine counterparts. An interesting emerging trend that occurred from the summative test data involved the lower achieving students. The students involved in the social justice unit attempted the majority of questions on the test paper where the lower achieving students being taught using traditional methods simply left the questions unanswered. This trend may suggest that teaching mathematics for social justice may have improved the confidence of the low achieving students thus effecting their achievement on the mathematics test.

In conjunction with the summative test, students also completed a pre and post unit concept map to determine if learning was evident. When interpreting the students' responses on the initial concept maps it was interesting to note that all the students' answers focused on the traditional mathematical knowledge that was

taught through the high schools mathematics curriculum. However, these concept maps made no reference to the practical application of the use of mathematics. When interpreting the data from post-unit concept maps, evidence showed that there was still a strong link between the students' responses to the 'traditional' mathematics skills taught at the Western Victorian district high school. However, further analysis showed that the students' responses also included a variety of practical applications of mathematics that included money, percentages, budgets, cooking, food, weight that related to solving real life problems. These student responses reflected some of the learning outcomes that were covered in the global food and mathematics unit and suggest that learning was evident throughout the unit.

4. Conclusions.

Teaching mathematics for social justice is a relatively new approach for teaching mathematics in Victorian public schools. One constraint encountered in the study was that it only involved one mathematics class from a single Victorian Western district High School due to financial constraints. However, this constraint opens opportunities for further research studies that can be conducted in the secondary school classroom. These studies may include investigating teaching mathematics for social justice in different educational settings or undertaking longitudinal studies to compare student learning and student engagement taught in different schools.

Future studies may wish to investigate a larger sample, to improve the generalisability of the findings and confirm the findings from this study. Future research may also engage students in the greater use of ICT to perhaps allow direct contact with other cultures, as this is not readily available in many of the Education contexts that are presented in this study.

The findings from this investigation suggest that incorporating social justice issues in Mathematics education improves student learning and engagement. Evidence suggested that the pedagogy enables students to explore Mathematics beyond the classroom, develop specific mathematical skills, and acquire the knowledge to become active citizens. Teaching mathematics using social justice is an effective pedagogy that can be used to promote students to develop social tolerances between different groups of people within Australia's modern day multi-cultural society.

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