USING A CONTEXT-BASED PROBLEM SOLVING INSTRUCTION TO PROMOTE SOCIAL JUSTICE IN HIGH SCHOOL MATHEMATICS CLASSROOMS

Joseph J. Dhlamini[1]* and David Mogari[2]

[1,2]*Institute for Science and Technology Education, University of South Africa.*

[1]dhlamjj@unisa.ac.za, [2]mogard@unisa.ac.za

In this study a context-based problem solving instruction is used to promote learners' mathematical problem solving skills, and to highlight issues of social justice pertinent in mathematics classrooms. A convenient sample (n = 783) of grade 10 learners who were low-performing in mathematics participated in the study. Data were obtained from an achievement test, semi-structured interviews and classroom observations. Results suggest a positive link between instruction that incorporates elements of social justice and learners' problem solving performance (p < .05). On the basis of these results some suggestions are put forward for strengthening instruction that incorporates elements of social justice in South African mathematics classrooms.

INTRODUCTION AND BACKGROUND

The new National Curriculum Statement (NCS) has demonstrated intentions to address issues of social inequity and injustice deeply entrenched in the South African society. Equity and social justice have been placed amongst priority goals to drive an education reform agenda (Department of Basic Education [DBE], 2011). For instance, in the Curriculum and Assessment Policy Statement (CAPS) for mathematics the National Curriculum Statement Grades R - 12 (NCS R-12) is founded on the principle of "social transformation: ensuring that the educational imbalances of the past are redressed, and that equal educational opportunities are provided for all sections of the population" (DBE, 2011, p. 6). In particular, social justice is incorporated into the fundamental principle within which the NCS R-12 is to be realised. In terms of this principle, NCS R-12 is purported to be fundamentally sensitive to issues of "diversity such as poverty, inequality, race, gender, age, disability and other factors" (DBE, 2011, p. 6).

It seems NCS is making efforts to use schools as laboratories to prepare learners for the world around us. Primarily, this is because schools and education are intricately linked to

economic, political, and social power structures that serve to perpetuate inequity and injustice (Bartell, 2011).

In this paper, we focus on the notion of social justice as an ideal capable of enhancing optimal learning outcomes. Firstly, we define the phrase *teaching mathematics for social justice* as referring to a mathematics pedagogy that uses mathematics as a tool to expose learners to issues concerning power, resource inequality, and disparate opportunities between different social groups to illicit social and political actions (Gutstein, 2006).Furthermore, Pendlebury and Enslin (2004) conceive of this pedagogy as "largely about distributive justice" (p. 31) because, within a school setting, learners can share learning resources equitably.

This pedagogy seems to challenge traditional views such as believing that access to mathematics is reserved for certain groups and cultures. Further, this pedagogy also contests the view that mathematics should follow set procedures and pedagogies (Atweh & Brady, 2009). Given this background, in the current study social justice pedagogy is premised on the notion that group members learn to challenge each other's views and beliefs of mathematics, and those of the teacher. At group level learners discover that everyone gets an opportunity to participate meaningfully and equitably in a mathematics discourse. Finally, the social justice pedagogy that is advocated in this study challenges the view that the teacher is the only source of knowledge. Pedagogy for social justice views mathematics as socially constructed. Learners are not seen as depositories waiting for teachers to make deposits, what Freire (2000) calls "the banking concept of education" (p. 72).

Lastly, our conceptualisation of using a context-based problem solving instruction to promote social justice in a mathematics classroom draws especially from the work of Freire (1993), who conceived of such instruction as aiming to create a society where humans actively transform their society to make it better. In that way, we view social justice as a way of distributing educational goods equally and encouraging equitable access to them (Pendlebury & Enslin, 2004).

AIMS OF THE STUDY

The main aim of the study was to use a context-based problem solving instruction to promote grade 10 mathematics learners' problem solving skills. The secondary aim was to design instruction that promoted aspects of social justice in class. According to Gonzalez (2002, p. 23), there is a view that most of the existing examples of social justice units appear to rely on elementary mathematics rather than upper-level mathematics. Given this view, the study also aimed to teach mathematics to promote social justice in high school.

CONCEPTUAL FRAMEWORK

We have used Atweh and Ragusa's (2003) model of social justice to assess classroom practice. Young (1990) argues that grounding social justice in individual solutions does not provide enough space for the consideration of divergent social group. In terms of this conception, social justice is well articulated when individuals work as a group.

Figure 1: The ADMC[3] model for analysing social justice in international collaboration

	Affirmative	Transformation
Redistribution	***Mode 1***: *Aid* ***Attributes***: Sharing of information and resources among countries. Represents cultural classification based upon access to knowledge. Can generate misrecognition.	***Mode 2***: *Development* ***Attributes***: Restructuring of relations of knowledge production. Blurs group identification. Can help remedy misrecognition.
Recognition	***Mode 3***: *Multiculturalism* ***Attributes***: Acknowledging cultural differences, such as cross cultural research. Supports group identification.	***Mode 4***: *Critical collaboration* ***Attributes***: deep restructuring of relations of recognition. Blurs group differentiation.

Source: *Atweh (2004, p. 48)*

According to Fraser (1995), social justice requires both redistribution and recognition measures. In today's world claims for social justice can be classified into two types. According to Fraser (1996), the first and the most familiar type is redistribution. Redistributive claims seek a more just distribution of resources and goods (Fraser, 1996, p. 3). Examples include claims for redistribution from the rich to the poor, from those with most resources to those with fewer resources, from those who are advantaged to those who are marginalised, and so on. The second claim for social justice is recognition, known as the "the politics of recognition" (Fraser, 1996, p. 3). Here the goal is create a difference-friendly world where assimilation to majority or dominant cultural norms is not the price of equal respect (Fraser, 1996). Examples include advocacy for the recognition of the distinctive perspectives

[3] In figure 1, ADMC stands for Aid, Development, Multiculturalism and Critical collaboration.

of ethnic, racial, gender difference and sexual minorities (Fraser, 1996, p. 3). According to Fraser (1996), the discourse of social justice is divided between the claims for redistribution on one hand, and recognition on the other.

To deal with injustice that cuts across the redistribution-recognition divide, affirmation and transformation remedies can be applied. Affirmative remedies are those "aimed at correcting inequitable outcomes of social arrangements without disturbing the underlying framework that generates them" (Fraser, 1995, p. 82). Transformative remedies are "aimed at correcting inequitable outcomes precisely by restructuring the underlying generative framework" (Fraser, 1995, p. 82). The ADMC model offers two options to achieve social justice. Firstly, by a way of keeping the status quo as is, that is, without critiquing the underlying framework. Secondly, by first questioning existing status quo, that is, by restructuring underlying generative framework. Later we use figure 2, which provides some explanation for the components of ADMC model, to analyse and describe learners' actions during a mathematics instruction.

Figure 2: Mode definitions and descriptions for social justice

Mode	Definition	Description
Aid	The non-critical transference of tactile or symbolic resources/goods from one social group or individual to another.	Aid is a redistributive process that affirms the status quo. It seeks not to alter systems and normative structures but rather to affect immediate circumstances.
Development	The critical or non-critical restructuring of modes of knowledge and commodity production internally and/or externally.	Development is a transformative process whereby goods and/or knowledge are distributed across social structures, groups and/or individuals. Development seeks to change pre-existing patterns and norms of knowledge production and may have short or long-term effects. However, it does not necessarily problematize

		differences in interests and needs of the different participants.
Multiculturalism	The interactive process of recognizing and affirming cultural variation.	Multiculturalism acknowledges differences among cultures and supports multiple identities. However, it is an affirmative process in that it recognizes but does not seek to alter/change access to, or production of, material and/or symbolic goods.
Critical collaboration	Self-reflexive assessment, individual or collaborative, of existing and pre-existing normative structures and relations that characterize access to knowledge and knowledge production, taking into account differences in interests and needs.	Critical collaboration entails the deep restructuring of social structures and relations. It is a dynamic, dialectical process for assessing the ability to transform and change norms, political systems and codes of practice. Critical collaboration recognizes difference and creates a forum for authentic dialogue.

Source: *Atweh (2004, p. 3)*

METHODS

Study design and sample

The study employed a mixed-method approach (Creswell, 2008) with a convenient sample (n = 783) of a grade 10 mathematics learners from nine township high schools. All participating schools had performed poorly in previous grade 12 year-end mathematics examination ($M = 34.26$; $SD = 6.30$).

At the beginning of the study learners in experimental and control schools completed a demographic questionnaire. Of the 783 (322 boys and 461 girls) participants, 724 (92.5%) supplied information on their ages. The ages of the participants ranged from 15 years to 19 years ($M = 16.45$; $SD = 1.25$).

Instruments

The principal instrument for data collection was a standardised achievement test (see appendix A). The content of the test focussed on *Financial Mathematics*. Since the test was out of 60, learners were designated as low-performing (below 24), average-performing (between 24 and 42), and high-performing (above 42).

To gain access to learners' conceptions of the role of context-based problem solving instruction in promoting social justice we conducted post-intervention semi-structured with learners (n = 17) across all participating schools. The interviews were based on four questions (see table 4).

For the study of classroom practice and forms of interactions that either promoted or constrained the enhancement of principles of social justice, we conducted classroom observations.

Assessment of measurement properties

Content validity of the test was examined by experts in mathematics education and research. Teachers participated to check the correspondence between textbook content and test items. Feedback from individual experts did not differ significantly, suggesting consistency and adherence of the test content to CAPS grade 10 mathematics.

A pilot study was carried out (see Dhlamini, 2011; Dhlamini & Mogari, 2011) to assess whether instruments captured the phenomenon desired by the researchers. Measurement of the internal reliability of the test yielded r = .92, suggesting that the test was suitable to measure learners' problem solving skills.

To strengthen reliability of other instruments we agreed that: (1) interviews would be conducted by one of the researchers for consistency; (2) a script would be used to standardise the interviews, and (3) classroom observations would be conducted by one of the researchers and focused on pre-determined constructs. Convergent validity was shown by a strong correlation between interviews and observation data that measured similar constructs.

Instruction and intervention

On the first day all learners wrote a pre-test. The pre- test determined learners' initial problem solving status. Both groups were almost equivalent judged from their pre-test scores ($\bar{x}_{\text{experimental}}$ = 20.9; $\bar{x}_{\text{control}}$ = 22.0). We designed instruction that promoted aspects of social justice. We arranged desks in groups of five to seven learners to encourage learner interaction. We encouraged learners to listen when one learner was talking. Learners were asked to generate learning issues, report their findings, answer prepared questions from the researcher, and to give critique to each other's work. In terms of the definition of social

justice we provided earlier on, the social goal of this lesson was that learners consider some of the arguments relating to the topics in Financial Mathematics.

In experimental schools the potential of more robust learning was exploited with several worked-out context-based problem solving examples given to learners in worksheets (see appendix 2). In order to explore issues of social justice questions such as, "*what do you think about what your fellow learner said?*"; "*do you agree with your fellow group member?*"; "*do you think you can learn from other learners?*", etc. were asked to learners. We started by simple tasks such as:

An amount of R1 200 accumulates to R2 600 after 3 years. Find the interest rate if the investment earned simple interest.

When solving such problems group discussions led us into talking about other interest bearing systems such as payday lenders. Inevitably, we talked about who uses which system and why, delving pretty deeply into discussions about socio-economic class and capitalism.

Control schools were visited once on days agreed upon with teachers. On the last day both groups wrote a post-test. Two learners in each school were sampled for the interviews.

Results and data analysis

Achievement test

Of all participants, 706 (90.2%) participated in all context-based problem solving activities, including writing pre- and post-tests. Post-test results suggested greater improvement in experimental schools (M = 33.3; SD = 4.213; n = 378) when compared to control schools (M = 25.8; SD = 4.095; n = 328).

Table 2: Summary of achievement test performance between two groups

	EXPERIMENTAL n = 378		CONTROL n = 328	
CATEGORY	**pre-test**	**post-test**	**pre-test**	**post-test**
Low-performing	282 (74.6%)	16 (4.2%)	224 (68.3%)	127 (38.7%)
Average-performing	75 (19.8%)	311 (82.3%)	91 (27.7%)	181 (55.2%)
High-performing	21 (5.6%)	51 (13.5%)	13 (4.0%)	20 (6.1%)

According to table 2, it is observed that the experimental group outperformed the control group in post-test scores, particularly in categories of average-performing and high-performing.

Because the allocation of learners to groups was not random, one-way analysis of variance (ANCOVA) was used to statistically analyse results from the achievement test. Pre-test scores were entered as the covariate and post-test scores as dependent variable. The following output was obtained:

Table 3: The test of Between-Subjects Effects

Source	SS	df	MS	*F*	Sig.
Pre-test	42.977	1	42.977	2.490	.115
Groups	9643.604	1	9643.604	558.677	.00
Error	12134.837	703	17.262		

$p < .05$

Two important observations are noted. *Firstly*, it is evident that pre-test scores significantly predicted and influenced learners' context-based problem solving performance, as the significance value is more than .05 (p = .115). This result confirms the classification of pre-test scores as a covariate, and thus the use of an ANCOVA analysis. The *second* and far grander observation is the main effect of a context-based problem solving instruction

after controlling for pre-test scores. From the above output, when the effect of pre-test scores is removed, the effect of a context based problem solving instruction becomes significant, as confirmed by $F(1,703) = 558.677$, $p < .05$. Meaning, the context-based problem solving instruction is superior to conventional instruction in substantially promoting learners' problem solving skills in mathematics.

Given these results, we argue that the positive influence of context-based problem solving instruction was enhanced substantially due to a group approach that fostered adherence to principles of social justice, as opposed to conventional approaches that characterised instruction in control schools.

Semi-structured interviews and classroom observations

The following interview data was obtained and analysed (table 4). Atweh and Ragusa's (2003) model of social justice was used to analyse data.

Table 4: Analysis of learners' interviews (n = 17)

ADMC mode	Construct	Code	Interview question	Response	
				Positive	**Negative**
Aid	Attitude to group approach	AGA	What is your view of teaching mathematics using a group approach?	11(64.7%)	6(35.3%)
				More	**Less**
Development	Critiquing other members' work	COW	How do you value information from other group members?	9(52.9%)	8(47.1%)
				Yes	**No**
Multiculturalism	Acknowledgement of differences	AD	Do you think it is possible to do mathematics in more than one approach?	13(76.5%)	4(23.5%)
				Yes	**No**
Critical collaboration	Restructuring relations of recognition	RRR	Do you think it is a good idea to group together learners who high-performing low-performing in	5(29.4%)	12(70.6%)

			mathematics?		

Results of the first question suggest that learners' responses leaned more (64.7%) towards mode 1 (aid). This suggested that during context-based problem solving tasks learners tended to be more willing to share educational goods (problem solving knowledge), to promote social justice. However, in terms of ADMC model and mode 1, this could also imply that learners abstained from interrogating existing social structures. In responding to the second question, which is linked to mode 2 (development), there was an almost equal response distribution (with 52.9% for learner and 47.1% for teacher). It seems, respondents equally valued responses from both learners and teachers, thus restructuring modes of knowledge. In mode 3 most respondents favoured doing mathematics in various approaches (76.5%). In terms of ADMC model the latter addressed issues of multiculturalism (acknowledgment of differences). Finally, most respondents objected to integrating both low- and high-performers (70.6% objection rate), suggesting a need to empower learners on this aspect.

Observations in control schools revealed that most of teachers' styles of instruction were less interactive, more formal and less individualistic, elements that potentially constrained enhancement of social justice.

DISCUSSION AND CONCLUSSION

The study endeavoured to achieve three aims: (1) to use context-based problem solving instruction to promote grade 10 mathematics learners' problem solving skills; (2) to design instruction that promoted aspects of social justice in class; and (3) to demonstrate mathematics instruction that promotes social justice in high school. The achievement test evaluated the first aim of the study. Post-test results suggested greater improvement in experimental schools, suggesting that context-based problem solving instruction is superior to conventional teaching approaches in promoting learners' problem solving skills.

Using interviews, classroom observations and Atweh and Ragusa's (2003) ADMC model of justice we explored the second aim of the study. Data from these sources yielded positive results in promoting principles of social justice. In particular, results from interviews discussed in previous sections pointed to a conclusion that a group approach, mainly employed in experimental schools, opened opportunities for learners to explore issues of social justice.

Finally, the third goal of the study was achieved when a group approach was opted to promote social justice during a high school mathematics lesson. This approach not only improved learners' problem solving skills it also enhanced learners' socio-cultural skills needed to promote social justice.

From these observations we can conclude that the results of the study are particularly convincing because of the use of multiple methods for triangulation, convergent validity and internal consistency, all of which point to a more rigorous study than is typical. We do however recognise that including only one topic in mathematics curriculum does regrettably appear to set limits to the study and also constrain our generalisation power. We advise that studies that explore issues of social justice should be conducted further to include topics that are purely mathematics. Furthermore, we advise that courses that address issues of social justice should be incorporated in pre-service teacher training programmes to promote deeper understanding of learner diversity as a notion that relates to teaching. We conclude by making a call for the inclusion of group approach in mathematics instruction to advance and realise the goals of the new curriculum (NCS) in achieving a just society.

REFERENCES

Atweh, B. (2004) Towards a Model of Social Justice in Mathematics Education and its Application to Critique of International collaborations. In I. Putt, R. Faragher and M. McLean (Eds.), *Proceedings Mathematics Education Research Group of Australasia*, (pp. 47-54). Townsville, Australia.

Atweh, B., & Brady, K. (2009). Socially response-able mathematics education: Implications of an ethical approach. *Eurasia Journal of Mathematics, Science and Technology Education, 5*(3), 267-276.

Atweh, B., & Ragusa, A. (2003). *Issues in social justice in international collaborations: Views of Educators from around the World*. Paper submitted to The Australian Sociological Association's 2003 Conference, Armidale: University of New England.

Bartell, T. G. (2011). Learning to teach mathematics for social justice: Negotiating social justice and mathematical goals. *Teaching Mathematics for Social Justice,* 1-35.

Creswell, J. W. (2008). *Educational research: Planning, conducting and evaluating quantitative and qualitative research.* (3rd ed.). New Jersey: Pearson Merril Prentice Hall.

Department of Basic Education. (2011).Curriculum and Assessment Policy Statement (CAPS) for mathematics grades 10-12. Pretoria: Department of Education, South Africa.

Dhlamini, J. J. (2011). Context-based problem solving instruction to induce high school learners' problem solving skills. In H. Venkat and A. Essien (Eds.), *Proceedings of the 17th National Congress of the Association for Mathematics Education of South Africa (AMESA), 11-15 July 2011*(pp. 135-142). University of Witwatersrand, Johannesburg, South Africa.

Dhlamini, J. J., & Mogari, D. (2011). Using a cognitive load theory to account for the enhancement of high school learners' mathematical problem solving skills. In D. Mogari, A. Mji and U. I. Ogbonnaya (Eds.), *Proceedings of the ISTE 2011 International Conference: Towards Effective Teaching and Meaningful Learning in MST, 17-20 October 2011,* Kruger National Park, Mpumalanga, South Africa.

Fraser, N. (1995). From redistribution to recognition: Dilemmas of justice in a post-socialist society. *New Left Review,* July-August, 68-93.

Fraser, N. (1996, April 30–May 2). *Social justice in the age of identity politics: Redistribution, recognition and participation.* The Tanner lectures on human values, Stanford University.

Freire, P. (1993). *Pedagogy of the oppressed.* (M. B. Ramos, Trans.; revised ed.). New York: Continuum.

Gonzalez, L. (2002). Teaching mathematics for social justice: Reflections on a community of practice for urban high school mathematics teachers. *Journal of Urban Mathematics Education, 2*(1), 22-51.

Gutstein, E. (2006). *Reading and writing the world with mathematics: Toward pedagogy for social justice*. New York, NY: Routledge.

Pendlebury, S., & Enslin, P. (2004). Social justice and inclusion in education and politics: The South African case. *Journal of Education, 34*, 31-50.

Young, I. M. (1990). *Justice and the politics of difference*. New Jersey: Princeton University.