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EQUITY, DIVERSITY, SOCIAL JUSTICE AND ETHICS IN MATHEMATICS EDUCATION: PERSISTENT NECESSITY FOR RESEARCH AND ACTION

INTRODUCTION

A basic premise behind the research reported in this chapter is that students experience their opportunity and achievement in mathematics education differently based on the social context of their families of origin and that of the school in which they study. Often such "background" factors are associated with disadvantage, marginalisation, disengagement and exclusion from the study of mathematics and also with a heavy cost, economically, socially and politically, to the individual student, their community and the societies they represent. Along with international efforts to increase the quality of mathematical experiences of students in schools, concerns about making mathematics education accessible to *all* students continues to provide a major focus for much research in the discipline, and a challenge for policy statements and initiatives as well as classroom practice.

Issues reviewed in this chapter were covered in MERGA reviews of literature since 1988 albeit under different headings and organisations. Research on gender issues has been dealt with in distinct chapters in all five Reviews since that time. Similarly, each previous Review contains some chapters which overlap with issues discussed here under the titles "social context", "sociocultural perspective", "Indigenous education", "language" and/or "politics". The continual attention paid to issues of marginalisation and disadvantage, and, as this particular chapter demonstrates, its expansion to include new domains of attention, attests to their persistent impediment to our practice of promoting quality mathematics education to all students.

The first section below considers research that deals with theoretical analysis of the very construct in the title of this chapter. This is followed by a section on each of the major areas of research. Some of these areas are well established in the literature such as gender, language and culture, and socioeconomic considerations. Other areas of concern are more recent in the literature such as rural education and global collaboration issues. In many studies these areas of concern overlap emphasising to the complexity of equity, diversity and social justice for researchers, practitioners and policy makers.

THEORETICAL CONSIDERATIONS

In addition to the continual concerns about inequitable access and participation in mathematics and attempts to remedy exclusion and disadvantage in the field, recent literature in mathematics education in Australasia reflects a noted increase in

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publications dealing with theorising the associated constructs and the search for epistemological approaches to investigate them. In this section, we examine four relevant themes illustrated in the recent published literature in the region.

The first theme is illustrated by the writings of Atweh and his colleagues (Atweh, 2007, 2009; Atweh & Brady, 2009) on issues related to multiplicity of discourses associated with issues of inequality and disadvantage. Atweh and Keitel (2008) pointed out that the social justice agenda is often discussed in the mathematics education literature in conjunction with the constructs of equity and diversity. In that context, the author points out that although the terms equity and diversity are at times used interchangeably, their usage differs in the context of the disadvantage under consideration (e.g. gender is usually discussed in terms of equity while language issues are often constructed in terms of diversity). They also noted that there may be some regional variations in their usage around the world (e.g. while the USA literature tends to use equity and diversity, continental literature tends to use social justice – at least in mathematics education). Atweh and Keitel went on to argue that in spite of the overlap in the aims of both agendas, there is an important difference between them in relation to their ultimate aims with regards to group status. Equity projects aim at reducing group differences (e.g. in differential achievement and participation), and hence its ultimate aim is to abolish such differences. Diversity discourse, on the other hand aims at enhancing group differences and status. .

As Gates and Jorgensen (2009) noted, the discourse of social justice is relatively more recent in mathematics education literature, although social justice concerns in the field are long standing as demonstrated by the long traditions that investigate issues of gender, low socioeconomic background, language and ethnicity. In an attempt to relate the construct of equity and social justice, Burton (2003), from the UK, argues that there is a "shift from equity to a more inclusive perspective that embraces social justice" (p. xv). Atweh (2007) discussed theories of social justice as elaborated by feminist writer Fraser (1995) that construct social justice as consisting of two dimensions, corresponding roughly to agendas of equity and diversity, namely, *distribution* and *recognition.*

The second theme related to theorising social justice is found in the introduction by Gates and Jorgensen (2009) to two Special Issues on social justice and teacher education of the *Journal of Mathematics Teacher Education*. Drawing on the work of Pierre Bourdieu, the authors explored the notion of social justice at the intersections of practice, habitus and field. With respect to their attempt to reach an understanding of the concept of social justice the author noted:

> The first challenge is perhaps to come up with a definition of social justice with which we can all agree. … Social justice is a relative concept; what is unjust to some, is not unjust to others; whether we consider something is socially unjust or relationally unjust will likewise differ. (p. 165)

The authors go on to present a three level model to understand the different ways in which different authors deal with the agenda of social justice, although they acknowledge that this is done 'at the risk of oversimplifying the problem of

definition".(p. 166). First, the authors point to what they call, *moderate* forms of social justice that focus on concerns of "fairness and equity". The authors argue that this form of social justice reinforces the status quo in that it does not challenge social conditions giving rise to inequity of educational opportunities. At the second level, *liberal* forms of social justice, are potentially more demanding in giving rise to structural inequality and do address them, but only "in some way" (p. 176). The target of this approach here is how to make the classroom socially just within the existing unjust social structures. They add:

> Hence the classroom becomes a political arena and politics is produced at the level of the individual in a small community. For example, it would see the politics of gender relationships and identities as constructed within classrooms. (p. 176)

The authors place research on social justice from a poststructural perspective within this level. At the third level, *radical* forms of social justice attempt to address social structures causing injustice by direct attempts of exposing and changing them. Of course, such an approach is more demanding of the social justice activist.

The third theme discussed here, perhaps in one sense in contrast to the arguments developed by Gates and Jorgensen, relates to poststructural critique of traditional approaches to understanding and remedying social injustice. Walshaw (2010) argued that concerns about lack of equitable participation in mathematical experiences by certain individuals and groups of people are not new. However, the author points out that "inequities in mathematics classrooms and in other mathematics educational institutions persist even when structural barriers are removed" (p.17). In particular, basing the understanding of inequity of participation on group identity (whether socioeconomic, cultural, linguistic or any other category) is a construction of identity as a unitary and fixed construct. The author argued that such discourse "lacks the analytic power to change existing formations" (p.17). She points to recent epistemologies of identity which posit it as multiple and fluid, hence it is "not reducible to one of its manifestations" (p. 2). Rather than dealing with the issues of inequality as abstract generalised constructs or leading into the trap of inaction in the face of such a dilemma, Walshaw argued that these understandings of identity are crucial for grounding "ethical practical action" (p.1) that is emancipatory for the different subjects traditionally excluded from experiencing the power of mathematics in their lives. Such an approach understands social change not as a result of a mere removal of barriers of social participation but "through making more visible the ways in which commonplace daily social relations are rearticulated" (p. 17). In another context, Walshaw (2011) utilised these poststructural constructs to place identity as the cornerstone for understanding both quality and equity in mathematics education.

This move in understanding of social justice from fairness and equity to "ethical practical action", and from focusing on structures giving rise to disadvantage to interactions between subjects within overall discourses of power lead us to the fourth theme. Atweh (2011) has used the construct of ethics to argue

for an approach to mathematics education that focuses on quality and equity. The post-ontological philosophical writings of Levinas have been influential in the re-introduction of ethics within philosophy by establishing ethics as the "First Philosophy". Atweh and Brady (2009) argued that the agendas of ethics and social justice are complementary and provided two reasons why ethics complements social justice. First, social justice issues are often constructed as concerns related to the participation of social groups in social activity and their enjoyment of their fair share of social benefits. Such a construction has less to do with the outcomes achieved by a particular individual - unless the outcomes are due to their belonging to a social group. Further, it is often silent on issues related to the interaction between two people – say of the same social group. Ethics, on the other hand, is concerned with a face to face encounter and interaction between people. Secondly, a focus on ethical responsibility establishes social justice concerns as a moral obligation, rather than charity, good will or convenient politics. Based on a presentation at the Key Panel at the International Congress in Mathematics Education in Monterrey, Mexico in 2008, Atweh (2011) reconstructed the two international agendas of quality and equity in mathematics education on the construct of ethical responsibility. Atweh and Brady (2009) describe Socially Response-able Mathematics Education as a means to reform teaching of mathematics in middle school.

In the following sections the research of social justice related to particular groups of mathematics students is located within these four theoretical considerations of social justice.

GENDER

Vale and Bartholomew (2008) reviewed Australasian studies that reported the re-emergence of differences in mathematics achievement favouring males and a decline in participation by females in tertiary entry level secondary mathematics. The studies reviewed provided evidence of persistent differences in positive affect also favouring males. They argued that most of the research exploring gender issues was underpinned by liberal feminist theory or deficit theory since "these differences were understood to be located within individuals" (p.287). Previous studies exploring pedagogy often essentialised girls and that teaching from a 'care' perspective had greater appeal for both girls and boys. Hence in the past research with respect to gender has been concerned with equity and distributive agendas of social justice along with a few studies that took a liberal and ethical approach to social justice. In the period since, these themes in equity and social justice prevailed. Researchers have continued to monitor the gender gap and have sought explanation for the re-emergence and widening of the gap in achievement and participation. Many of these studies have adopted a poststructural critique and explored aspects of identity and gendered mathematics. Another approach has been

the investigation of education policy and its impact on pedagogy and curriculum which addressed one or more of the dimensions of social justice.

The Gender gap: Distribution dimension of equity

Forgasz (2008a, 2010) and Vale (2010) discuss trends in the gender gap for achievement, participation and affective factors in Australia since the mid-nineties to reveal a widening gap favouring males in achievement in primary and secondary mathematics, and participation at the senior secondary level. They include findings from recent TIMSS and PISA studies (Thomson & De Bortolli, 2008; Thomson, Wemert, Underwood, & Nicholas, 2008) as well as from national testing (MCEETYA, 2008). Similar trends are observed for New Zealand though significant differences favouring males have been present since 2000 amongst 15 year olds for PISA (OECD, 2007) and fewer significant differences among 8 years for the achievement variables measured by TIMSS (Mullis, Martin, & Foy (2008). The 2009 PISA study of 15 year old students also found gender differences favouring males in Australia (Thomson, De Bortolli, Nicholas, Hillman, & Buckley, 2010) and New Zealand (OECD, 2010).

Forgasz and Leder, in various studies (Forgasz, 2008a, 2008b, 2010; Forgasz & Leder, 2010; Leder & Forgasz, 2010), focus attention on the gender gap among the highest achievers in the PISA study of 15 year olds (Thomson & De Bortolli, 2008; Thomson et al., 2010) and provide further evidence of the gender gap from studies of Victorian Year 12 VCE students and participants in the Australian Mathematics Competition, a competition for high achieving students in junior, middle and senior secondary school.

A study of 76 Victorian government schools in low socio-economic communities that were engaged in reforming mathematics teaching to improve learning outcomes for their students also found gender differences in mathematics achievement favouring males for students in all primary years and females for secondary students (Vale, Davidson, Davies, Hooley, Loton & Weaven, 2011). The numeracy intervention programs in which more females than males participated did not arrest the gender difference as growth in achievement was higher for the male students than the female students.

These studies which consider the distributive dimension of equity show that gender differences are clearly evident in the primary years and indicate that further attention and research needs to involve teachers' awareness of gender as a factor related to students' perceptions, participation and achievement in mathematics.

Gendered mathematics: Post-structural critique or a liberal approach to social justice?

Forgasz (2008a) and Vale (2010) report the persistent findings from a range of studies showing that male students are more confident, positive and interested and show higher levels of enjoyment and expectation of success in mathematics than females at all age levels. Collaborating with international researchers they reviewed studies of gendered perceptions and pedagogies of mathematics classrooms and settings in which students use digital technologies (Forgasz, Vale

& Ursini, 2010). Leder and Forgasz (2008) discuss the way in which the media interpret findings about the gender gap. They argue that media takes an uncritical stance and distorts the facts and so contributes to the perpetuation of gender stereotyping.

In the period under review researchers investigated perceptions and experiences of mathematics of students in the middle years, Year 12 students and high achieving students, while other researchers go further to investigate identity in the gendering of mathematics. Carmichael and Hay (2009) surveyed 366 middle year students to find that girls preferred statistics learning embedded in statistical surveys whereas boys preferred problem solving contexts and especially those involving sports. They acknowledged that teachers needed to cater for these different preferences; teachers however need to be mindful not to 'essentialise' girls' and boys' learning preferences. This issue is apparent also in the study of year 12 students in low socio-economic schools by Helme and Teese (2011). They found that girls taking the least demanding mathematics subject (Further Mathematics) were more dissatisfied with their learning experiences than boys taking this subject and students taking more demanding mathematics subjects. Girls were less likely than boys to perceive that mathematics was relevant to their future, more likely than boys to perceive that the teacher did not understood how they learned and that the pace of learning was too fast and least confident in their expectation of success. They argued that "despite decades of research in gender differences and strategies making mathematics content and pedagogy more responsive to the needs of girls, this study reveals that there is still more to be done" (p. 356).

If girls from low socio-economic school communities have lower expectations of success than males then what can we learn from high achieving girls and women with mathematics careers? Studies by Leder and Forgasz (2010b) and Harding, Wood and Muchata (2010) of high achieving students indicate a return to research methods common in the 1980 and 1990s to explore liberal approaches to social justice and affirmative dimensions of equity. Leder and Forgasz (2010b) surveyed the medallists of the Australian Mathematics Competition some years after they had won their medals. They found that competition success 'opened-doors' for the male medallists but the female medallists didn't gain particular benefit from their success and were less likely than males to pursue mathematical careers. Ultimately, for the female medallists, the mathematics environment did not hold as much appeal as those of their other academic interests.

Harding, Wood and Muchata, (2010) present seven case studies of women who completed doctorates in mathematics and mathematics education later in life to find out why women enter these courses later in life than males. They found that intellectual curiosity and academic or research challenges arising from their work prompt women to pursue mathematics learning and research later in life.

The study by Forgasz and Mittelberg (2008) highlights the situated nature of gender and identity with respect to mathematics, a position advocated by poststructuralists. Despite gendered attitudes about mathematics, Australian students perceive mathematics to be gender neutral; students in other countries

with a significant gender gap in achievement, in this case Arab and Israeli students, also believe mathematics to be a male domain. Walls (2010) conducted a longitudinal ethnographic study to illustrate the social construction of feminine/masculine identities and corresponding gendered mathematical identities. She tracked the experiences and preferences of toys, leisure activities, mathematics learning, work experiences and career aspirations of a group of ten children (4 girls and 6 boys) from different schools from 7 years of age through to completion of their secondary education. Her findings show how the parents' gendered experiences of school and career and their attitudes towards mathematics were reproduced in their children's preferences for leisure activities, reflections on learning mathematics experiences and aspirations for work. As young children the boys were more positive than girls about their mathematics experiences and while both boys and girls developed and expressed negative attitudes about mathematics during their secondary schooling the boys sustained a belief that studying mathematics in their final year(s) of schooling was useful to them. Walls argues that students perceive mathematics as "masculinising" and that boys take mathematics to be an "empowering signifier of their schooling" whereas a significant proportion of girls do not.

Leder and Forgasz (2010a, 2011) took up this theory of reproduction of gendered perceptions of mathematics and investigated the public's perception of mathematics. They wondered whether a public information or advertising campaign, as was conducted during the 1980's (Mathematics Multiplies Your Choices) was needed to confront the re-emergence and widening of the gender gap in mathematics and conducted a survey of 103 adults. Perhaps surprisingly they found that the majority of respondents were positive about mathematics, believed that they were good at mathematics (especially in their primary years of schooling), and agreed that students should continue to study mathematics after it was no longer compulsory. Almost all respondents thought that both boys and girls should study mathematics; those that believed there was as a gender difference in ability to do mathematics were more likely to believe that boys were better at mathematics than girls. Leder and Forgasz argue that public awareness about issues of gender and mathematics needs to be raised.

Education policy: For or against gender justice?

Vale (2010) sought explanations of the turnaround in the trend toward gender equity by examining shifts in education policy and mathematics curriculum. She traced Australian government policy from the 1980s to 2000s to discuss the way in which feminist theories influenced education policy and policy for women in Australia both positively and negatively. She describes how affirmative and transformative approaches to gender mainstreaming in education was easily discarded by change of government predisposed to feminist backlash ideology. Vale argues for an ethical stance on social justice arguing that just as researchers have successfully drawn attention to poor outcomes for marginalised and disadvantaged students in Australia, a plan for action for gender justice for girls in mathematics is needed now.

ETHNIC AND LANGUAGE DIVERSITY

Traditionally, diversity has been invoked "as an 'explanation' for the students' performance in mathematics" (Civil, 2011, p. 18). The move now is "away from deficit views" (Civil, p. 19) towards an understanding that reconciles "the identities that [students] are invited to construct in the mathematics classroom" (Cobb & Hodge, 2002, p. 249) with their participation in the practices of home communities, local groups and wider communities within society (see Atweh, Graven, Secada, & Valero, 2011). Although there is much willingness across the research community to understand those contributions with a view towards providing equitable access to quality mathematics education across a wide range of diversities, "there is also an urgent need to provide guidance as to how this might occur" (Gervasoni & Lindenskov, 2011, p. 319).

Exploring the relation between a classroom setting in a remote community context, and the students within those settings, Treacy and Frid (2008) looked at the counting approaches of Years 1 to 11 students. They noted that whilst Western mathematics is generally taught in Australian schools and is the primary means by which many people create an understanding of their environment, the ways in which Aboriginal people make sense of and organise their environments is distinctly different. Students in the study were provided with both standard counting tasks and a task that involved gathering a culturally familiar resource (maku) for a number of individuals in a picture. The students chose to draw on Western methods to answer the standard counting tasks, but used culturally-specific methods to solve the maku task. A number of other studies have investigated the challenges of teaching mathematics in diverse contexts. In a study by Edmonds-Wathen (2011), exploring the spatial concepts in Iwaidja, an Indigenous language spoken in the Northern Territory, children tended to use different spatial frames of reference to those typically used by English speakers. Clearly, teachers need to pay attention to the different needs and strategies that result from different home environments. .

In their study on teachers' professional learning in the Kimberley, Gervasoni, Hart, Croswell, Hodges, and Parish (2011) showed that Aboriginal Teaching Assistants play a critical role "in helping school communities in the Kimberley provide high quality learning environments for students and their families" (p. 306). Howard, Cooke, Lowe, and Perry (2011) point out that Australia's indigenous people "are the most educationally disadvantaged group" (p. 365) in the country. A number of programs, such as *Mathematics in Indigenous Contexts* (MIC) and *Wii Gaay*, designed to address disparity, have been developed and implemented to enhance outcomes of specific groups of students. A more recent program, *Make It Count* (2009-2012), implemented nationally, has the potential to develop partnerships between the school, the family, and the community for long-term change. In Western Australia, the impact of the project on teachers was explored in relation to best practice in teaching Indigenous children. Hurst,

Armstrong, and Young (2011) report that those practices included the use of oral discussions and drawing to communicate ideas, the use of game playing to teach key concepts, and the use of natural resources as well as rhyme, rhythm and movement.

Specific teacher-student relationships have been shown to strongly influence academic performance of minority group students. In a study of 100 Year 10 mathematics lessons involving six teachers and their classes, Averill (2011) found that teachers who demonstrated "essential caring teacher behaviours" contributed to the enhancement of equitable access to mathematics learning. In a Māori medium education setting, Hawera and Taylor (2011) found that Māori values, language and culture provided a context for an enhanced engagement with mathematics for Years 5-8 children. The influences helped children develop a broader view about the nature of mathematics, enhanced whānau (family) involvement in children's mathematics learning, and connected children's learning experiences with the mathematics in their community.

Social class, like ethnicity, differentiates students and is a marker of proficiency. From their research, Mills and Goos (2011) illustrate the ways in which teachers are able to enhance student proficiency in low socio-economic areas. One of the research schools was a small inner-city primary school and the other a remote Indigenous community school. Students at both schools had a history of poor performance in mathematics. Mills and Goos looked closely at the effects of high quality pedagogies on students and the use of open-ended investigations. At the city school, the principal's and teachers' willingness to change and a desire to improve teaching practice contributed to improved student performance. At both schools the principals' interest in effective instructional practices initiated a shared sense of purpose amongst staff. Both principals were able to generate enthusiasm and enhance teachers' belief in their own capabilities.

Meaney, Trinick, and Fairhall (2009) explored how projected beliefs in capabilities influenced a group of Māori-medium school teachers' level of engagement at a national English-medium mathematics teachers' conference. Invariably, inequitable social structures at the conference impacted on the teachers' feelings of belonging, and their professional experiences at the conference sessions. Greater evidence of collaboration and a shared sense of purpose amongst the teachers at the conference might have resulted in higher levels of capacity building.

Language

Language plays a central role in building bridges between students' intuitive understandings and the mathematical understandings sanctioned by the world at large. As Bose and Choudhury (2010) and Ilany and Margolin (2010) note, language constructs meaning for students as they move towards mathematically acceptable modes of thinking and reasoning. In a study on pre-service teachers'

analyses of middle school English Language Learners (ELLs) ideas of measurement, Fernandes (2011) found that the teachers recognised the importance of incorporating language goals into mathematics lessons, but that they needed to develop their expertise in doing this, particularly when working with ELLs students. Working from the premise that the language that students use derives from the language used by their teacher, Ilany and Margolin (2010) developed an instructional model to assist students to make sense of and solve mathematical word problems. They found that their nine-stage model enabled students to forge links between natural language and the language of the discipline, whilst sensitising them to the particular nuances of mathematical language.

For many researchers, inviting dialogue in the classroom is a socially responsible pedagogical practice. However, in some settings this invitation not only brings significant barriers, it also raises serious ethical issues for teachers. Jorgensen (2010) reported on a project in which the overarching aim was to implement reform pedagogies in remote Aboriginal communities. Instructional practices relating to student discussion, explanation, justification and sharing of ideas were imported into the culture of the Kimberley communities on the understanding that such interactions would be beneficial, both mathematically and socially, for students. Jorgensen found that these practices were not able to be successfully implemented. Teachers in these settings reported that these pedagogical approaches violated many cultural norms. The implications of these findings to the role of traditional pedagogies of drill and practice are not made clear.

Given that Australia and New Zealand are characterised by considerable ethnic and cultural diversity, challenges for teaching raise significant social justice issues within mathematics education. This is made particularly acute in that mathematics "uses culturally laden language to express problems whose interpretation requires sophisticated linguistic and cultural competence" (Arkoudis & Love, 2008, p. 74). However, as a number of studies have revealed, there are very real pedagogical difficulties in integrating mathematical content with English language learning. As Bautista Verzosa (2011) found in her study with second grade Filipino children solving additive word problems in English, "mathematical difficulties were uncovered, but only when linguistic difficulties were minimised through the provision of linguistic scaffolds" (p. 21). Similarly, language-related misconceptions were reported by Jaffar and Dindyal (2011) in their study on post-secondary students' understanding of the limit concept.

Bose and Choudhury (2010), Arkoudis and Love (2008), and Parvanehnezhad and Clarkson (2008), for example, have all studied the tensions that arise in multilingual classrooms between mathematics and language. Arkoudis and Love (2008) looked at these tensions as experienced by one teacher and eight of her students. The students were Chinese international students in Australia, enrolled in

the senior school subject, Specialist Mathematics. All the students had studied in Australia for around one and a half years with the expressed purpose of gaining entry into university. For their part, the goal-focused students prioritised their mathematics skills rather than English for developing understanding. Drawing on the notion of imagined communities, Arkoudis and Love (2008) argue that the international students' identities, at odds with those of local students, limited their participation in class. Specifically, the international students' identities were structured around an imagined future community rather than the present classroom community of practice.

Parvanehnezhad and Clarkson (2008) explored the ways in which a group of Iranian students used their home language as a resource to develop mathematical understanding by switching between the two languages when doing mathematics. They found that 14 of the 16 students tended to switch language while solving mathematical problems. Perhaps predictably, an increasing item difficulty amongst the word problems in the research led to higher use of language switching.

In some multi-lingual classrooms, teachers explicitly acknowledge cultural heritage by switching between the language of instruction and the learners' main language in order to advance students' understanding. Bose and Choudhury (2010) found evidence of language switching (code switching) for bilingual students, particularly when students could not understand the mathematical concept or when the task level increased. Code switching involved words and phrases as well as sentences and tended to enhance student understanding. The location of the study undertaken by Bose and Choudhury (2010) was in Mumbai (Bombay) at a camp held for lower achieving Grade 6 students over a period of two months for one and a half hours each week. While the first language of the teacher and students was Hindi, the official language of instruction, in keeping with the common practice was English. 'Code switching' occurred as the teacher and students switched between languages and tended to enhance student understanding. From a social justice perspective the practice empowers students and "helps in breaking the authoritative approach of mathematics teaching" (p. 99).

In Papua New Guinea, vernacular languages and Indigenous knowledge-based systems are emphasised in curriculum policies for the first three years of schooling. English is gradually introduced in the years that follow. Muke and Clarkson (2011) examined how eight teachers used multiple languages to teach mathematics in year 3 classes. They found that when the teachers used the available languages, it was with a view towards making English more accessible to the students. Matang (2008) investigated the influence of primary school students' first language and traditional counting systems on their early number development in Papua New Guinea, Students' mathematical tasks were taken from the *Count Me in Too* project (NSW Department of Education, 2001). It was found that, generally speaking, the 125 children in the study learned more quickly and made fewer errors

in task solution when they used traditional counting systems and learned in their home language.

Since students with limited English proficiency value hearing their peers use mathematical language, the researchers recommend that to assist in overcoming potential and real language difficulties, more competent bilingual students might be encouraged to support less able peers to solve mathematical problems. Home language exchange amongst students, Niesche (2009) argues, is a resource by which students are able to negotiate mathematical meaning. In her study of recent immigrant 7th grade students from Mexico into the United States context, Civil (2011) found that when students were given the option to explain their mathematical thinking in Spanish, their home language, it provided the researchers "access to very rich and lively mathematical discussions, which in turn gave [them] a window into their thinking about mathematics" (p. 21).

However, home language exchanges between peers in the remote Aboriginal classrooms researched as part of the Kimberley project did not assist peers mathematically. Peer interactions, Jorgensen (2010) found, were not typically focused on advancing student understanding. For their part, teachers were challenged by not knowing what the students were talking about. Friction between family groups in these settings often carried over into heated discussions within the classroom, resulting in the adoption of a more disciplinarian teacher stance.

RURAL AND REMOTE COMMUNITIES

International studies as well as the national testing programs in our countries have brought home the significance of disadvantage for students in rural communities. Students in Australian rural communities do not perform as well as metropolitan students and achievement is related to the degree of remoteness and size of community as many studies in this section demonstrate. The most recent PISA study (Thomson, et al., 2010) has found that the gap in mathematical literacy for 15 year old rural students in remote Australian locations is almost one-and-a-half years of schooling behind their metropolitan peers. The gap between provincial students and metropolitan students is less but statistically significant. The most recent Australian national assessment program reported that there were 10% fewer students in remote locations than metropolitan who reached the national minimum standard at each year level assessed (MCEEDYA, 2010). The margin is up to four times greater for very remote students. Findings are similar in New Zealand and around the world (Williams, 2005).

Mathematics achievement of students attending schools outside metropolitan areas is also related to socio-economic status, indigenous status, language background and gender (McConney & Perry, 2010). The geographic pattern of socioeconomic status and other demographic factors are not common and provide further evidence of the complexity and diversity of regional and rural school communities. School or student factors such as teacher preparation and approaches, classroom climate and students' self-efficacy contribute also to mathematics

achievement of rural students (De Bortolli & Thomson, 2010; Panizzon & Pegg, 2007a). Furthermore, the issues for schools in rural communities are subject to the influence of transient and fluctuating populations, immigration, rural economic circumstances, and seasonal conditions, climate and natural disasters (Pegg, 2009).

In 2004 the National Centre of Science, Information and Communication Technology and Mathematics Education for Rural and Regional Australia (SiMERR) was established at the University of New England to bring to the attention of educators and policy makers social justice for the education of rural students, to collaborate with communities, education authorities and organisations and to undertake strategic research in the field to improve outcomes for students. MERGA recognised this emerging field of socio-cultural and social justice research in mathematics education when it approved a special issue of Mathematics Education Research Journal in 2011 focussing on rural issues in mathematics education.

In this section we review the research literature resulting from the much stronger recognition of the needs of rural students and teachers that has emerged in the previous four years. We begin this section by reviewing theoretical perspectives for research involving rural schools and school communities and relate these theories to the themes of social justice that are the focus of this chapter.

Diversity perspective of social justice for rural education

According to Howley, Howley, and Huber (2005) equity oriented initiatives in rural school communities aimed at addressing the needs of marginalised or excluded students and closing the gap in achievement outcomes are often based on the presumption of deficit and a shallow understanding of poverty and culture. Corbett (2009) agrees challenging the "set of inter-connected assumptions about educational success and failure, assumptions which … end up painting people who remain in rural places as somehow deficient" (p. 2). He argues that formal education for students in rural communities is about disconnecting with place and "learning to leave." Corbett describes standardized curriculum and traditional pedagogies as "urbanization of the mind" and argues for recognition and valuing of difference through "place-based pedagogy".

Identity and place are strong themes in the theory of researchers working with indigenous communities. Wallace and Boylan (2009) brought the "rural lens" metaphor and the themes of "challenging deficit theory" and "understanding place" to the attention of Australasian researchers. Using a 'rural lens' means that strategies are developed from within to sustain and strengthen social, cultural, economic and community attributes and capacity rather than be imposed from outside. They seek to challenge the deficit perspective that teachers, educators and policy makers have of rural society, schools, communities and the conditions in which they will work. They argue that "place" is important in rural contexts because:

> Place recognises that uniqueness, value and relevance that the history, cultural value system, language, social infrastructure, the impact of the environment and the economic realities have on shaping the local community in ways that define it as different to other places. (p. 25)

Place-based education is about connecting with local concerns and traditions, including relevant place-based experiences and driving educational decision-making from within. The "rural lens" is consistent with the social justice strategy of "transformative-recognition" since initiatives involve local mutual critical collaboration, develop agency and lead to shared and contextualised-learning. It has been deliberately adopted by some mathematics education researchers (e.g. Ell & Meissel, 2011), and implied or imbedded in the work of others (e.g. Connor, Auld, Eakin, Morris & Tilston, 2010; Goos, Dole & Geiger, 2011).

Policy, programs and resourcing for rural schools

Pegg (2009) reported that researchers and educators believe the underachievement of students in Australia's rural schools needs to be addressed in an integrated way and that educational renewal and reform in rural and regional Australia must be supported by policy and programs for development more broadly. Earlier Panizzon and Pegg (2007a) reported the findings of a survey that compared the issues and needs of rural and regional teachers with urban teachers. Teacher shortages, lack of opportunities for professional learning, in particular time-release for participation, ICT resources and support staff were high on the list of issues for rural teachers. Teaching higher order thinking skills was their most pressing professional learning need, while teachers from schools where at least 20% of students were indigenous requested support for teaching in context. These issues were taken up by those designing professional learning programs discussed below.

Following up on the issues of ICT resources Loong, Doig and Groves (2011) conducted a survey of 700 rural and urban students on their use of ICT for in-school and out-of-school mathematics learning. Few differences between rural and urban students emerged suggesting equity of access to ICT is not a problem. Where differences were found in almost all cases rural students were found to be more frequent users of the technology. These findings challenge any perceptions that rural students, schools and communities are technologically deficient.

Improving teaching and learning for rural students

Studies reporting on research of teaching and learning in rural locations typically involved multiple settings including projects across states and education systems. Watson and Stack (2008) describe the way in which collaboration among education researchers, teacher organisations, schools and the education systems under the SiMERR umbrella were conducted to improve teaching and learning for rural students in Tasmania. Their paper is a meta-analysis of the 14 projects initiated by SiMERR 'hub' members, teachers or academics; four of these projects focussed specifically on mathematics. Watson and Stack noted success for most of these projects in the short-term but raised two significant issues: sustainability and

scaling-up of these projects and, foreshadowing Pegg (2009), they called for broader based systemic programs to support new rural teachers and the need to further engage parents and community. However since Watson and Stack described the SiMERR programs as "interventions" these projects may be interpreted as reactive and deficit focussed.

In contrast, two of the projects briefly described by Pegg and Krainer (2008) included a more proactive approach. The first gathered data on the attributes of schools in regional Australia which recorded outstanding achievements in mathematics; the second provided teachers with the expert advice and support to initiate professional learning or innovations. Comparing the various reform initiatives across different countries Pegg and Krainer identified collaboration, communication and partnership as crucial elements.

Panizzon and Pegg sought to improve student learning by encouraging secondary teachers to review their assessment practices through their participation in a professional learning program. The program which was conducted over two years was designed to enable teachers to interpret student responses using the SOLO taxonomy to provide for more effective scaffolding of students' learning. Teachers nominated curriculum areas to trial these approaches and hence participated to some extent in the design of the program. The program providers also visited teachers in between sessions to provide further support to individual teachers in the program and their school colleagues. The authors noted the value of the two-year term of this program for sustaining changes in teachers' practices. It is not known whether this knowledge enabled better mathematical connections with students' rural identity.

In another SiMERR project Perry (2010) reports on a study involving pre-school rural educators conducted across three Australian states (New South Wales, Queensland and Victoria). The key findings (Hunting et al., 2008) included: pre-school practitioners' recognition of mathematics learning through play; need for educators to promote 'sustained shared thinking' in pre-school settings and to enhance their confidence and knowledge. He argues that these issues are not confined to rural practitioners.

The study by Gervasoni, Parish and colleagues (2010) also struggles to provide a 'rural lens'. They provide compelling evidence of the success attributed to a numeracy intervention approach for children in the early years (Extending Mathematical Understanding) through the appointment of a school mathematics coordinator to lead a whole school approach to mathematics curriculum, assessment and intervention. Part of the success of the project at the case study school was the engagement of parents. They argued that the project had "enhanced the capacity of the entire school community to learn mathematics successfully." But what is required for these outcomes be sustained and scaled up to include students in all year levels and other schools in the region?

Rather than bringing an urban model of professional learning to schools Beswick and Jones (2011) set out to design and implement a teacher-centred approach to a professional learning program for primary and secondary teachers of mathematics in a cluster of three remote schools in Tasmania. The program was

negotiated with principals and based on teachers' responses to a questionnaire about their professional learning needs and included individual and small group coaching or mentoring as well as after school seminars or forums. These took place on location. The school principals liked the flexibility of the program as it fitted in with the schools in terms of timing and teachers' expressed needs. However, perhaps because of the brevity of the program or its timing in the first week of the school year, the program failed to build a collaborative culture that could sustain reflective practice or begin to generate place-based pedagogy.

The professional learning program designed by Goos, Dole and Geiger (2011) was more successful in this regard, though perhaps more by accident than design. Their program was teacher-centred but focussed explicitly on developing capacity for numeracy teaching in context and with a critical orientation through the design and implementation of problems and investigations in secondary mathematics classrooms. Goos, Dole and Geiger chose to focus their discussion on the design features of the program to build teacher agency, but could have focussed instead, or as well, on authenticity in rural teaching and learning and the personal connection the students made with this problem.

A proactive, designed from within, capacity building project for secondary school teachers of mathematics from a cluster of schools in regional New South Wales that sets out to establish collaborative relationships is described by Connor, Auld, Eakin, Morris and Tilston (2010). The mathematics teacher leaders from four schools reviewed aggregated data about their region to develop a common purpose and focus for their praxis inquiry that they shared with their school colleagues. This project illustrates the importance of teachers defining the problem and focus of their collaboration to generate collegiality, a blame free environment, authoritative ideas and democratic empowerment to achieve sustainable collaborative practices.

Collaboration among primary teachers from a cluster of five schools in rural New Zealand was a significant feature of the reform project studied by Ell and Meisell (2011). The cluster was significant because it had a strong self-determination agenda having been initiated and sustained by teachers rather than outside experts. The cluster chose to focus on basic facts and all teachers in the cluster of schools worked in a group to design and implement action plans. Ell and Meisell documented the strategies investigated by the teachers and measured improvement in student achievement. The strategies included changes to school organisation, a focus on the test items, developing particular teaching strategies or a focus on knowledge in context. The most progress was made by students in the school taking action to make connections between basic facts and problems in context.

Researchers set out to work with rural schools and communities to improve teaching and learning for students and to meet the needs of teachers in rural and regional schools, however a 'rural lens' that challenged deficit thinking and included place-based pedagogy was rarely stated explicitly in the theoretical frameworks of these studies. Perhaps this is because 'learning to leave' still dominates thinking when it comes to education in rural and remote locations.

SOCIO-ECONOMIC FACTORS

Even though research around the world has consistently pointed out to the crucial role that socioeconomic factors plays in determining access and outcomes of educational experiences in mathematics, relatively a limited number of research studies were reported in the Australasian literature dealing with these issues directly. Further, this pattern is consistent with previous reviews covered by this series of publications. However, this observation should be moderated by the fact that many other studies reported in this chapter deal with issues that overlap with socioeconomic factors – for example, gender, rural education and linguistic background. In this section, we identified two quantitative studies that dealt with evidence of the relationship of socioeconomic factors to participation and achievement in mathematics education and three qualitative studies that dealt with intervention programs in low socioeconomic schools.

McConney and Perry (2010) presented a detailed analysis of the PISA 2006 data in 15-year-old students to examine in detail the patterns of relationship between SES and mathematics and science literacy. In addition to the student background, the study examined the socioeconomic background of the school in which students attend. The authors noted that PISA's measure of student-level SES is a composite index of the following: highest parental occupational status, highest parental educational attainment (years of education), and economic and cultural resources in the home based on a questionnaire that the students complete. The reported findings indicated that the SES of individual students matters considerably in science and mathematics literacy performance. Further, the SES measure of the school similarly was related to students' achievement in mathematics and science literacy. In their conclusion the authors declared:

> Our findings show that where one goes to school in Australia makes a significant difference for all students' mathematics and science performance. This is inequitable because it means that a student's achievement is heavily influenced by his or her family's ability to afford a good school. Moreover, our findings show that achievement gains are sharpest in middle-high and high SES schools. Yet access to these schools in Australia is restricted. (p. 446)

Similar results were reported by Ainley, Kos, & Nicolas (2008) who noted that

> Two of the largest differences among specified groups of Australian students concerned socioeconomic background and Indigenous status. The difference in the [mathematical] literacy scores between students in the lowest and highest quarters of the distribution of socioeconomic background ... 78 points. (p. 6)

The first study reported here is that of Thornton and Galluzzo (2010) who reported on a study at the Catholic Archdiocese of Canberra/Goulburn as part of the Commonwealth Government Literacy and Numeracy Pilots in low SES

schools. In this project, professional development sessions were conducted with considerable time devoted to discussing the fundamental concepts of mathematics that have been shown to be both troublesome and essential for further understanding. Teachers were not given set procedures to use with their interventions; rather they were asked to respond to students at their point of need. Many of the teachers involved were familiar with the *Reading Recovery* program which was chosen as a way of structuring the intervention. For each lesson, teachers were asked to plan using a template based on a combination of ideas from Reading Recovery and the concepts of brain based learning. Evidence from this project pointed to modest cognitive effects but strikingly positive affective results as reported by classroom teachers. However, the authors point out to one inhibiting factor to mainstreaming such interventions was that they are expensive to run.

The second study is reported by Gervasoni and Parish and their colleagues (2010) reports on a collaborative project between 42 school communities under different Catholic Education Offices and Australian Catholic University. In this project, classroom teachers administered a one-on-one interview-based mathematics assessment using the *Early Numeracy Interview.* Similarly, teachers had access to a specialist teacher to assist in the use of these data to guide instruction and curriculum development at individual, class and whole school levels. The authors concluded that "this collaborative and rigorous approach for designing highly effective learning environments is having a positive impact on mathematics learning and instruction" (p.202).

A final study conducted by Vale and colleagues (2010) was also a component of the Federal Government's Pilot program and concerned student-centred approaches (SCA) – one element of the multi-faceted approach implemented by the Victorian government. They investigated interpretation and implementation of SCA provided through personal accounts of practice by teachers and instructional leaders. Differentiated and targeted teaching based on various student assessment data was the dominant interpretation that was implemented in diverse ways in classrooms and schools. A major improvement in the practice of many teachers included more focussed lessons that connected mathematical ideas and included the explicit use of language to model mathematical thinking and explanation of that thinking.

GLOBAL COLLABORATIONS

Social justice concerns in the Australasian region in the period of the review are not restricted to social groups within the countries represented. In an increasing globalised world, Australia and New Zealand have an increasingly important role in international contacts and collaborations. This includes international conferences, international students, publications and collaborative research. The publication of a MERGA supported book on Internationalisation and Globalisation in Mathematics and Science Education (Atweh, Borba, Barton, Gough, Keitel,

Vistro-Yu, & Vithal, 2008) has allowed a few Australasian mathematics education researchers to raise issues relevant to social justice on the global scene.

In particular, Neyland (2008) used the discourse of ethics, as discussed above, to look at the role of mathematics education in a globalised world. He noted that mathematics education has been a tool of cultural imperialism. One of the patterns of globalisation is new and growing social stratification resulting in increased bureaucratic domination of the poor. The author concluded the foci that are likely to be useful to avoid the negative effects of globalisation on mathematics education in poor countries. These include conceiving of education as a public good in service of the world community; using mathematics as a corner stone for the development of participatory democracy; and, presenting mathematics in programmes of work that emphasise its humanistic qualities and its basis in human ideas.

The chapter by Atweh and Keitel (2008) utilised the elaboration of social injustice by Young (1990) as markers of social injustice in international collaborations. The authors concluded that international contacts in education may be said to be *exploitative* if the knowledge of one social group is advanced at the expense of another group. Similarly, if the research questions and methodologies of some countries dominate international research at the expense of issues of concern of other nations, then the latter can be said to be *marginalised*. Economic situations in many less industrialised nations limit the capacity of educators from those countries to take an active and equal role in international academic activities and hence can lead to a sense of *powerlessness*. Further, the non-critical transfer of curricula and research results from one country, with a certain perceived higher status, to another can be said to be a form of cultural *imperialism*. Finally, the tying of international aid and development monies to the impositions of agendas, policies and priorities developed in Western countries can be regarded as a form of *violence* on less affluent nations.

The chapter by Southwell, Phanalasy and Singh (2008) discuss some pertinent observations based on the authors' involvement in projects in three countries, Laos, Malaysia and Maldives. While the issues encountered differed in the three counties, the authors identified the crucial role of appropriate communication between local educators and foreign consultants. In the majority of international development projects, local educators are expected to communicate with the international team in a foreign language. Further, the theories of learning developed in the foreign language need to be translated by the local educators to be used by local teachers without having a strong base of research and publications in their own language. A related issue is that often the ignorance of the foreign consultants of the local philosophies of education and social problems give rise to the adoption of a globalised mathematics education curriculum and pedagogy.

In another context, Atweh, Balagtas, Bernardo, Ferido, Macpherson, & Salana (2007) discussed a collaborative project between an Australian university and the government of The Philippines. The project employed the construct of capacity building in its design and implementation and was designed in collaboration between leading academics from The Philippines with two Australian

counterparts. The authors argued that collaboration does not necessary imply an equal amount or the same type of contribution. Parity of esteem (Grundy, 1998) should be the guiding principle by which collaboration should be judged. In developing projects of this scale, each participant has their own expertise and knowledge, which is often complementary to the others' contributions.

Finally, two studies reported in the period of the review discuss the issue of conducting cross country research. Cao, Forgasz and Bishop (2008) discuss the challenges and difficulties that researchers face in the process of designing and administering a survey to be used in cross cultural settings, and how cultural factors can influence researchers' activities and research results. Some of the problems identified include: designing a survey that was intended to apply to two cultural contexts, choosing a topic of equal importance in both countries, choosing the right format of the instrument, the appropriate number of choices in response formats of the Likert scales, the adequateness of the survey content, and the precision in the translation of the questionnaire. Similar problems are identified by a more recent contribution to a MERGA conference by Davis, Seah and Bishop (2009) who were involved in a Doctoral research project for an Australian institution conducted in Ghana. In order to obtain ethical clearance for the project, the Australian University required a letter of approval from the educational authorities in the country. The educational officials in Ghana were reluctant to issue that letter because it did not match their own procedures. Interestingly the University insisted and the official had to change his stance in order for the project to proceed. Similarly, school teachers and principals were often suspicious of the need to sign the letters of consent even to the extent that some schools had to withdraw from the study.

CONCLUDING REMARKS

It would be an onerous task to attempt to reach definite conclusions from the diversity of research studies reported here. The theoretical frameworks, research questions, target samples, and methodologies vary considerably from one study to another. Rather, we will make some observations on the status of the research in this area and raise some of its implications for policy and practice including challenges for its own future directions.

First, we note that the literature reported here includes engagement with theoretical constructs used in the research covered here and reflected in the policy statements it supports. There seems to us to be a movement from the disparate agendas such as equity, diversity and inclusion to a more comprehensive and perhaps unifying construct of social justice. Likewise, a few authors are beginning to understand the agenda of social justice in terms of ethics. How future research and policy in mathematics education may benefit from these developments, remains to be seen.

Second, we note a diversification of the social justice agendas in terms of groups of people traditionally marginalised in the discipline. As the many authors

noted, factors of gender, language and culture, and socioeconomic status still play a decisive role for many students in access to, and participation and achievement in, mathematics. However, research in social justice in Australasia has begun to investigate new marginalisation issues such as rural education and globalisation. We commend this trend. It demonstrates that social justice concerns are more wide spread than a handful of agendas. Arguably, there are social justice concerns behind every action we take as mathematics educators, not to mention actions that we do not take. Perhaps the discourse of ethics may lead to raising questions of social justice in situations where we have not raised it before – such as in monolingual, monocultural and high achieving settings.

Third, by and large, the literature on social justice in mathematics education, has considered one or more of what can be called "background" factors of marginalisation or disadvantage in the study of mathematics. Many authors have warned against the threats of essentialising students' differences and blaming the victim for explaining educational exclusion. However, we note, with an amount of disquiet, that factors related to physical, emotional and mental disabilities have not received the same level of attention of researchers in Australasia – and arguably neither are they widely represented in the international literature in mathematics education.

Finally, as the literature reviewed above demonstrates, even after years of concerted policy and action to remove inequalities in mathematics education, it still persists. This is not to say that progress has not been made and that the patterns of inequality are the same. However, it draws our collective attention to maintain the vigilance and resolve to keep up with research that uncovers injustices and finding ways to deal with it. Research and action towards achieving social justice varies, as the "intervention" studies reported above demonstrate. In this context we raise the question, is social justice in mathematics education a utopian ideal to achieve? In other words can we solve problems of social injustice once for all? Commenting on several international projects designed to achieve equity for different social groups in mathematics education, Atweh (2011) raised the question of whether the road to equity has "no highway and no destination". But it is a road we are compelled and committed to travel.

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