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Re-imagining mathematics and mathematics education for equity and social justice in the changing South African university

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Abstract

Debates about transformation for a more equitable and socially just South African university and society more broadly have highlighted the need to consider how university curricula may (re)produce enduring historical and societal inequities. They also suggest the need to bring student voices into conversations about reimagining these curricula. There is a silence in these crucial debates about the role that the practices and language of mathematics and mathematics education may play in (re)producing or transforming inequities. This article proposes conceptual tools that help, firstly, to understand and to challenge this silence in the historical and socio-political context of the South African university. Secondly these tools can be used to re-imagine mathematics and mathematics education for equity and social justice in the changing South African university. These tools – a *socio-political perspective* and a framework of *equity* as *access*, *achievement*, *identity* and *power* are drawn mainly from the work of critical mathematics educators Rochelle Gutiérrez, Ole Skovsmose, Paola Valero and Renuka Vithal, and critical linguist Norman Fairclough. The proposed equity framework offers a way to work with the tension between providing access to and achievement in the dominant mathematics practices and critiquing and transforming these practices. To illustrate the potential of these tools I use the voices and actions of university students as represented in my research conducted at an elite English medium historically white university in South Africa.

Keywords: access, achievement, equity, identity, mathematics education, power, socio-political perspective, university mathematics

Introducing the voices and actions of university mathematics students

This article seeks to bring mathematics and mathematics education into the conversation about language and literacy for a more equitable and socially just university. To begin, I

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present two vignettes that bring into the conversation the voices and actions of black[2] university students at an English medium elite historically white university in South Africa. At the time of the respective research studies, these students were studying towards undergraduate science degrees which require the successful completion of at least a first-year level mathematics course. On application to the university these students were, on account of their home and school backgrounds[3], placed in an extended degree programme designed to provide students with the foundations for studying university science. Students in this programme studied their first-year courses over one-and-a-half or two years, before enrolling for year-long senior courses. I draw on the two vignettes in the rest of this article.

Vignette 1 [4]

In these extracts the students Joseph, Josephine, Luthando, Philisani and Thabo (pseudonyms) talk about their experiences of being undergraduate science students.

Joseph:	No, it [studying hard at school] was important because I mean I have, like since well like I grew up in a virtually destitute background so I have to improve their living conditions, family lifestyle and stuff so it's very important.
Joseph:	[The name of university] is not a school, it is an institution of higher learning where we have to stand by ourselves, have to kind of swallow, absorb the knowledge being given.
Thabo:	When you write tests [in pure mathematics] there is some, you know those nouns and verbs, you have to understand, you know to answer the questions […] it's a problem, most of the lecturers are white, so when they set the papers, they understand, they know how to write questions and you come there with your less knowledge of it and then you can't answer it well.
Luthando:	You get students, really smart students, students who really, really love maths and really do some research […], you get them interacting a lot with the lecturer and you are totally lost and they will be having a very nice conversation with the lecturer about the topic and you don't know jack, you don't know anything, you don't know what to say.
Josephine:	I think when you do study here, you not only learn things academically, you learn things in the classroom that are not related to academics, so I learnt to, you know, adjust to someone [a lecturer] with a different accent, someone's set of notes, you know adapting to making my own and going to do my own

[2] I use the term 'black' broadly to refer to students who identify as black African, coloured or Indian.

[3] In South Africa who has access to meaningful participation in school mathematics is characterised by a complex interplay of race, social class, geographical location and language repertoire (Spaull, 2013).

[4] The extracts in this vignette are from a longitudinal study of students' transitions to and through undergraduate studies at an elite English medium historically white South African university. The study was funded by the Andrew W. Mellon Foundation.

research on a project, but I don't think [pure] maths is that relevant for my future, the maths that I did in class wouldn't be that relevant but I think being able to calculate things and I think just having a maths background would help depending on what I plan on doing in the future.

Philisani: It's [the university's] reputation speaks for itself you know it opens many opportunities for... people... for kids actually... especially from disadvantaged I've heard a lot about [the university].

Philisani: If everyone says all these great things about... you and how you can make it… if you really don't believe that... and if you don't really don't have something within yourself...

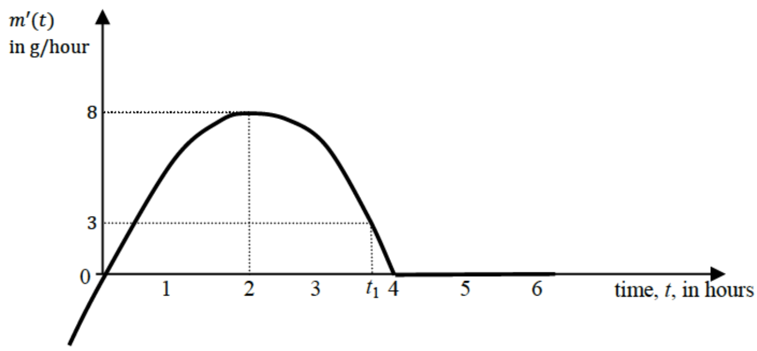
Vignette 2 [5]

The four students Kelsa, Lwazi, Ndumiso and Thokozile (pseudonyms) are working in a small group in a tutorial in their first-year extended mathematics course. They are attempting to find the equation the parabola graph in question (d) of the chemical reaction problem in Figure 1.

The students begin by using their knowledge of school mathematics and propose three general equations; $y = a(x - x_1)(x - x_2)$ (Ndumiso), $y = ax^2 + bx + c$ (Kelsa) and $y = a(x - p)^2 + q$ (Lwazi). Thokozile is using an alternative method that was introduced in their university mathematics class. Initially the students do not write down their formulae, but state the symbols in words from left to right. Ndumiso, for example, announces his choice with the words 'y is equal to *a* then *x* minus *x* one *x* minus *x* two'.

[5] The description in this vignette is taken from a study of the pedagogy of an extended mathematics course at an elite English medium historically white South African university. This study was supported by the National Research Foundation in South Africa under Grant Number TTK2006040500009. Any opinion, findings and conclusions or recommendations expressed in this material are those of the author and therefore the National Research Foundation does not accept any liability in regard thereto.

Quantities of two chemicals A and B are mixed together in a reaction chamber, and they react to form a new product. The **rate** at which the produce is formed is given by $m'(t)$, where m is the mass of the product formed, in grams, and the time t from the start of the reaction is measured in hours. The graph of $m'(t)$ is a parabola graph until time $t = 4$ hours, after which it is zero. It is also given that, from the start of the reaction, some of the product X is removed from the reaction chamber at a constant rate of 3g/hour.



d) Find the equation of the parabola graph – it will express $m'(t)$ as a quadratic function of t.

Figure 1. The chemical reaction problem, course material for the first-year extended mathematics course[6]

What follows in Transcript 1 is a discussion about which of these general equations is correct (is 'it'). Justifications are based on the students' personal opinions – the underlining and upper case text in the transcript shows how the students emphasise certain words – rather than on mathematical arguments. The discussion suggests that the students do not view the three equations as equivalent, but view each as representing a different mathematical process (le Roux and Adler, 2012).

Transcript 1:

Lwazi: There is an equation like that
Ndumiso: For what though? (Looking at Lwazi)
Lwazi: But that's not it though
(Ndumiso and Kelsa laugh, Thokozile is looking at Lwazi)
Lwazi: No really the *a* is right at the beginning but the stuff in the middle isn't (Pointing at Ndumiso's equation $y = a(x - x_1)(x - x_2)$)
Ndumiso: It IS
Lwazi: It's not
Ndumiso: I know it is
Lwazi: It's not … I'm telling you it's not

Eventually, Lwazi calls the tutor to their desk and tells him, 'We have a big problem'. Kelsa, however, counters this by indicating that she and Thokozile 'don't have a problem', to which Lwazi and Ndumiso look surprised. In the discussion that follows in Transcript 2 the tutor

[6] Course problems such as this that make links to disciplines other than mathematics are modelled on those originally promoted by the undergraduate calculus reform movement which originated in the United States in the 1980s (e.g. Hughes-Hallet et al., 1994).

encourages the four students to work together. In particular, he encourages Kelsa and Thokozile – named firstly as 'guys' and then 'girls' (with emphasis) – to contribute what they know. This strategy is not successful and he interacts with Lwazi and Ndumiso only.

Transcript 2:

Kelsa:	They're the ones who called you (Pointing at Lwazi and Ndumiso)
(Thokozile continues to work on the problem)	
Lwazi:	Okay we have a problem
Thokozile:	No no no guys wait
Tutor	You guys can talk about it (Using his hand to indicate all members of the group)… you guys are clever (pointing at Kelsa and Thokozile)
[…]	
Tutor	You girls are clever… are so clever you can explain it
Lwazi	No no [Tutor's name] please
(They all laugh)	
Ndumiso:	We don't trust them

Mathematics and mathematics education in the changing university

Debates about transformation for a more socially just South African university and society broadly are part of academic discourse (e.g., Cooper, 2015; Hlalele and Alexander, 2012; Leibowitz and Bozalek, 2014; Shay, 2016; Soudien, 2008; the edited volume by Tabensky and Matthews, 2015). These debates have focused, for example, on whether black, first-generation, working class students such as Joseph and his peers gain access to and succeed at university, what opportunities they are afforded to fulfil their potential, who teaches them, the power dynamics in their classrooms, and their sense of belonging in the university. These debates also engage with what knowledge is valued in degree programmes and whether this knowledge is appropriate for these students, the world of work and for addressing societal problems.

University transformation debates in South Africa assumed a greater energy and urgency in 2015 with the emergence of predominantly student-led movements inserting their voices into the debates and pushing for 'decolonisation' – with its various interpretations – of these institutions. University curricula in focus tend to be those in the humanities, social sciences, and economics (e.g. Bassier, 2016; Garuba, 2015; Gibson, 2015; Oyowe, 2016). Science curricula have, however, started to feature in conversations and online opinion pieces in late 2016 (e.g. Joubert, 2016; Wild and Nordling, 2016). The term 'curriculum' has itself taken on various meanings in these debates, and in this article I use it broadly to refer to content, pedagogy and assessment in university programmes.

Shay (2016) has argued that these transformation debates need to consider how curriculum 'at every point – from who gets admitted, who thrives, who survives, who fails – mirrors back the historical and current unequal distribution of educational resources in the broader society' (para.16). Mathematics and mathematics education have tended not to feature specifically in these curriculum debates. In other words, how the discipline of mathematics and the practices of mathematics education at universities may (re)produce or transform existing inequities. By mathematics I mean the network of socio-political practices that includes pure and applied mathematics, quantitative literacy, and the use of the knowledge of these practices in other disciplines such as science, technology, design and economics. By mathematics education I mean the range of socio-political practices of classroom teaching, assessment, policy, textbooks and so on through which students gain access to mathematics. Indeed, only a few South African researchers have grappled with whether mathematics and mathematics education at university may be transformative (e.g. Brodie, 2016; Paxton and Frith, 2015), promote social justice (e.g. Mhakure, Jaftha and Rughubar-Reddy, 2013), and develop critical thinking about society (e.g. Lloyd and Frith, 2013). This, despite a growing body of theoretical and empirical literature on this issue at university level beyond South Africa (e.g Wolfmeyer, Chesky and Lupinacci, 2015; Skovsmose, 2009).

The question posed in this special issue – 'How might we re-imagine language and literacy for socially just, creative practice in the changing university?' – provides the space to open up the debate about mathematics and mathematics education practices. These are practices in which language use plays a significant role in (re)producing meaning. Answering this question in relation to these practices requires conceptual tools for understanding. Firstly, we require tools to understand why mathematics and mathematics education have largely been 'vested with a veil of sanctity' (Valero, 2004: 13) and seldom questioned about their role in (re)producing or transforming historical and social inequities. For example, we seek tools to view how the power relations in Thabo and Luthando's pure mathematics classroom, co-constituted by language repertoire, knowledge and race, contribute to their experience of exclusion. To view how Josephine represents pure mathematics as an opportunity to adapt to the accents and teaching styles of her lecturers rather than to actively explore how the practice may solve or create the pressing problems experienced by the students' families, communities, and society. To view how the respective mathematics performances of Kelsa, Lwazi, Ndumiso and Thokozile are a function not of just of their individual mental conceptions but of a complex interplay between their mathematical activity, language use and the power relations between classroom participants. Secondly, we seek tools that help us to re-imagine how these students' experiences of mathematics and mathematics education could be different.

The key conceptual tools I propose in this article are a *socio-political perspective* of mathematics and mathematics education and a concept of *equity* as *access*, *achievement*, *identity* and *power*. These tools are drawn mainly from the work of critical mathematics educators Rochelle Gutiérrez, Ole Skovsmose, Paola Valero and Renuka Vithal, and the critical linguist Norman Fairclough. I argue that these tools can be used to re-imagine the university mathematics curriculum as what Moje (2007: 3) refers to as *socially just* in the sense that it offers 'equitable opportunities' to learn what is currently valued in the academy. These tools can also be used to re-imagine a curriculum *for social justice* in the sense that it opens opportunities for critique and transformation of the student, knowledge and the context (Moje, 2007).[7]

[7] Moje (2007: 3) refers specifically to 'socially just *pedagogy*' and '*pedagogy* for social justice' (emphasis added). I use the concepts to refer more broadly to curriculum, which in this article includes pedagogy.

Throughout this article I use the voices and actions of the students introduced in vignettes 1 and 2 to illustrate the potential application of these tools. These vignettes are selected from my research at an elite, historicallywhite university in South Africa. While these vignettes are in no way representative, narratives such as these are necessary if we are to gain a deep understanding of how the practices of universities are experienced by participants (Matthews and Tabensky, 2015; Shay, 2016).

Understanding the 'sanctity' of mathematics and mathematics education: the autonomous perspective

As a first step to understanding how mathematics and mathematics education have largely escaped scrutiny in debates about curriculum transformation at South African universities, I introduce the *autonomous* perspective of mathematics. Drawing from Street's (1984) autonomous model of literacy, Baker (1996) has used this term with reference to mathematics, but the underpinning ideas have been used more broadly in mathematics education.

The autonomous view represents mathematics as skills-based knowledge that is socially, politically and ethically neutral (Baker, 1996). Mathematics is seen as epistemologically transparent in the sense that 'truth' or what counts as knowledge is intrinsic to the logic of the discipline (Skovsmose, 2009, 2016; Vithal, 2012). Language in this perspective is regarded as a carrier of mathematical meaning. Thus, when Thabo has to learn mathematics in English for the first time at university he tries to 'grasp the accent, the way they say the words and then put them in my mind'.

The autonomous view suggests that mathematics has 'the potential to adequately represent the essential characteristics of all things' (Gutiérrez and Dixon-Román, 2011: 29) in an objective way (Bishop, 1990). Thus, mathematics can be transferred unproblematically across contexts. In this sense, mathematics is seen to have 'intrinsic' power (Valero, 2008: 46); it can be used to make unbiased decisions about the social world, with questions of quality lying in the rigour of mathematical proof (Gutiérrez and Dixon-Román, 2011). Mathematics offers a 'salvation narrative' (Popkewitz, 2002: 2) as it is seen to contribute to social, economic and political progress (Skovsmose, 2009). From this perspective, universities and the state can use mathematical calculations to make unbiased decisions about who qualifies for student financial aid, the size of annual increases in student fees and whether certain university staff can be insourced.

If mathematics itself is 'powerful', then mathematics education through which students are to access this knowledge can be viewed as personally empowering (Valero, 2008: 48) or as 'saving' the individual student (Popkewitz, 2002: 1). Thus Josephine views her school mathematics as equipping her to 'purchase a house'. Although she cannot see the relevance of what she is learning in pure mathematics at university, she continues to believe that 'just having a maths background' will help her in the future.

If mathematics and mathematics education contribute to social, economic, political and individual progress, then it is important for as many students as possible to access mathematics (Valero, 2004). Thus the focus of mathematics education becomes efficiency and improving the teaching and learning process (Pais and Valero, 2011). Certainly, performance data for universities in South Africa point to the urgent need for attention to these aspects of mathematics education. For example, only half of students complete a three-year undergraduate science degree within five years, with the completion rate for white students fifty percent higher than that for black African and coloured students (CHE, 2013). At the university attended by Joseph and his peers, only twenty-three percent of students in the extended science programme who attempted the second-year pure mathematics course between 2005 and 2009 passed. Less than half of those students who passed this second-year course (only six students) went on to achieve a mathematics major.[8]

The autonomous view of mathematics as neutral and epistemologically transparent has been taken up in psychological theories of mathematics learning. According to these theories the structure of mathematics can be transferred to individual mental structures (Valero, 2008). This suggests that the mathematics curriculum should be organised according to the intrinsic logic of the discipline (Skovsmose, 2009), and that success in mathematics is a product of individual mental ability. So Joseph sees the role of mathematics students as 'stand[ing] by ourselves' and having to 'kind of swallow, absorb the knowledge'. When Philisani is failing mathematics he feels that he is missing 'something within [him]self'. Mathematics education researchers who subscribe to psychological theories would focus on the structural and operational mental conceptions of Kelsa, Lwazi, Ndumiso and Thokozile as they find the equation of the parabola (refer to le Roux and Adler, 2012 for discussion of this approach).

Writing two decades ago, Apple (1995: 331) argued that mathematics education discussions were 'strikingly internalistic', drawing on the ontology of mathematics and looking 'but a short distance – to psychology'. Mathematics education has, since then, 'turned' more to the social (Lerman, 2000), discursive (Morgan, 2006) and political (Valero, 2004). However, I argue that Apple's argument still applies to discussions about the practices of mathematics education at South African universities. To further develop our understanding of why this might be the case, I introduce next the ideological/socio-political view of these practices.[9]

Mathematics and mathematics education as networks of socio-political practices

The term *ideological* has been used by Baker (1996) to describe mathematics – again drawing on Street's (1984) ideological model of literacy – but I adopt the more widely used term *socio-political* perspective (Valero, 2004). From this perspective, mathematics and mathematics education are viewed as related networks of socio-political practices. Pure mathematics, quantitative literacy, work-based mathematics, mathematics teaching, etc. are *practices* in the sense that they are relatively stable, recognisable combinations of activities, knowledge, technologies, social relations, values, attitudes, identities, and language use

[8] References to institutional data have been removed due to concerns about recognisability of the university.

[9] By comparing the autonomous and ideological/socio-political views in this article I do not intend to suggest that the complexity of mathematics and mathematics education can be represented by simple binaries. Rather, I have chosen these perspectives as productive for understanding the problem and for moving us forward to re-imagine how the context might be different.

(Fairclough, 2003). These practices are *social* and *historical* as they involve people and their activities, interactions, values, etc. in particular spaces and at particular times (Valero, 2004). Mathematics and mathematics education practices are also *political* since they (re)produce relations of power between and within practices. Here *power* is not a physical force that resides in a person, an organisation, or a discipline (as in the view of mathematical knowledge as powerful). Rather, from a Foucauldian perspective, power is a form of ‘distributed positioning’ (Valero, 2008: 52) between and within practices. While there are different mathematics and mathematics education practices, these practices are given more or less value in social institutions such as the university (Fairclough, 2001, 2003). Furthermore, within a practice there are asymmetries in the extent to which participants can control the content, language use, social relations, and available subject positions (Fairclough, 2001). Thus Kelsa and Thokozile are, on account of their gender, positioned as not trustworthy by Lwazi and Ndumiso.

From a socio-political practice perspective, *identity* is not a fixed attribute of a student but is a way of being situated in a socio-political practice. A practice sets up subject positions for participants by identifying them in certain ways (Fairclough, 2001). In addition, since abstract concepts such as race, gender, and social class take on specific meanings in a practice (Fairclough, 2003), depending on one’s race, gender, language repertoire etc., there are different ways of being a mathematics student. However, identities are not determined by the wider context and students act agentically to position themselves in relation to these subject positions (Fairclough, 2001, 2003). Empirical research shows how university students like Thabo, Josephine and Luthando act to resist, reconfigure, accommodate, and balance the multiple positions on offer (e.g., le Roux, forthcoming; Soudien, 2008).

Language use in the network of mathematics and mathematics education practices

Language use in mathematics and mathematics education practices is multi-modal. The vignettes show that doing mathematics involves written and verbal language, symbols, visuals and non-verbal communication such as bodily movement, facial expressions and gestures. These various language modes are related to the knowledge, activities, values and so on of a practice in two respects (Chouliaraki and Fairclough, 1999). On the one hand language use represents the non-language aspects, for example, we use symbols and visual representations to represent abstract mathematical objects. On the other hand language use is a form of ‘action’ in the social world (Fairclough, 2003: 26).

How language use in mathematics and mathematics education can be a form of action is illustrated by Yasukawa, Skovsmose and Ravn’s (2012) three-part concept of *mathematics-based human action*. This concept brings into view how people as agents use mathematics in ways that may act for or against social justice. Firstly, mathematics-based human action has ‘technological imagination’ (268) in that a technological possibility that only exists in the human imagination can be expressed mathematically using the language of symbols, visuals and so on. Secondly, a mathematical model of an imagined technology together with ‘hypothetical reasoning’ (268) can be used to predict what might happen under certain conditions. Finally, mathematics-based human action has ‘formatting power’ (269) in that mathematics is used as an active component of technologies, both material and conceptual, that describe who people are and how they can act alone or with others. Technological advances mean that this mathematics-based human action becomes increasingly invisible, including to pure mathematics students such as Josephine and Thabo.

The concept of mathematics-based human action has been used to explore a range of technologies, for example, climate change, taxation, Body Mass Index classification, intelligence, staffing policies in universities, and airline booking systems (e.g. Hall and Barwell, 2015; Hauge and Barwell, 2015; Yasukawa, Skovsmose and Ravn, 2012). Of interest in mathematics education is how mathematical measurement of individual 'ability' in standardised tests is used to construe differences in mathematics performance between groups as an 'achievement gap' (Gutiérrez and Dixon-Román, 2011). At universities these measurements, together with measures of a student's 'background' in the form of parental income or level of education, may be used to identify a student as 'at risk' (Fine, 1990) or as 'educationally disadvantaged'. Once named in language, these subject positions have the potential to benefit students, for example, Joseph and his peers receive additional mathematics support (Fine, 1990; Gutiérrez and Dixon-Román, 2011). However, subject positions such as 'at risk' also act in the world by fixing student identities, reinforcing deficit views of certain individuals as not likely to graduate, and representing interventions to 'fix' students as natural (Apple, 1995; Fine, 1990; Gutiérrez and Dixon-Román, 2011). Indeed, the student Philisani names himself as 'disadvantaged' in the university context.

Revisiting how mathematics and mathematics education act in the historical and socio-political context of South Africa

Equipped now with the socio-political perspective as tool, we are better able to understand the need for mathematics and mathematics education to be brought into the conversation about curriculum change at South African universities. From this perspective what is currently recognised as school or university mathematics in this context – what I refer to as the *dominant* mathematics practices – are not just sets of symbols and structures. Rather, they are networked, historical and socio-political practices characterised by particular social relations, identities, values, and attitudes (Bishop, 1990). These are also not the only mathematics practices (Bishop, 1990). In this section I draw on literature – mainly in mathematics education – for one possible account of the history of the current, dominant practices. In representing this history I acknowledge my own positioning as a product of this history and the structuring effects of the dominant practices on my language use (Apple, 1995).

Historical and anthropological studies of the dominant mathematics practices point to their origins in societies in China, India, North Africa, the Arab world and Western Europe (Bishop, 1990; Vithal and Skovsmose, 1997). However, it is the location of these practices within a network of socio-political practices in Western Europe in the past three-hundred years that has impacted the geopolitics of mathematics, shaping what mathematical knowledge is valued in South Africa and who has access to this knowledge (Bishop, 1990). In this network the symbols and structures of the dominant mathematics practices came to 'carry with them' (Bishop, 1990: 62) and be put to work with other concepts valued in that wider network. These concepts – to which the collective descriptor 'modern' or 'modernity' may be attached – are those of rationalism, objectivism, progress (through science and technology in particular), liberal democracy, and industrialisation (Bishop, 1990; Skovsmose, 2009; Vithal and Skovsmose 1997).[10] Thus, the mathematics practices valued in Western Europe during this time became part of a 'cultural kitbag' (Bishop, 1990: 58) that was transferred to other societies as 'Modernity marched along with colonization of the so-called New World' (Skovsmose, 2009: 325).[11]

The valued mathematics and mathematics education practices of Western Europe took on particular meaning in South Africa. In this context the societal, economic and educational divisions given meaning by colonialism became entrenched during apartheid (Badat, 2009; Khuzwayo, 2005; Vithal and Skovsmose, 1997; Vithal and Volmink, 2005). Indeed, mathematics was used as an early justification for such divisions (Khuzwayo, 2005; Vithal and Volmink, 2005). Vithal and Volmink (2005: 16) describe the mathematics of curriculum of apartheid as underpinned 'by a deep disrespect for indigenous knowledge', with its power residing in what it offered the labour market. While mathematics education drew on curriculum reform in Western Europe and the United States (Vithal and Skovsmose, 1997), it was given meaning by its location within an education system underpinned by an interpretation of the philosophy of fundamental pedagogics. This interpretation represented mathematics as abstract and uncontested, to be taught in an authoritarian manner that encouraged passivity on the part of learner (Khuzwayo, 2005). Mathematics education researchers viewed 'ability' as determined by a student's culture, race and language repertoire (Khuzwayo, 2005).

In the 'rebuilding project' (Vithal and Volmink, 2005: 12) of post-apartheid South Africa, university mathematics and mathematics education have been positioned as offering a particular version of the 'salvation narrative' (Popkewitz, 2002: 2). Rebuilding has meant redressing past injustices and developing an inclusive, democratic society in a context of enduring poverty and inequality. It has also meant competing economically and technologically in a globalised context characterised by neoliberal ideas of marketisation, growth, competition, quality, human capital and individualism (Badat, 2009; Fairclough, 2003; Llewellyn and Mendick, 2011; Vithal and Volmink, 2005). Thus in the university context, redress has come to mean using mathematics to classify students such as Joseph and his peers as 'at risk', and offering them additional support. Attempts have been made to blur the boundary between mathematics, the everyday and the workplace in the development of university-level quantitative literacy courses (Vithal and Volmink, 2005) and in the use of 'real life' problems such as the chemical reaction problem (Figure 1). Josephine is convinced that she will be able to use her school and university mathematics in her personal and working life. Joseph and Philisani see education as offering opportunities for progress and a

[10] What constitutes 'modern' or 'modernity' is contested. For example, Harding (2009) suggests that it may be used to name a certain time period or a particular set of structures, practices, discursive constructs or worldviews. The latter are not necessarily unique to Western Europe during a certain era.

[11] It is this socio-political history that has led the current, dominant mathematics practices to be named as 'western, modern mathematics'. I choose not to use this term as it renders the complex history and politics of these practices opaque. Where others use these terms I use quotes or scare quotes as appropriate.

means to improve conditions for themselves and their families. When it seems he might not progress as expected, Philisani locates the problem in himself.

Referring to science and mathematics respectively, Harding (2009) and Skovsmose (2009) point to critiques of the 'modern' foundations of knowledge in the social sciences and humanities, as well as evidence of the contribution of science and mathematics to environmental and societal problems. Yet, they argue, the socio-political histories of science and mathematics continue to escape scrutiny. Certainly, the general silence about mathematics and mathematics education in transformation debates at South African universities suggests that these practices retain their sanctity in this context.

Inserting mathematics and mathematics education into conversations about social justice in the changing university

In this section I propose Gutiérrez's (2012) framework for *equity* as a tool for re-imagining the role of mathematics and mathematics education in the South African university. The use of the term 'equity' in mathematics education has increased over the past thirty years, and its multiple meanings are contested (Apple, 1995; Gutiérrez, 2012; Pais and Valero, 2011). I find Gutiérrez's (2012) framework productive as it recognises the dominance of particular views of mathematics, mathematics education and equity. It also opens the space to consider how the practices of mathematics and mathematics education may be put to work for or against social justice and the possibility of transformation. Gutiérrez's (2012) framework also extends the focus beyond the university to society and the environment; it is about what students like Philisani can do and be at university and beyond.

Gutiérrez's (2012) framework includes four meanings of equity; *access* and *achievement* (the *dominant* meanings) and *identity* and *power* as defined in the socio-political perspective (the *critical* meanings).[12] The two dominant meanings are about 'playing the game' of mathematics (Gutiérrez, 2012: 21). These meanings can be likened to Moje's (2007: 3) *socially just* curriculum which offers 'equitable opportunities' to learn what is currently valued in the academy. The two critical meanings are about 'changing the game' (Gutiérrez, 2012: 21). These meanings can be likened to Moje's (2007) curriculum *for social justice* which opens opportunities for critique and transformation of the student, knowledge and the context.

Gutiérrez (2012) argues that, although not all four meanings in the framework will be present at a particular moment, all four are necessary for 'true equity' (21). There is also a tension between the dominant and critical meanings, that is, 'changing the game requires being able to play it well enough to be taken seriously' (Gutiérrez, 2012: 21). Referring to literacy more generally, Janks (2010: 24) discusses how this tension leads to an unavoidable *access paradox*: 'If we provide access to dominant forms, this contributes to maintaining the

[12] Gutiérrez (2009, 2012) refers to access, achievement, identity and power as 'dimensions' of equity. In addition, she refers to dominant and critical 'axes' and 'definitions'. My reading suggests that she uses the term 'dimension' colloquially to mean 'aspect' or 'feature'. Consistent with a social-political perspective of language I refer to both dimensions and axes as *meanings*.

dominance of these forms. If, on the other hand, we deny students access, we perpetuate their marginalisation in a society that continues to recognise the value and importance of these forms'. The challenge for mathematics educators is to balance the tension between the dominant and critical meanings, and Gutiérrez (2009) provides the illustration in Figure 2 as a simple yet useful 'mapping space' for working with this challenge.

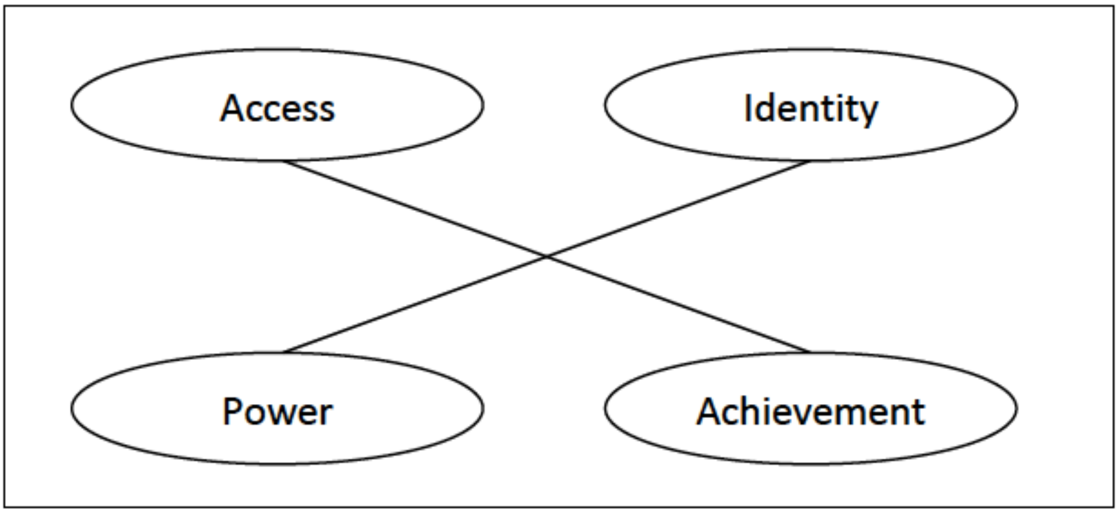


Figure 2. Four aspects of equity (Gutiérrez, 2009)

The dominant meanings of equity: access and achievement

For Gutiérrez (2012) the dominant meanings of equity refer to access to and achievement in 'mathematics that reflects the status quo in society, that gets valued in high stakes testing and credentialing, that privileges static formalism and that is involved in making sense of a world that favours the views and perspectives of a relatively elite group' (20). As noted, the dominant mathematics at South African universities is a product of a particular history.

Equity as achievement in mathematics

Achievement is about student outcomes in the dominant mathematics and is signalled by student participation in class, course-taking patterns, assessment scores, and participation in the 'pipeline' (Gutiérrez, 2012: 19). In South Africa this pipeline involves participating in the school subject Mathematics (rather than the subject Mathematical Literacy) that enables a student to apply to study a range of university degree programmes. This pipeline involves succeeding in pure or applied mathematics courses at university that identify a student as having the 'maths background' (Josephine) valued in a knowledge society.

A focus on student achievement is a more traditional view of equity, and is commonly named as an 'achievement gap' (Gutiérrez, 2012: 19). The data for South African universities quoted in this article point to such a gap in mathematics and science performance by race (and associated constructs such as social class, language, and geography). The notion of achievement in the equity framework brings into view the material and social implications of what it might mean to **not** have access to the dominant mathematics practices (Gutiérrez, 2012). For 'having a maths background' (Josephine) opens doors to study bursaries, to careers in science, engineering and technology, and remuneration that allows students to improve the 'living conditions' and 'lifestyle' (Joseph) of themselves and their families.

Yet framing inequity as a problem of an 'achievement gap' between different groups has the potential for concepts such as race and social class to become reified and used to explain performance, while diverting attention from the structural constraints on performance (Gutiérrez and Dixon-Román, 2011; McGee and Martin, 2011). In addition, Vithal and Skovsmose (1997) note that measures of achievement by race, social class and so on focus only on a student's background and not on his/her *foreground*, that is, the student's interpretation of what future opportunities are made available by society. Joseph, Philisani and Thabo see going to university as opening doors and suggest that few of their school classmates 'dreamed' (Thabo) of this post-school route as a possibility. At times during his science degree, Luthando doesn't 'understand why I [am] doing maths' and stops attending class. However, he regains his focus when he identifies mathematics achievement as his route to a study bursary and a future career in engineering.

Equity as access to quality mathematics education

The concept of access in the equity framework is about 'opportunities to learn' (Gutiérrez, 2012: 19) and what resources are available for students to participate, for example, good teachers, adequate classroom materials, quality curriculum, and support outside of class. Joseph and his peers have achieved sufficiently at school to gain entry to university studies, but access in this framework is about what resources are available for them to participate in the dominant university mathematics practices. Student voices point to inequitable participation patterns in university mathematics classrooms and assessments. Thabo suggests that his participation in mathematics is negatively affected by asymmetrical power relations co-constituted by race, language repertoire, and knowledge. Luthando feels he cannot participate in the 'very nice conversation' between the lecturer and the 'really smart students'.

In South Africa over the past three decades the problem of epistemic access to university disciplines has traditionally been tackled by some form of 'foundation' provision. This may take the form of extra tutorials in 'regular' courses or stand-alone, formalised support courses such as the extended curriculum programme described in this article (see Rollnick, 2010, on this provision in science degree programmes). Research shows that structures such as these have provided physical and epistemic access to university study in science for some groups of students. For example, data for the extended programme in which Joseph and his peers were enrolled show that, during the 2000s, eighty percent of black African students accepted to study science at this particular university gained access via this programme, and half of the black African students who graduated in science made use of extended courses in science.

Yet, measures of achievement that point to the persistence of an 'achievement gap' and student voices about foundation provision suggest that these interventions are not a solution in themselves. Indeed, there is a need to look critically at foundation provision at South African universities to consider whether this may inadvertently (re)produce inequities. For example, concerns have been raised about how such programmes label students as deficient (Hlalele and Alexander, 2012). My research on the mathematics provision provided to Kelsa and her peers shows that certain features of problems such as the chemical reaction problem (Figure 1) may, in fact, work against student access to abstract, pure mathematics. This research also points to how asymmetrical power relations between students in small tutorial groups may work to excluded certain students from participation (see C.J. le Roux, 2011, K. le Roux, 2014; le Roux and Adler, 2012, 2016 for more details). Longitudinal interviews with Joseph and his peers point to the extended programme as a valuable social space where students feel at home with students who share their background (le Roux, forthcoming). However, this apparent homogeneity may work against social inclusion (Hlalele & Alexander, 2012), with the students having to 'stand by ourselves' (Joseph) when doing mathematics beyond that social group. Looking back at their experiences of the extended programme later in their degrees, both Thabo and Luthando critique the programme for not preparing them for abstract, pure mathematics beyond the extended first-year course.

While the notions of achievement and access may be necessary in a conception of equity focused on 'playing the game' (Gutiérrez, 2012: 21), they are not sufficient for exploring the dominance of this practice and these students' sense of exclusion.

The critical meanings of equity: identity and power

Identity and power are the two critical meanings in Gutiérrez's (2012) equity framework. Consistent with a socio-political perspective, this view recognises that mathematics and mathematics education are historical, social and political practices that are used by humans to work towards or against a more just society. It also recognises students' multiple identities as they participate in different practices.

Gutiérrez (2012) uses a window/mirror metaphor to explain the concept of identity; this is about the student seeing – in the past, present and future – the self (the curriculum as mirror) and also seeing others (the curriculum as window) in the curriculum. This concept is closely related to the notion of power, for how a student sees him/herself and others cannot be separated from both the power relations between participants in mathematics practices and the power relations between mathematics practices and between mathematics and society. Thus, power brings into view transformation at various levels (Gutiérrez, 2009, 2012); it is about who has a voice in the mathematics classroom, about recognising knowledges other than the dominant mathematics, and about recognising the role of humans in mathematics in action and using this concept to explore how mathematics can work for and against social justice.

Seeing oneself and having a voice in the university mathematics classroom

The concepts of identity and power bring into view Thabo and Luthando's exclusion (which Thabo represents as a function of race, language repertoire and knowledge) from the 'nice conversation' (Luthando) about the dominant knowledge between the lecturer and other students. In the absence of a mirror of themselves and a voice in university mathematics classrooms, some students have no option but to 'swallow, absorb' this knowledge (Jackson) or to adapt to the 'different accent' of the lecturer (Josephine). For some students this absence means no longer attending mathematics classes (Luthando) or feeling you 'don't have something within yourself' and eventually being excluded from university due to poor academic performance (Philisani). The concepts of identity and power bring into view how the two students Kelsa and Thokozile are, on account of what is constituted by the participants as asymmetrical gender relations, denied a voice in the small group discussion about solving the chemical reaction problem.

Re-imagining the mathematics classrooms of these students involves asking, how might lecturers draw on the 'frames of reference and resources' (Gutiérrez, 2012: 21) of students so that more students are brought into meaningful mathematical conversations? How might the lecturer or tutor use the discussion between Kelsa, Lwazi, Ndumiso and Thokozile as a window for students to identify one another differently?

Seeing oneself in the curriculum: the possibilities and constraints of ethnomathematics

Joseph describes the knowledge valued in his university mathematics classroom as 'given', rather than as negotiated or as a mirror. Ethnomathematics has been proposed as offering interpretations of what it might mean for a student to see him/herself in the mathematics curriculum. Vithal and Skovsmose (1997) note that this perspective highlights the silence about the contributions of societies other than those in Western Europe to dominant mathematics practices and brings into view additional mathematics practices. In addition, the ethnomathematics perspective proposes that the mathematics curriculum should be based on the culture of the student.

With its 'oppositional stance' (Vithal and Skovsmose, 1997: 152), this perspective has held particular appeal in the transition from apartheid South Africa. Certainly, one way to re-imagine the university mathematics curriculum is for all students of mathematics (and not just prospective mathematics teachers) to explore the social, historical and political origins of the dominant mathematics practices. In addition, Skovsmose (2009) suggests that asking questions about the formulation of the fundamental theorem of calculus and Newton's second law of motion provides an opportunity to explore historical relations between mathematics, science, astronomy, cosmology and theology.

However, beyond these ideas, the potential use of the ethnomathematics perspective for re-imagining the university mathematics curriculum is limited. Firstly, both Vithal and Skovsmose (1997) and Gutiérrez (2012) note that attention to student identities cannot be restricted to a student's past, but needs to take seriously how the student sees him/herself in the future. Secondly, Vithal and Skovsmose (1997) note that this perspective relies uncritically on a concept of 'culture' and fails to ask the question: 'Whose culture?' From a socio-political perspective, culture cannot be separated from power relations. Vithal and Skovsmose (1997: 136) use the example of apartheid mathematics education to illustrate the consequences of a lack of such critique: 'in the framework of apartheid ideology, culture took on a particular meaning enmeshed with race and its outcomes were devastating'. Indeed, Apple (1995: 337) extends this debate beyond ethnomathematics to mathematics education reforms that promote using 'real life' contexts in the mathematics classroom and asks: '*Whose* vision of real life counts?' (emphasis in the original). This question can also be asked of problems such as the chemical reaction problem (Figure 1) used in Kelsa's extended mathematics course, aspects of which I have already noted are problematic in terms of enabling access to abstract, pure mathematics.

Finally, scholars in fields other than mathematics and mathematics education have attempted to move away from binaries such as 'modern' vs. 'traditional' by arguing for a concept of *Africa-centred* knowledges in a 'third space' (Cooper and Morrell, 2014: 2). This conception backgrounds the origins of knowledge while focusing on how knowledge is shaped through use in African contexts. What a third space between dominant mathematics and ethnomathematics might look like deserves further exploration.

Reading and writing the world with mathematics

Josephine, Luthando and Joseph express a general belief that their university mathematics knowledge, although abstract, will in some way serve them well beyond the academy. Gutstein's (2005) notions of *reading and writing the world with mathematics* – developed from Paulo Freire's notion of reading and writing the world with language – provides a tool for thinking about how these students' convictions could be developed. The three-part concept of mathematics-based human action (Yasukawa, Skovsmose and Ravn, 2012) has particular potential in this respect. This concept allows the student to read how human use of mathematics works with the discursive, social, political, technological and economic to represent the world in particular ways, to regulate subjects, and to work for and against social justice (Ernest, 2016; Skovsmose, 2016).

Writing in 1997, Vithal and Skovsmose pointed to the need for such readings of the world in the socio-political context of South Africa. They argued at the time that in a context in which levels of mathematical and technological literacy are generally low and also inequitable, 'and those in power make decisions which intimately affect everybody – about taxes, benefits, etc. – with the use of technologies based on complex mathematical modelling, a problem of democracy becomes urgent' (144). Twenty years later in South Africa where the notion of democracy is in flux (Pithouse, 2016), there is a need for mathematics students who can critically read how mathematics is used in our society. Understanding how mathematics can work for and against social justice lays the groundwork for students such as Joseph, Kelsa and their peers to, where necessary, write a different world through mathematics, that is, to 'change the game' (Gutiérrez, 2012: 21) by constructing new technological possibilities (Skovsmose, 2009).

Conclusions

Shay (2016) has called for debates about curriculum change at South African universities to foreground how curricula 'at every point – from who gets admitted, who thrives, who survives, who fails' (para.16) reproduce enduring historical and societal inequalities. The involvement of predominantly student-led movements in these debates in recent months has added an energy and sense of urgency to these considerations and highlighted the importance of student voices in these conversations. However, how university mathematics and mathematics education practices may (re)produce or transform these inequities both at university and in society has been a silence in these conversations. In this article I have brought together conceptual tools from critical mathematics education and critical linguistics with the voices and actions of university students in order to insert these practices into the curriculum debates.

The socio-political perspective of mathematics and mathematics education and view of language use in these practices as both shaped by and acting in the social world helps us to understand the apparent ‘sanctity’ (Valero, 2004: 13) of these practices in the transformation debates. This perspective also brings into view the complexity of what it might mean to challenge the dominant meanings assigned to these practices. That is, responding to Shay’s (2016) challenge is not simple, ‘for social and ideological interests and beliefs are not only found in what and how we teach. They are also fused with the deep structures of how we understand mathematics’ (Apple, 1995: 339).

Certainly, I have not offered any simple solutions in this article, but I have presented Gutiérrez’s (2012) framework for equity as a possible way to re-imagine a socially just university mathematics curriculum and a university mathematics curriculum for social justice (Moje, 2007). The dominant and critical meanings in this framework offer a means to work with the tension between, on the one hand, the recognition that access to and achievement in current dominant mathematics practices matters materially, socially and emotionally for university students. On the other hand is the recognition of the urgent need to assess the affordances and constraints of the dominant practices and their relations with society and the environment.

Valero (2004: 15) argues from a socio-political perspective that power relations are transformed ‘through participation of actors in construction of discourses’. The ‘actors’ in this mathematics-based human action in the changing South African university are lecturers and students like Kelsa, Luthando, Lwazi, Joseph, Josephine, Ndumiso, Philisani, Thabo and Thokozile. The university community needs to open up the conversation about how to enable the necessary student participation for transformation. Apple (1995: 341) reminds us, however, of the need for ‘double reflexivity’ in such conversations, that is, we should be critical about dominant perspectives on mathematics and mathematics education and also critical of the alternatives we propose.

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