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Girls becoming mathematicians: identity and agency in the figured world of the English-medium primary school

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Abstract

This paper focusses on the process of learning mathematics in primary school from the perspectives of 62 girls aged seven to eleven. For many of these Singaporean girls, English is not the dominant home language, but they all learn mathematics in English. Despite the fact that achievement in mathematics is high nationally, girls appear to be less confident than boys. Adopting notions of identity and agency at the intersection of language and gender, the paper explores how the girls oriented themselves and others to the figured world of school mathematics as successful or not through their interaction in focus group interviews. While some were confident in their mastery of the subject, for some others, the discipline, its language, and other artefacts, such as model drawing and assessment, restricted and frustrated them. Girls experienced a sense of security in their own fellowship and appreciated considerate pedagogies, such as space for individual agency and for improvisation and expression of language, through which they could achieve understanding and progress.

Keywords: identity; language; gender; primary school; mathematics; multilingual context

Introduction

This article is about the figured worlds (Holland, Lachiotte, Skinner, & Cain, 1998) that children enter at school. Specifically, we write about how young girls aged from 7 to 11 construct their identities as learners in the Singaporean world of mathematics. By international standards, mathematics is learnt very effectively in the country. The Trends in International Mathematics and Science Study (TIMSS) (Mullis, Martin, Foy, & Hooper, 2016) showed no statistical difference in achievement by gender at grade 4 in the 2015 tests. Cvencek, Kapur, and Meltzoff (2015), however, found stereotyped views about mathematics among children in primary schools in Singapore as well as weaker self-concepts among girls compared to boys, suggesting that emotional factors may affect the processes of learning. The fact that the girls learn mathematics in English in a multilingual and multicultural society adds another dimension to our study. Although English is a working language and the official medium of instruction in Singapore, for approximately half the children in primary school, it is not the dominant home language. Thus, in order to deepen our understanding of girls' experiences and perceptions of mathematics, a high-status and usually compulsory subject on the Singaporean curriculum, we conducted and analyzed focus group interviews with 62 girls of primary one (P1), three (P3), and five (P5). This exploration of identity and agency at the intersection of language and gender demonstrates how girls are enculturated into becoming pupils of mathematics in a multilingual educational context and how they interactionally orient themselves and others to the subject. It was guided by the research question, 'What are young girls' experiences of learning mathematics in a multilingual context at the levels of P1, P3, and P5?' Interview questions directly focused on language and gender; however, evident in the girls' conversations were features specific to the discipline of mathematics, which were significant in shaping subjectivities. Although situated in Singapore, the close scrutiny

of pupils' personal experiences and reflections has relevance to other contexts where English is the language of learning but not necessarily the dominant language of pupils, and where girls may be high achievers but not necessarily confident in their abilities.

Review of literature

Identities in figured worlds

To first consider the situatedness of experience, we adopt Holland et al.'s (1998) notion of figured worlds, specific contexts where membership is realised through conventionalised practice, participation, and interaction. As individuals act and interact in recognisable ways with appropriate cultural tools, they simultaneously grow as individuals and structure the figured world. As the worlds are socially reproduced over time through the interactional formation of identities, they become accepted as familiar cultural models.

According to Holland et al. (1998) identity 'is a concept that figuratively combines the intimate or personal world with the collective space of cultural forms and social relations' (p.5). Identities are the 'imaginings of self in worlds of action' and 'are lived in and through activity' (p.5). Taking a child-centred perspective and drawing on children's conversations about the family, the school, and healthcare, James (2013) demonstrates how past, present, and future connect in identity construction. She explains that children's identities and present states of knowledge depend on memories and reflections of the past, yet children's agency in the present drives a future orientation. In that an individual's sense of self filters and mediates relationships with practices and others in a world of the present and of the past, identities also determine emotions, attitudes, orientations, and acts directed towards future practice

People's desires predict and envision cultural worlds which are imagined, storied, and populated by characters, resulting in figurative identities (Holland et al. 1998). As figurative identities are the outcomes of imagination or experience envisioned, Sfard and Prusak (2005) view the identity work of *being* as a hidden undercurrent to the manifested *doing*, deserving of deeper scrutiny. They define identities as 'those narratives about individuals that are *reifying*, *endorsable* and *significant*' (italics in the original) (p.16) that are true to the tellers themselves.

Interrelated and overlapping with figurative identities are positional or relational identities (Holland et al. 1998), which are grounded in experience and actualise it. Positional identities reflect social relationships and the behaviour which indexes them. Holland et al. (1998) state,

Positional identities have to do with the day-to-day and on-the-ground relations of power, deference, and social entitlement, social affiliation and distance – with the social-interactive, social-relational structures in the lived world (p.127)

The concept of positioning explained by Davies and Harre (1990) occurs through institutional discursive practices. As people learn and enact ways of talking, they position themselves and each other through their conversations. The joint interactions have the potential to produce multiple subjectivities, depending on the context, participants' points of view, and the categories made available. Taylor's (1994) acknowledgment of identity being 'a vital human need' (p.76) signals how recognition or misrecognition of an individual's identity by others is also a crucial aspect of group acceptance and an individual's sense of belonging. Recognition therefore presages how the individual may further engage in group practices. Importantly, according to Davies and Harre (1990) and Holland et al. (1998), the sedimentation of identity positions over time may result in dispositions which become fossilised and the bases of assumptions made by individuals and groups.

Learning and discourse in figured worlds

Holland et al. (1998) suggest that individual growth might result from participation in the activities of figured worlds. However, it is not only practices that have to be acquired by learners but also the social languages or discourses that reflect them. Social languages are associated with ‘specific socially situated identities’ (Gee, 2002, p.32). Indeed, Sfard (2001) proposes that to learn mathematics is to learn discourse: learning involves change in discourse (Sfard, 2007). Thus, figured worlds are equally communities of discourse historically, culturally, geographically, and ideologically located (Gee, 2001; 2002).

A socio-cultural view of learning when applied to educational practice envisages learning, (including language learning) and identity creation as intertwined. For Vygotsky (1962), discourse is the crucial means by which children develop both language and conceptual knowledge through interaction with someone more knowledgeable. Language and everyday concepts first develop externally through socially-mediated speech and then merge to become part of the interiority of the individual as technical, abstract language and scientific concepts. Language and thinking become inner speech and a means by which a person maintains an internal dialogue to understand and represent the self (Holland et al., 1998). Thus, Vygotsky’s (1962) developmental perspective accounts for children’s acquisition of language and thinking through everyday, externalised speech becoming specialised, inner discourses, while Holland et al.’s (1998) identity perspective sees internalised dialogue accomplishing identity work.

Artefacts and agency in figured worlds

In figured worlds, discourse is one of the artefacts by which people access and mediate practice. In addition, Holland et al. (1998) propose image, the material, and the symbolic as cultural artefacts. These conceptual and material resources become conventionalised and specialised

through association with the practices of figured worlds. Focussing on learning, Sfard's (2007) cultural tools of the mathematical world include mathematical words, visual mediators, such as graphs and symbols, narrative about mathematical practices as well as about the discourse which encodes them, and routines of discourse patterns specific to mathematics.

Cultural artefacts are appropriated and improvised by people as they act as agents and instruments of practice. As James (2013) argues, the developmental process of socialisation is not one in which children are passive; instead, they agentively negotiate, contest, and organize relationships, beliefs, and ideologies in their peer and adult communities. Thus, learning language and culture requires agency on the part of the individual in the appropriation and improvisation of artefacts as well as on the part of the culture in affording those artefacts and resources.

The world of school

A more deliberate, institutional form of enculturation than that envisaged by the theorists discussed so far is the institution of school where, through the processes of teaching and learning, children acquire discourse in specific domains of curricular knowledge. The language of school is a variety almost always distinct from that spoken at home (Halliday, 2007; Schlepegrell, 2001; Unsworth, 2001). Even more so, discipline-specific registers and semiotic modes of communication are associated with each subject on the curriculum and therefore constitute particular, marked worlds. Consequently, children's control of the associated discourses and practices grants them access to the knowledge, the emotions, and the ways of behaving, thinking, and valuing that a subject indexes.

Mathematical discourse

We have already referred to Vygotsky's (1962) theory of how children develop the inner speech necessary to learn concepts. Similarly, for Sfard (2007; 2008) mathematical thinking is constituted

in, by, and, through language. Sfard encapsulates her ideas in a theory of commognition, a ‘communicational approach to cognition’ (Sfard, 2002, p.13). Additionally, Barwell (2007) notes how the discourse of the mathematics classroom comprises the language in which the subject is conceptualized and explained and not only the register of the discipline (Barwell, 2007). Participating in the discourse of learning and explanation in mathematics classes can be challenging for multilingual pupils (Adler, 1998; Cameron, Moon, & Bygate, 1996). This is especially so when language is treated merely as a transparent conduit of mathematical thinking rather than constitutive of it (Tuveng & Wold, 2005).

According to Fang (2012) the register of mathematics consists of everyday language, abstract language (including specific technical vocabulary) and metaphorical language. For example, Laborde (1990) highlights the nominalisations, heavy noun phrases, and sequencing of information specific to mathematics while Middleton, Llamas-Flores and Guerra-Lombardi (2013) point to the use of prepositions, comparatives, and conditionals. Not only does the discourse feature complex language, but symbols and images are also prominent in mathematics (Danesi, 2003; Fang, 2012; Lemke, 2003). O'Halloran (2015) describes mathematics as the learning of a particular variety of language:

Mathematics is a multimodal semiotic enterprise, the outcome of using language, symbolic notation and mathematical images to describe and predict patterns in space, number, quantity and arrangement (2015, p.73).

Crucially, to gain membership in the mathematics discourse community, all children need to access and learn this alien language. However, such a feat is challenging for children for whom the language of learning is not dominant. Even though multilingualism in itself does not necessarily cause difficulties for children (Setati, 2005), features of varied linguistic contexts and

the status differences among languages and their speakers seem to. Difficulties for children found in research without a direct focus on identity are: reading mathematical word problems (Chan, 2005; Cheng, 2015; Martiniello, 2008), accessing language and the practices of mathematics (Gutierrez, Sengupta-Irving, & Dieckmann, 2010; Moschkovich, 2002), and receiving appropriate, responsive teaching (Adler, 1997; Khisty & Chval, 2002). From the perspective of identity building, Turner, Dominguez, Maldonado, & Empson (2013) found that a teacher's language, such as statements of validation and invitations to explain and justify their thinking, positioned bilingual pupils as mathematically competent and had a positive effect on the students' confidence.

Mathematical identities

Pickering (1995) suggests that when learners are tasked to follow the rules of the discipline, they are deprived of immediate agency which becomes located in the strength of the subject itself. This affects children's sense of progress for the future and the way they construct mathematical identities. Theorists note how the discipline itself is gendered. Mendick (2005; 2006) argues that mathematics is perceived as masculine while Palmer (2009) notes its dependence on Eurocentric, male thinking. Social and cultural conceptualisations of mathematics as a discipline orient to Western, rational thinking and to its knowledge being presented as truths, impersonal, immutable, and non-negotiable (Becker, 1995). Burton (1995), too, notes how mathematics is taught in many classrooms as inert, individualistic, and competitive.

Considering variations in the social contexts of classrooms, Leyva urges us to 'examine the influences of different contexts on students' mathematics achievement and experiences at intersections of gender and other socially constructed identities' (2017, p.426). Bishop (2012) highlights the value of analysing peer to peer discourse in researching identity construction, showing that in similar circumstances, children may construct very different academic identities.

Research into gender, agency, and identity includes Boaler's (2002) meta-analysis which demonstrates that girls strive for understanding, trying to connect rather than merely receive knowledge. Accordingly, they find it difficult to adapt to pedagogic styles which do not recognize this characteristic. Boaler and Greeno (2000) discovered a lack of agency among those in classrooms which endorsed an authoritative, remote pedagogy. In a study into gender, affect and classroom environments, Forgasz (1995) found that the salience of variations in the learning environments were different for boys and girls.

Work on gender and affect sees anxious girls feeling little sense of belonging when they are in the top set for mathematics (Solomon, 2007), girls denying their intelligence and competence (Mendick, 2005), and feeling vulnerable and fearful of not being good enough (Wolfe, 2019). Learners' stereotyped view of mathematics as a masculine discipline is evident in international research (e.g. Tatre & Fennema, 1995). Cvencek, et al. (2015) find this among Singaporean children too, as well as girls having weaker self-concepts than boys. Steffens, Jelenec, & Noack, (2010) even found that the perception of mathematics as a masculine domain was implicit as well as explicit among the girls in their study.

However, identity construction may be affected by other factors, such as class or diversity. For example, Atweh and Cooper's (1995) comparison of mathematics in two girls' schools distinct in class and neighbourhood found that teachers' assumptions about the girls' future need for mathematics led to them constructing both the subject and the female learners differently. Other studies have found race intersecting with class (e.g. Cobb and Hodge, 2002) and contrasting with out-of-school identities (Nasir, 2002). Barwell and Kaiser (2005) prefer a dialogic, inclusive approach to pedagogy in diverse classrooms.

Thus, the review of literature into children's building of mathematical identities shows both individual affective and cognitive aspects as important as well as multiple intersections of diversity, class, gender, and language. Identity construction is also affected by external factors, for example, language policies and the environment of classrooms, pedagogies, and the ways in which knowledge is constructed and presented.

Method

The project is situated in one primary school in Singapore, a multilingual context, and explores the experiences of girls learning mathematics from their own standpoints. About 1,300 pupils aged 7 to 12 attend the school. In general, their families are middle-income, speaking a variety of home languages, such as English, Mandarin and other Chinese languages, Tamil, Malay and others from the region. The project focuses on the processes by which subjectivities are produced through discourse (Bishop, 2012; Davies & Harre, 1990) in relation to the subject, its artefacts, and agents at intersections of gender and language. Although not a longitudinal study, examining different levels gives the project a developmental angle while the school's labeling of classes as mid- or high-progress highlights achievement. Thus, the study takes into account both institutionally recognised achievement and the girls' own perceptions of their participation in mathematics (Leyva, 2017).

The data for this paper are interviews with 62 girls about whom more details are provided in Table 1.

Table 1. Participants

school level	P1	P3	P5
age	7	9	11
progress descriptor	mid-progress	mid-progress	high-progress
number of girls	21	9	32
English not the dominant home language	38%	44%	22%

We chose to interview the girls in focus groups arranged by friendships and level. Although individual depth of reflection may have been compromised, we felt it important to provide the girls with a sense of security so as to encourage talk (Punch, 2002). We acknowledge that the conversations represent joint constructions and in-the-moment negotiations of girls' histories of their shared experiences of learning mathematics. They are the accepted narratives of each of the groups at different ages and achievement levels (Pole & Morrison, 2003).

Since our aim was to gain a deeper understanding of how pupils' make sense of their experiences in school, criteria for judging the project were credibility and applicability (Creswell, 2014; Lincoln & Guba, 1985). Triangulation for credibility was achieved through the collection of three datasets: lesson observations, interviews with teachers, interviews with pupils. Lesson observations contextualized the interviews, which were structured to focus on the same topics with both teachers and pupils (Corbin & Strauss, 2015), but the questions were open to allow space for reasoning and examples (Creswell, 2014). Two of the three-member research team interviewed all the girls about what they had learnt in the observed lessons and their opinions on their experiences of learning. They were also asked about their attitudes to learning mathematics, to whom they turned for assistance, the use of language in mathematics, and about differences among boys and girls in learning mathematics. Although the topics were the same across all levels, the techniques

of interviewing the seven-year-olds were more participatory, such as asking for ‘hands up’ or taking a walk while talking in order to maintain engagement.

The groups were composed of between 3 to 5 children. Each interview took from 15 to 30 minutes, depending on the number of children and their ages. The older children had more to say and were able to say more. The research was reviewed by our university’s Institutional Review Board and all procedures were followed. All the girls’ names in this article are pseudonyms.

All three members of the research team analysed the interview data, first responses that were conceptually similar were grouped and labelled within each cohort in open coding (Saldana, 2016). We derived 15 codes in the P1 data, 11 in the P3 data, and 17 in the P5 data. Second, the codes were applied across the grade levels for re-analysis into themes in axial coding (Saldana, 2016) and a process of constant comparison was employed at this stage (Corbin & Strauss, 2015; Charmaz, 2006). Four major themes were derived from the conceptual analysis: the discipline, the language, (in)security, and progress. In a third micro-analysis of the interview data (Bishop, 2012; Bloom, Power Carter, Christian, Otto, & Shuart-Faris, 2005) the themes were reread with a discourse-analytic spotlight on figurative and positional identities (Holland et al. 1998). Employing Sfard and Prusak’s (2005) criteria of endorsability and significance, we examined the way the girls jointly negotiated experience, the positions they took, and the artefacts they adopted and/or improvised - relative to themselves, others, and the discipline.

Findings and Discussion

As the girls constructed mathematical identities, four aspects of their learning emerged as endorsable and significant (Sfard & Prusak, 2005). These are the discipline, its language, the girls’ feelings of (in)security, and their sense of progress.

1. The discipline. Throughout the data, girls showed their awareness of the authority of the discipline. In their descriptions, they created an anonymous, distant community referred to as ‘they’ who set ‘tricky’ questions and ‘trick you with language’. Even at P1, Moira’s comment about the clarity in a question evidences her perplexity in subjecting to a shadowy, depersonalised authority, ‘It was clear, but it didn’t tell us you need to use the four numbers.’

Some of the girls can be heard discursively maintaining and reconstituting their group identity as unsuccessful learners in relation to the agency of the discipline (Pickering, 1995), its artefacts, and its masculine parameters (Burton, 2006; Mendick, 2005; Palmer, 2009). The artefacts particular to Singaporean primary mathematics are associated with problem solving. A major heuristic is the drawing of models (Kho, Yeo, & Lim, 2009; Ministry of Education, 2012), especially models of comparison and part-whole. The girls at P3 in a mid-progress class struggled to draw models. Although Natasha said that she found multiplication and subtraction ‘simple’ and ‘easy’, she was frustrated when tasked to apply these operations in problem solving ‘by our own’.

Extract P3 group 2A

- Natasha Because you can see right ((points to practice question)) here got the number but this one we got to fill up by our own. And then everything we got to do by our own also. We don’t know whether it’s times, divide, addition, or subtraction.
- Jessica And then I hate drawing models. It’s very hard.
and
- Natasha Yeah, and there’s two types of models//
- Jessica And I need to cut into half, my//
- Natasha ((laughs))
- Jessica My that thing is not equal equally at all.
- Natasha And for me it’s difficult because of the comparison, and...
- Diana Part-whole.
- Natasha Part-whole right. And then after that we need to cut into small pieces, one, two, three, four, five, six, seven, eight, nine, ten.
- Jessica And then my one is slanted one, my models.

The girls' conversation shows their recognition of the three-way translation of semiotic modes in problem solving (O'Halloran, 2015): determining the type of model from the word problem, translating familiar language into technical language and symbols, converting language into an appropriate image, and following the 'rules' of achieving straight lines and equal proportions for the units. However, their thinking lingers in the concrete, for example in the use of 'cut' and 'pieces' which suggest the material rather than the visual or symbolic. Each participant built the conversation by contributing their personal difficulty, interrupting each other at times. Diana suggests the word Natasha looked for and mutual agreement was developed through 'we', 'yeah', and 'right', as they described their struggle to conform to the required demonstrations of independence, understanding, abstract and visual thinking, and technical ability.

Some girls felt a loss of agency when subjected to the restrictions imposed by the discipline itself (Pickering, 1995) and its representatives, the teachers (Boaler & Greeno, 2000). When teachers questioned pupils and checked for accuracy and precision in model drawing, methods, and language, they were imagined as instruments of the discipline, exemplified in the comments about Miss T in the extract below.

Extract P5 group 2A

- | | |
|--------|---|
| Fay | And then the worst is the model. You must put like zero point five cm. One unit, it must be this one, and then you must label the question mark// |
| Grace | Yeah and then I think Miss T, she gets a ruler and measures how long our thing is, and then she says said, okay it has to be one centimeter. |
| Trisha | Yeah! |
| Fay | It's one cm short. |
| Trisha | Yeah, it's very precise. |
| Grace | Yeah. It's one centimeter short you must do it shorter! |

However, although complaining about model drawing in this extract, the P5 girls adroitly used comparative forms and precise measures of units. Indeed, Grace admitted gaining a ‘better understanding’ through the use of models. Victoria said, ‘you can visualize the question’, while for Harriet, models meant that ‘you can see the question and understand the question more’. As this group talked, they reinforced peer solidarity in the complaints while at the same time showing a mastery of mathematical discourse and models.

Positioned by their school as high-progress, many of the P5 girls expressed an appreciative, insider view of mathematical cognition. The attraction for them was the creative and intellectual potential of mathematics (Pickering, 1995).

Camelia I like math because of the questions – they make you think a lot and they help your brain grow.

Carrie It challenges our minds and it’s very fun.

Dora said, ‘it makes sense’. Angie noted, ‘the principle is the same while just the numbers change’, presenting an ability to engage in abstract thinking. Fay knew that ‘you must use the units, oh my God the units’. Tara and Fiona spoke of concepts, and for Dora, a lesson on ratio was about ‘comparing quantities’. Carrie described the experience of flow (Csikszentmihalyi, 1996) ‘by fun I mean we have a lot of questions to do, which really helps us, and it’s just very exciting to do, you want to keep doing it.’

2. The Language. The connection between dialogue, learning, and thinking theorised by Vygotsky (1962) and Sfard (2007) was significant in the data. English not being the dominant home language

of 38% of the P1 girls, 44% of the P3 girls, and 22% of the P5 girls meant that the language of mathematics was more remote for some in this multilingual environment where teaching and learning is in English. Trisha, a P5 pupil who speaks mostly Mandarin at home, made language distinct and distant by describing it as ‘proper’ and naming it the ‘English’ necessary to ‘do’ mathematics.

Extract P5 Group 2B

- Trisha In P5, they have many – they confuse you with the English, so you need the proper English to do it.
- INT Ah. Like what?
- Trisha For like fractions they – *of* the remainder, so we need to know the proper English word to do it.

Abigail of P3 commented, ‘my favourite language is Tamil, because it’s my mother language and maths is not so easy’. Her emotional connection to Tamil as ‘favourite’ contrasted with the difficulty experienced in mathematics; ‘not so easy’ shows her tacit awareness of the relevance of language in learning and yet its strangeness and her insecurity. She later added, ‘I am not so sure.’

To learn mathematics is to learn its words (Sfard, 2007) and girls showed how they had to reconsider familiar language in the context of mathematical problems (Fang, 2012).

Extract P1 Group 4A

- June We learn ordinal numbers.
- INT Ordinal numbers. Okay, that’s great.
- Esther We learned between – we learned between.
- INT Between.
- Ruth I was going to say that!
- INT Oh, Ruth, do you have anything else to add? What else did you learn?
- June Next, first, second, third, fourth, fifth.
- Esther And then ten is different from – tenth is different from ten.
- June Sixth, seventh, eighth, ninth, tenth.

Extract P1 Group 5A

- INT So why are those words important?
Anna Because it tells you after or between.
INT Ah. And how are they ordinals?
Donna Because they have *th*.

June's contribution of 'we learn ordinal numbers' prompted the girls' (Extract P1 Group 4A) development of mathematical identities through reflecting on its discourse and their collective listing of prepositions and ordinals.

Words were also important to the P5 children, most of whom showed confidence and metalinguistic awareness in the variety of positions they adopted. Angie expressed the necessity to learn 'some other word' as novel, technical mathematical language and she also acknowledged the precise significance of prepositions in the contexts of word problems (Middleton et al. 2013).

- Angie And sometimes they like tell you *of* something, you must understand what does *of* something means, and what word means what. Because sometimes they tell you a triangle is the same side but they won't say in the same side they'll use some other word, so you must like understand the word then you can do the word problem.

Camelia was more matter of fact, 'If you don't know how to read the question, then you also don't know how to solve it.' Expressing an appreciation of the language of mathematics was Dora, 'It's interesting and it makes sense... for example, the equals sign cannot be used if it is not exactly the same.'

However, some children's preoccupation with mathematical words and teachers' attempts to avoid uncertainties in language could result in reductionist, short-term pedagogies being used, such as 'key words', a technique which is unlikely to lead to understanding (Boaler, 2000). While

this confused Fay, Trisha explained how she operationalised ‘key words’ by scanning for the word indicating the mathematical operation within the word problem (Extract P5 Group 2C). She unequivocally equated ‘remainder’ with ‘times’ here, thus ritualising mathematical knowledge (Moore, 2000), short-circuiting meaning and understanding, and likely further confusing Fay.

Extract P5 Group 2C

- | | |
|--------|--|
| Fay | Like key words. |
| INT | Key words? |
| Fay | Yeah, they always say like, oh is this the right one like, money, remaining money is not the same at all and then when she asks individually and like oh, I think this is the same, she’s like no, it clearly says remainder, you know! Oh, my gosh, do you even pay attention in class? |
| Trisha | In the question they have the steps for you to do. Like in the middle, if they write the remainder, then you know that it’s times the number. |

The girls valued expression and explaining in their learning. In an account of a recent lesson on ordinal numbers that included a task in which groups of pupils had to place various pictures of animals in order based on given clues, June’s explanation of her problem-solving method constructed at interview (Extract P1 Group 4B) is neither grammatical nor technically precise. She nevertheless used the process language of the discipline to make clear her logic, evidencing the distinction between this and the technical register of the subject noted by Barwell (2007) and Sfard (2001; 2007). Her use of ‘means’ and ‘so’ show her improvising with language to justify the logic of her thinking in arriving at the ‘right’ answer. June, who speaks English at home, was not positioned by ‘proper English’, unlike Trisha in P5 (Extract P5 Group 2B).

Extract P1 Group 4B

- | | |
|--------|--|
| Esther | Yes, because then Paula, June and me and Meg, all of us we said, how are we going to figure out of tiger between |
|--------|--|

snake and monkey? But who's first? So, then we don't know who's first.

June Then I suggest the right answer. Means if there's no horse, that means – because it cannot be at the last, so dog is the last, means it must be the middle. Then the horse must be the front. I suggest that thing. Something like that.

The interview gave June space in which to express her awareness of mathematical thinking, in the same way as the group discussion around a flashcard activity did for the P5 girls. April remarked, 'it's fun'. When asked what would happen when a group member made a mistake, Tara and Phoebe demonstrated both the pedagogic value of explaining to achieve understanding as well as the affective value of the care and collaborative effort that the pedagogy enables.

Tara Um, I'll have to teach you how to do it and then explain why.

Phoebe We – our whole group explain to that person, and we will explain to her clearly and make her try to understand.

Boaler and Greeno (2002) report a similar finding and argue that discussion-based pedagogies provide girls with space to exercise agency and, as a result, build positive mathematical identities. Nevertheless, Angie was also realistic about the process, observing, 'Some people explain you can't understand, some people explain you understand more.' The girls' views show how instructional approaches involving the production of language (Turner et al, 2013) may satisfy their quest for understanding and the need to make connections, noted by Boaler (2002).

Just as might be predicted from Boaler's (2002) findings, striving to understand mathematics was a strong theme in the interviews. One barrier to understanding was to do with genre. April of P5 commented, 'They set it like a story, but then sometimes you don't get it.' illustrating Solomon and O'Neil's (1998) argument that the logic of mathematics cannot be

effectively presented in the temporal structure of the narrative genre. Another barrier was that mathematics problems may be understandable as statements of everyday situations but may not be comprehensible to pupils as indicators of mathematical practice. Jessica of P3 said, 'I don't understand what the question is asking for'. Jane of P5 remarked that 'in word problems they will use English to trick you into doing wrong things and getting wrong answers'. Understanding may also be hindered by an over proceduralisation of method leading to a loss of agency, as exemplified by Fay's characterisation of her feelings of subjugation to the procedures of the discipline.

Fay	It's because like just, sometimes it's just about the methods, we have to times this, and then you must highlight this, and then you must write down, and then if sometimes you just don't understand it but the method says so and you're just down there like ((makes a blank face)) I don't understand this.
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3. (In)security. At all levels, some of the girls experienced great satisfaction in mastering mathematics. However, the need for mastery and its performance could equally result in insecurity, disappointment, and a sense of failure. For some, especially at P3, it was the distant or unfamiliar linguistic demands; for others, it was the authority of the discipline, its artefacts and pedagogies which restricted their agency. Therefore, for some, the *process* of learning could be rough (Solomon, 2007). The imagined conversation between Fay and a teacher in Extract P5 Group 2C (Oh, my gosh, do you even pay attention in class?) reflects her struggle to connect discourse with practice (Boaler, 2002). Her envisioning also shows her feelings of misrecognition (Taylor, 1994) when this mental effort was attributed to not paying attention.

Sometimes understanding and practice were viewed as achievable but the performance of practice, that is, how to write mathematically, gave rise to confusion. Ruby identified the difficulty

as knowing ‘how to write’ to prove her capability and competence in mathematics on particular problems (Extract P3 Group 1A).

Extract P3 Group 1A

- Abigail I sometimes have a bit of problems but yesterday, I didn’t have – I mean last Friday, I didn’t have because my friend, she was – she knows mathematics very much and then she will – she can help me. And also help herself. I know what to do but I don’t know exactly what to write.
- INT Okay, so//
- Brenda Yeah, that was exactly what I wanted to say.
- May Same here.
- INT You know what to do but you don’t know what to write.
- Ruby How to write.
- INT How to write it. How to express it.
- Ruby Yes.
- INT Okay. So is it that the question is tough, or...
- Ruby Mm, sometimes it’s tough.
- Abigail Sometimes.
- INT So you have no problem understanding the question, you just – you’re not sure what to fill in there, is that right? ((points to blanks in practice questions))
- Ruby Yeah. Some the question also I get a little bit stuck, like which one am I supposed to times with like, is the same number amount like, three times of something, so I don’t know twenty times three or hundred fifty-six times three. So, I get a little confused. Or something.

The language of this extract, ‘a bit of problems’, ‘a little difficult’, ‘a little confused’, ‘a little bit stuck’, and ‘I don’t know exactly’ is typical of the girls who say they experience some distress in mathematics, hedging the extent of their confusion and its destabilising effects in the process of their learning (Solomon, 2007).

Girls attributed a direct role to friendships in their learning. Even at P1, girls were learning the logic of the subject and explaining it to each other. For example, Bobby helped Natalie by explaining, ‘if you don’t know whole right, the plus – you have part plus part will give you the

whole.’ ... ‘and whole minus part, it will give you the other part’. At P3, Natasha’s frustration from having to do everything ‘by our own’ (Extract P3 group 2A) is extended by a later report of copying from her friend who ‘will teach us a bit’. Thus, friendships in class are a resource both for learning and for building co-operative learning identities. Through girls’ own agency or through discursive pedagogies, they ‘coached’ and ‘encouraged’ each other. At P5, Carrie explained how ‘friends helped us, encouraged us’, especially in light of Kate’s comment.

Kate	Maybe if like you don’t know the question then like the topic, then you like very shy to ask teacher, then like when like group discussion, then you can ask your friends.
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The girls’ accounts from all of P1, P3, and P5 suggest vulnerabilities in classrooms where the focus is on the performance of mathematics. They also suggest that these insecurities can be relieved by pedagogies, which include discussion and which allow space for attention to the process of learning and identity building (Bishop 2012).

However, other examples, such as the key words technique referred to by Trisha and Fay (Extract P5 Group 2C) and Natasha’s copying from her friend, show how group solidarity and camaraderie interactionally built and rebuilt both successful and unsuccessful positions relative to the subject, reinforcing orientations which would perhaps lead to aligned, fossilised dispositions, therefore closing off imagination and vision for some (Holland et al., 1998).

A direct question about gender led girls to express a sense of efficacy, categorically rejecting the idea that boys are better at mathematics than girls. The general view across the levels was that mathematics as a marker of intelligence be considered an important subject for all. Comments were that there was no difference; success depended on ‘hard work’, ‘practice’, and ‘attitude’. However, at P1, Anna suggested that boys like to ‘threaten’ girls academically and a

conversation from P5 depicts a battle to enter the competitive, masculine world of mathematics (Palmer, 2009; Mendick, 2005), with Pearl showing how girls' performance of mathematics demonstrates their intelligence and overcomes any suggestion of female weakness.

Extract P5 Group 6A

INT I wanted to ask. Do you think it's true that boys are better at math?
All No!
April Definitely not.
INT Definitely not? Okay, so why do you think it's important for girls also to learn math well?
April Because girls are//
Pearl Because every time we learn maths and there's a boy coming along, and they say oh I'm smarter than you, then you have to talk back and talk about how good you are at maths. And then they ask you random maths question and you can answer it, and then when you ask them what's the answer they don't know the answer. So, you can top that person.
April You feel very triumphant.
Pearl Yeah. Yes.
INT Right, okay so you have to make sure you//
Pearl Make sure you know your rights.
INT Know more math.
April To show them that girls can do it too. Cause sometimes they're like very bad and then they say like ha, girls are very weak and everything.

4. Progress. Although positioned by their school in terms of progress, the girls evaluated themselves against the discipline and their performance on tasks and in assessments. June reported her satisfaction at suggesting 'the right answer' to the problem about ordinals in her group (Extract P1 Group 4B). In the P3 mid-progress class, Natasha positioned Jean as a 'division expert', saying, 'division is kind of hard to do, but she knows how to do it a lot'. She later highlighted again that Jean 'knows her division very well...she just knows how to do right.' Natasha's positioning of Jessica as unsuccessful, 'usually she got problems', was reinforced by Jessica herself who was

well aware of the requirements of performance in the subject and her position in relation to them shown by assessments. She partially attributed her difficulties to her insufficient command of the aspects of mathematics which need to be automaticised (Pickering, 1995). She stated, ‘because I also don’t know my times table. That’s why I’m not sure with my division.’ She expressed a sense of futility, lamenting that even when she thought she had learnt a mathematical concept, ‘no use, because when I exam and then I also fail, or fifty plus – fifty plus only.’ Thus, for Jessica, a sense of progress was elusive as the expectation of future performance in assessment seems to dominate and divert her attention from the process of learning.

However, most of the P5 girls, institutionally positioned as high-progress, exhibited the confidence of pupils who had been able to successfully navigate the figured world of mathematics. Even those who expressed negative orientations, such as Hannah who claimed to be ‘very bad at it’, April who positioned herself as ‘just average’, or Pearl’s ‘stable – not too good, not too bad’, displayed awareness of how to perform as a successful student of mathematics in Singapore. In the extract below about attitudes, although Sally referenced the inherent logic of the subject, Joey and Cathy both found a sense of security in its logic of assessment and Zoe remarked that ‘it’s the only subject that we can score hundred, like full marks.’

Extract P5 Group 5A

- INT Okay. So tell me a bit about learning math. How do you feel about learning math?
- Joey Um... math is the only subject can get full marks, cause English has oral and mother tongue also has oral.
- Hannah Composition.
- Cathy Because maths is the only logical one.
- Sally Because math is all about numbers and all that.
- INT Mm okay, you said math is the logical one. What do you mean by that?
- Cathy Like, if you know your topics then you can get all correct. Because//

Joey

If you revise your topics more you can get all correct.

Conclusion

In conclusion, this study at the intersection of language and gender in a multilingual context reveals girls' perspectives on the figured world of Singaporean primary school mathematics. As suggested by the literature as well as our data, relations between individuals, the discipline, and its artefacts were multiple, layered, and overlapping. The world constructed by the girls is depersonalised, competitive, marked for intelligence, and requires linguistic and artefactual accuracy and precision in performing process and demonstrating products of learning. In this figured world, we see how for these girls, four aspects of their learning of mathematics were significant: the discipline's requirements, its language, the girls' feelings of (in)security and their sense of progress. Girls could feel alienated by the way the subject was constructed and presented, policed by its agents, and by the need to manage its unfamiliar artifacts. Some, especially those for whom English is a non-dominant language, experienced the technical language as foreign and were powerless to improvise and understand through explanations and expression, unlike others whose familiarity with the language gave them agency. Even girls in the P5 high-progress class preferred pedagogies which offer space to dialogue. Girls aimed to understand rather than merely follow procedures so as to experience a sense of progress, yet they judged themselves wanting against perceptions of performance. To achieve, it seemed that girls had to ward off threats to their sense of mathematical selves from the necessity of competitively performing mathematics in class, in assessments, and from boys. However, security could be experienced by collaborative friendships and a sense of agency. Girls who had progressed were confident in their mastery and metalinguistically aware.

There are three clear implications for teacher education from these findings about identity and agency in the figured world of mathematics in the English-medium primary school. First, although the world of mathematics will not change, pathways into it can be reformed by recognising and accepting the pedagogies and classroom environments preferred by girls such as these we interviewed. Second, we should realise the importance of language, not only the technical register of mathematics, but the role of discourse in both learning and identity construction. Third, we conclude that the notions of figured worlds, identity, and agency have been valuable in revealing what was significant and endorsable for Singaporean girls in learning mathematics. Conceptualising learning as identity formation may ‘focus the teacher's attention on the whole person and their becoming, rather than part of the person and their knowing’ (Lerman, 2009, p.155). This refocussing will lead to attention to process and progress, as well as achievement, and so smoothen the journey into the alien figured world of mathematics for girls.

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