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The incident of the quadratic equations: Recognising exclusion

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In this paper we explore the hidden nature of girls' exclusion from mathematics in a Norwegian lower secondary school. Drawing on ethnographic data from a three-year longitudinal study, we focus on a particular incident of 'choosing' a challenging task. Viewing the incident through the lens of Figured Worlds we note how the researcher's perception of mundane acts in the classroom is expanded by witnessing a rupture within one student's narrative of the incident. As researcher and researched co-construct events, it becomes apparent that equal opportunity in the form of choice does not necessarily deliver inclusion.

Miss A has done a bit of a stupid thing with that, the quadratic equations then, when she says that not everyone is skilled enough, then it's difficult to learn such things yourself. (Emilia, 10th grade)

Emilia's words, spoken in an interview in 10th grade, signalled an apparent critique of her mathematics teacher, Miss A. Although the first author had spent over two years in Emilia's mathematics class, she had not realised that Emilia, and potentially some of the other students, did not feel that they could access the more challenging mathematics on offer. This moment in the interview became a 'breakthrough moment' which provided an opportunity to for the researchers to re-reflect on the nature of mathematics teaching and learning, and enabled recognition of exclusion in terms of gender.

Girls' exclusion from mathematics is an established issue in the research literature in mathematics education, from Walkerdine's early work (1989/1998) to more recent discussion (Jaremus et al., 2020; Radovic et al., 2018). The research reported here took place in Norway, which is known for its strong claims about gender equality. In this paper we focus on girls' exclusion from the most advanced mathematics in a lower secondary classroom. Focusing on the habitual acts that underpin expected ways of being and acting in classroom mathematics – the rules of the 'game', we address the problem of becoming aware of moments of exclusion that are embedded within the mundanity of a classroom culture, where it may be disguised as routine and innocuous. We illustrate how, in becoming aware of such moments, they may work as seeds of change, for both the researcher and the researched.

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Being a girl in the game of mathematics learning

Much research on girls' and women's experience of mathematics classrooms reports that they are excluded by the everyday actions and mundane aspects of mathematics classroom cultures in which students 'play the game' of learning mathematics. Many have recognised that girls in mathematics need to play this game differently in order to survive. For example, Bartholomew's (2002) study of high attaining groups found that girls often expressed a stronger desire to understand mathematics in order to enjoy it, and were consequently more vulnerable to the fast-paced teaching style common in such groups along with a classroom culture which "tends to marginalise many of the girls" (2002, p. 6), by its 'laddish' style. Echoing Boaler's (1997) findings that boys turn school mathematics into a game, Bartholomew (2002) argues that girls need to play the game of mathematics learning differently in such classrooms, illustrating this complexity of being both feminine and successful in her case study of Tanya, who realises that she must focus on personal progress rather than competition with others.

The intersection of femininity and mathematics achievement in a high attaining classroom is further investigated by Foyn, Solomon and Braathe (2018). They found that in this classroom culture the girls both self-policed and policed each other in order to prevent themselves from visibly performing ways of being good at mathematics through the enactment of 'natural ability' and competitiveness, which were acceptable for boys but not girls. This is exemplified in the case of Anna; like the other girls, she is 'invisible' during lessons, but her visible enjoyment of mathematics challenges and her overt interest in achieving high grades, combined with a 'boyish' performance of carelessness means that she crosses the line of what is acceptable for girls in this classroom. She pays the price for this behaviour by being called a 'nerd', while the other girls are careful to position themselves as 'not Anna'. In contrast with Bartholomew's Tanya, the high achieving girls in this classroom balance on 'a knife edge' as they focus on maintaining their positionality as good in mathematics at the same time as not exposing themselves as behaving inappropriately.

However, there might be alternatives for high achieving girls to play the game differently within a classroom culture other than taking up the ascribed positions connected to traditional femininity. This is demonstrated by Radovic et al. (2018) who notice how three high achieving girls in three different peer groups in a classroom culture relate to mathematics in different ways. They developed and negotiated their mathematical identities in accordance with their peer cluster memberships of mature/ popular/hyper-feminine, 'Korean/weird', and normal/quiet girls/loud boys, taking up a variety of stances on mathematics - as effortless/effortful, as a natural ability, as different, as male. The groups also related to what they valued about doing mathematics - independent and collaborative, wider and complex, straightforward and procedural (p. 449). Thus, they combined being female and good at mathematics differently within peer groups that existed on the margins of the classroom culture. Radovic et al. (2018) conclude, by drawing on a nested model of

identity, that “peer relations had a central role in mediating each girl’s [mathematical identity]” (p. 457).

In these studies, there is no indication that girls explicitly recognise their situation as one of potential exclusion, compromise or difference. Solomon’s (2012) study of Roz, a female mathematics PhD student, explores the nature of reflexivity in her account of her experience of being a woman in mathematics, and how her resistance to ascribed positionality may lead to a change. Roz describes her struggles with mathematics and her challenges to the dominant discourse of male competition, storying herself as part of a collaborative group of female students who raise a counter-voice to traditional values in mathematics. However, a contradiction in Roz’ story emerges when she explains her success in mathematics as due to having a ‘male brain’, despite her claim that you “don’t have to give up being a woman to be a mathematician” (p. 180). Solomon argues that conflicting voices such as these are indicative of a struggle to find a space combining being a woman and a mathematician, and that “there is no easy link to be made between the reflexive accounts of gender and ability and a change in the (self)positioning of women in mathematics” (p. 181). However, she argues that recognising the inevitable existence of multiple voices indicates that there are possibilities for creating new meaning: “‘figuring it otherwise’ is still on the agenda” (p. 182).

The studies reviewed here raise the issue of the extent to which girls may become aware of their positioning in mathematics, and the potential for reflexivity as a result of such awareness. In this paper, therefore, we address the research question: How is exclusion brought to consciousness, for researcher and researched?

Theoretical framework: bringing the unconscious into awareness

In this paper, we draw on Holland, Lachicotte, Skinner and Cain’s (1998) theory of Figured Worlds in order to understand classroom cultures. The concept of a figured world draws attention to the role of norms and the significance of certain behaviours; it is a

socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others [...] moved by a specific set of forces. (Holland et al., 1998, p. 52)

A figured world is constituted by the actors within it, over time. Newcomers to the world learn which acts give value over others, what are the significant markers of positionality, and how power and privilege are distributed. Everyday happenings in the figured world become the frame for how to act and how to construct the meaning of actions, embedded within the mundane happenings that routinely take place:

A figured world, too, is played out; a frame becomes a world—a space and time established imaginatively—that one can come to sense after a process of experiencing, acting by virtue of its rules [...] Players become ever more familiar with the happenings of a figured world (...) and learn to author their own and make them available to other participants. By means of such appropriation, objectification, and communication, the world itself is also reproduced, forming and reforming in the practices of its participants (Holland et al., 1998, p. 53).

The rules and norms of positionality in a figured world are played out unconsciously for much of the time. However, sometimes, actors experience events – ruptures – that lead them to become conscious of the position they have developed, and which has been so far out of awareness. Holland et al. (1998) notice that this moment of realisation may happen in different ways: people may become aware of their positionality within the figured world, through a process of realisation of their entitlement or lack of entitlement, which have become habitual within the mundanity of the figured world. Or it can happen through more dramatic incidents, as sudden activities or happenings that radically affect their entitlement in accordance with social position. Either way, new consciousness of one's positionality may lead the actor to reconsider their access to acts, leading to a possibility of affecting their own behaviour, including active resistance to such positioning. Thus, positionality within the figured world is

more or less conscious, more or less habitual, moving sometimes out of awareness, toward fossilization, and at other times toward consciousness and susceptibility to manipulation (Holland et al., 1998, p. 237).

Since a figured world is reproduced by the actors in that world, there is always the possibility of changing the rules of the game, but this is dependent on becoming conscious of those rules. Holland et al. note that

Ruptures of the taken-for granted can remove these aspects of positional identities from automatic performance and recognition to commentary and re-cognition. [...] Some signs of relational identity become objectified, and thus available to reflection and comment [...]. Alternative figurings may be available for interpreting the everyday, and alternative ways of figuring systems of privilege may be developed in contestations over social arrangements. (Holland et al., 1998, p. 141–142).

Awareness that we occupy an unfavourable position which derives from the mundanity of the figured world is of crucial importance for 'figuring it otherwise' and moving towards a new figured world. These new worlds may just be images of how things should not be, a counter-world that is not necessarily played out. But this may be the seed of a new reflexivity in assessing how things are. In this paper we consider how rupture may not only function as a potential catalyst for one girl's reflection on her position in a mathematics class, but may also provide an insight for the researcher into the what lies beneath the mundanity of classroom events.

Methodology

This paper draws on a three-year ethnographic study of a mathematics classroom in a lower secondary school just outside Oslo, with students drawn from mid to high socio-economic backgrounds, conducted by the first author. Employing the lens of Figured Worlds provided a means of capturing the values, norms and frames of 'Class A' as the students and their teacher moved together through the years from grades 8 to 10. Conducting an ethnography in these circumstances means that the researcher herself is at least partly an actor in the figured world, providing various opportunities but also constraints. In this paper, we see that

everyday happenings may come to be what is expected, meaning that it is possible to overlook moments of exclusion.

A variety of data were collected in this study. Fieldnotes in every lesson aimed to record habitual acts and mundane activities and map students' relationships with the teacher and each other. They also aimed to capture the students' enactment of their relationships with mathematics as they moved around the room. Focus group interviews with the students while they were in grades 8 and 9 provided a broad information base about their shared beliefs about mathematics and what it was like to be a mathematics student in Class A. These accounts of Class A were supplemented by interviews throughout the 3 years with their teacher, Miss A, who played a significant role in this figured world as the bridge between the students' classroom lives and the world of education policy and assessment. Copies of Miss A's records throughout the period provided insights into her view of students' performance and progress, along with twice-yearly test results. Students themselves provided further data in written reflections after the end of year tests in 8th grade and 9th grade.

Individual interviews with the students in grade 10 aimed to capture their personal histories and individual accounts of Class A. As Braathe and Solomon (2015) argue, agency is enacted within the interview through the co-construction of a dialogue; this has particular significance in this paper in terms of its role in creating a space for recognition. In this paper, we focus on the interview with one student, Emilia, set against the backdrop of the figured world of Class A and a particular incident recorded in the fieldnotes. Analysis focuses on the role of rupture and recognition, and on reflexivity for both Emilia and the first author.

The incident of the quadratic equations: How exclusion is hidden in plain sight

The incident of the quadratic equations occurred in a 10th grade lesson on algebra and reduction of fractions. During this school year, and perhaps in response to pressure to ensure good grades in the national tests at the end of the year, Miss A had begun to bring extra problems which extended beyond the level targeted by the textbook the class was using. On this occasion, she presented a worksheet on quadratic equations, telling the students that these problems were for those who wanted to challenge their understanding of simplifying algebraic fractions by factorisation and who were confident they were able to cope with the most difficult questions in the textbook. The lesson continued with business as usual. The students chose freely what task level they would work on; most worked in their usual places, while some asked permission to move in order to work with students who were different from their neighbour.

From her vantage point in the classroom, the first author noticed that the only students who chose to work with the quadratic equations were a group of boys. She had learned from conversations with Miss A that these boys were called the 'smart boys' due to their high grades and their obvious (and sometimes noisy) interest in mathematics. Several students had mentioned this group of boys in their interviews as being 'quite a lot better than the

Ross and Alexander ('Smart boys')

Ross: works concentratedly on his own and raises his hand to ask me for assistance. He works on factorizing algebraic expressions using knowledge of the quadratic equations to reduce fractions. He is focused and thoughtful in our talk, and our conversation is about how to know when to use quadratic equations. He gives an impression of both enjoying and understanding the conversation

Alexander: works on his own on factorizing algebraic expressions using knowledge of quadratic equations to reduce fractions.

I 'look over his shoulder' to see how his work is going. What he has done in his workbook seems to be correct, and he gives me the impression that he has no need for assistance. I

Figure 1: Fieldnotes on two 'smart boys'

Emilia, Eva and Sarah

Sitting next to each other, work on tasks in the textbook – on level 2 tasks out of 3 levels. Do task after task checking the 'fasit' [solutions] and seem happy when it's right and carry on. I ask why they choose level 2 tasks, Sarah and Emilia reply that it is to be sure they get it right.

Figure 2: Fieldnotes on three girls

others' and 'at a higher level'. The rest of the students chose to work on problems in the textbook. The first author took field notes, as in Figures 1 and 2. At the time, the events recorded in these field notes were not seen as anything special; rather, they seemed to be just examples of everyday happenings in Class A, descriptions of habitual acts rather than of an incident as such. At most, they were seen as reflections of a pattern of test results which showed that the 'smart boys' achieved consistently high grades across the years; although two of the girls in Figure 2, Emilia and Sarah, were high achievers with scores of 5 on a 6-point scale, they did not score the 6's which were seen to define the 'smart boys'. At this point in time, the field notes had no singularity and no apparent significance among the other data. However, something happened to change this situation, and they became significant as part of our understanding of the impact of norms in the figured world of Class A.

Emilia's story

Emilia's words create a rupture in this perception of events as inconsequential. They are themselves a rupture in her otherwise positive narrative, which tells of her long-term love and enjoyment of mathematics, and indeed she is good at mathematics according to Miss A's account of her grades. Her story prompts a new view of the habitual acts in the figured world of Class A, drawing attention to how these field notes were describing more than the enactment of apparently innocuous choices. Her words describe a moment of exclusion from

the most advanced mathematics, situating the field notes and revealing the significance of what lies behind them, enabling the researcher to see through her eyes to what is hidden in plain sight.

Emilia stories herself as the main actor in her narrative, generally responsible for her own actions in Class A. Her story circulates around how she manoeuvres within the dynamics of this figured world to find a way to do what she needs to do in order to understand, which is important for her if she is to enjoy doing mathematics: “I need to understand what and why I’m doing it somehow, [...] get it [the work] done and for it to be fun”. Her need for understanding makes it important that she can ask questions, but she hesitates to do so in some whole class situations:

if we’re at the start, a startup, in a new topic, then it might be useful [to ask questions], but not if we’re in the middle of a new topic and I don’t understand it, because then, I don’t know why, then I just don’t understand it, because then it goes very quickly on the board, because then they go through it so fast.

It seems that there are others in the class who set the pace of teaching in these plenary sessions, described here by the unknown and distant ‘they’, and the pace means that she cannot or does not choose to ask questions. She adds that she prefers to ask Miss A questions afterwards instead, and this is a first indication that her situation in Class A is not as straightforward as it may seem.

Emilia says that she enjoys the freedom in Class A that means that she can choose for herself who to work with: “I like it the way we do it, because we know best who we like to collaborate with, and then we can choose more ourselves.” This also applies to choosing the level of problems to work on, but tensions in her rationale for this emerge. She says that at school she works on easier problems than those she does for homework: “then I choose a bit more advanced”. It turns out that, at school, working with the boys means that she can challenge herself, because they are more competent than the girls – “some of the boys are very smart, and sometimes I like to work with them occasionally because some of them have a lot more skill than many of the girls” - but the pace of work that she knows from the plenary holds her back. As she says, “I need to ask my questions during the explanations”, and she prefers to work with her friends (the girls), even though “it might not be that smart, because I don’t get to challenge myself that much”. Despite these ‘ifs and buts’, Emilia doesn’t blame anyone or express dissatisfaction with her situation in the classroom. This is in keeping with how she has acted since 8th grade, matching the first author’s impression of her as a student who easily adapts to situations and rarely speaks out to express a negative opinion. But at the end of the interview, when asked if there is anything she would like to change about mathematics in Class A, she says there is:

Miss A has done a bit of a stupid thing with that, the quadratic equations then, when she says that not everyone is skilled enough, then it’s difficult to learn such things yourself.

Her critique of Miss A is unexpected, and creates a rupture in the genre of her talk so far. Suddenly, Emilia starts talking about grouping according to attainment in the classroom, and why she thinks this is a good idea, because it might provide opportunities for people like

her; groups would enable the teacher to work with “those who struggle with one thing to go through it with them. And those who are at a high level might learn something new”. Furthermore, even though just some minutes ago she had emphasised that she enjoyed the freedom of choice that Miss A provides, she says that she should take control over this. This unexpected outburst and its associated contradiction strikes the first author the moment it is articulated, revealing that Emilia doesn’t see herself as having access to the same mathematics as the smart boys. When she is asked if she has learned about quadratic equations, she laughs and says: “No, I never understood it, but then we haven’t had any tasks with it, or we’ve had it, but I found another way to solve it.” It seems that she has some level of awareness that she is missing out on the more advanced mathematics, but she plays its importance down:

I’d love to learn how to understand maths better, but that’s not one of the most important things I’m thinking of now, because I know we’re going to learn it in high school.

Discussion: Gender breaks out of mundanity

Emilia’s unexpected critique of Miss A captured Emilia and the first author jointly in a moment of co-construction of awareness, but in different ways and with different outcomes. For Emilia, this incident and its telling may have signified just a beginning of realisation. Without knowing what happened next, it is difficult to argue that this is a moment of realisation for Emilia, but it is possible to claim that it had the potential to lead her towards a new consciousness of her lack of access to the most challenging mathematics in the figured world of Class A. As Holland et al. (1998) point out, actors may experience events – ruptures – that lead them to become conscious of the position they have developed and which have been so far out of awareness. In this case, Emilia’s articulation of the incident of the quadratic equations may play a part in a process of realisation of her lack of entitlement, until now embedded within habitual acts but now revealed in a first step to ‘figuring it otherwise’. Perhaps Emilia is a younger version of Solomon’s Roz, noticing injustice and articulating it, even if that articulation is contradictory and incomplete. For now, perhaps, the event is perhaps just “available to reflection and comment” (Holland et al., 1998 p. 141), and she improvises a response in terms of future opportunities for learning rather than addressing the present.

For the first author, although (or perhaps because) she had been a partial actor in the figured world of Class A for some time, and as such had not recognised the presence of differential access to more advanced mathematics, this incident was much more dramatic; it ignited a rethink of what underlay these mundane acts in Class A. Reflecting on this moment in the interview, we realised that Emilia’s comment that she enjoys the freedom to choose who she works with and what they work on, while at the same time saying that she thinks the teacher should decide, is not the contradiction it appears to be. Her words suggest that she wants the opportunity to choose, but her story shows that she pays a price for the choice. If she chooses to work with the group of ‘smart boys’, she has to work in their way; consequently, she chooses to work with the girls on less demanding problems, even though

she would like to challenge herself more. Emilia's manoeuvring within this frame in order to keep hold of her enjoyment of mathematics is reminiscent of Bartholomew's Tanja: Emilia improvises so that she can play the game of mathematics differently from the hegemonic frame which supports her male peers at the same level.

Exposure to Emilia's view of the incident of the quadratic equations forced a re-reflection on what we had understood so far about the norms of positionality and access to what were deemed significant acts in Class A. It also provides a context for a possible interpretation of the gender differences in the attainment scores in favour of the boys in this class. As the field notes show, the first author had noticed that Emilia and her girlfriends did not choose to work with the quadratic equations, choosing to work instead from the textbook, even though they were high achievers. Emilia's story gives more colour to the picture of Class A, in particular its norms of positionality and their effect on her sense of entitlement to work on the more advanced mathematics – it can and must wait until she is in upper secondary school. What this reveals about an apparently simple difference in results is that there may be exclusion in Class A which goes beyond what appears to be just *self*-exclusion. The incident of the quadratic equations, seen from Emilia's complex perspective, makes it possible to understand how gender positions the students in this classroom differently. It provides a glimpse into how equal opportunity defined as freedom of choice does not mean equity for male and female students in Class A.

The incident of the quadratic equations illustrates how the norms of a figured world may be unconsciously reproduced and out of awareness. As Holland et al. (1998) emphasise, awareness is the first step towards change. For the researcher, recognising exclusion that is embedded within the mundanity of a mathematics classroom may be difficult when one does not experience the classroom culture from the perspective of the disadvantaged. But Emilia's participation in the co-constructive space of the interview enabled us to recognise what was hidden in plain sight. Exposing and opposing exclusion, raising one's voice and rejecting the rules, is difficult from a position of disadvantage, as in the case of Emilia. This makes it even more important for researchers in mathematics teaching and learning to be conscious of how to capture aspects of exclusion that may be embedded within the mundanity of classrooms, as hidden rules of the game. Researchers employ a space that enables us to use our voice, unlike those students who experience exclusion, and we are ethically bound to do so, especially in contexts where, like Norway, equal opportunities with respect to gender are seen to be no longer a problem.

References

- Bartholomew, H. (2002). Negotiating identity in the community of the mathematics classroom. In P. Valero & O. Skovsmose (Eds.), *Proceedings of the 3rd international MES conference* (pp. 1–11). Copenhagen: Centre for Research in Learning Mathematics
- Braathe, H. J., & Solomon, Y. (2015) Choosing mathematics: The narrative of the self as a site of agency. *Educational Studies in Mathematics*, 89, 151–166. <https://doi.org/10.1007/s10649-014-9585-8>

- Boaler, J. (1997). Reclaiming school mathematics: The girls fight back. *Gender and Education*, 9(3), 285–305. <https://doi.org/10.1080/09540259721268>
- Foyn, T., Solomon, Y., & Braathe, H. J. (2018). Clever girls' stories: the girl they call a nerd. *Educational Studies in Mathematics*, 98, 77–93. <https://doi.org/10.1007/s10649-017-9801-4>
- Holland, D., Lachicotte Jr., W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge: Harvard University Press.
- Jaremus, F., Gore, J., Prieto-Rodriguez, E., & Frey, L. (2020). Girls are still being 'counted out': Teacher expectations of high-level mathematics students. *Educational Studies in Mathematics*, 105, 219–236. <https://doi.org/10.1007/s10649-020-09986-9>
- Radovic, D., Black, L., Salas, C. E., & Williams, J. (2018). Being a girl mathematician: Diversity of positive mathematical identities in a secondary classroom. *Journal for Research of Mathematics Education*, 48(4), 434–464. <https://doi.org/10.1007/s10649-018-9819-2>
- Solomon, Y. (2012). Finding a voice? Narrating the female self in mathematics. *Educational Studies in Mathematics*, 80, 171–183. <https://doi.org/10.1007/s10649-012-9384-z>
- Walkerdine, V. (1998). *Counting girls out: Girls and mathematics*. London: Falmer Press. (Original work published 1989)