# Using real-life context to mediate mathematics teaching and learning

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This paper presents a joint early stage analysis of data from a doctoral pilot study and the Mathematics for Education & Industry (MEI) funded 'core maths' project, which explored the contextualization of real-life problems in the teaching and learning of mathematics in post-16 core maths classrooms. The study considers the 'criticality' or 'criticalness' of students' intuitive mathematical reasoning on problem-solving real-life problems through dialogue generated between students, and teachers during lesson study sessions. Bakhtin's philosophical orientation concerning dialogue and difference, captured in a methodological application called 'dialogism', offers significant insights to classroom discourse. To Bakhtin, dialogue, as an antidote to monologism, generates a difference and, as a consequence, has the potential to expand students' capacity to cross individual borders. Case study data was collected from two sixth form schools and an FE college, with real-life context mediated pedagogy as the overarching research theme. Initial findings suggest that dialogism and dialogical pedagogical practices in this context have the potential to develop students' critical mathematical thinking (CMT).

**Keywords: critical mathematical thinking; core mathematics; classroom discourse; Baktin's dialogism; teacher pedagogy**

## Introduction

Mathematics take-up for post-16s in UK colleges is a current public policy debate. In England, continuation study in mathematics is very low compared with other OECD and Asian countries (OECD, 2010). Policymakers advocated that a new mathematics curriculum is needed, that will provide a better grounding for students with a grade C and above in GCSE mathematics. The necessary mathematical skills and knowledge that will transcend their current mathematical knowledge position (Gove, 2011 In MEI, 2013), and to improve confidence level, in order to encourage their continual participation in mathematics education right through to the age of 18. Gower (2012 In MEI, 2013) proposed Critical Core Maths, a mathematics-based thinking curriculum for level 3, to address these policy goals. Its design seeks to further encourage students to develop, beyond GCSE mathematics, the knowledge, skills and understanding in mathematics and statistics they need to become educated citizens in the context of today's society. This includes the ability to draw conclusions from data and critically evaluate conclusions, which are put forward by others. As such, students' mathematical thinking skills will be developed from "problem-solving" real-life problems through dialogue. That is, mathematical dialogue will be initiated from real-life problem context rather than starting from the mathematics (MEI, 2013; Stein, Engle, Smith, & Hughes, 2008). In essence, students will be able to reach mathematical optimality based on their 'criticality' or 'criticalness' as informed by classroom dialogue.

Moreover, criticality' or criticalness is a manifestation of critical maths education, which refers to a set of concerns mainly to do with the social and political aspects of maths learning (Skovsmose & Säljö, 2008). It is concerned with providing access to mathematical ideas for everybody irrespective of their social class and the development of critical citizenship. It is concerned with classroom dynamics, which represents a democratic forum based on ideas being presented and negotiated (Skovsmose & Nielsen, 1996). With these concerns in mind, criticality or criticalness, as developed in a core maths classroom, would involve complete students and teachers' autonomy in engaging in mathematical dialogues. Students simply being critical of each other does not necessarily imply criticalness but rather criticality could be achieved through complete students and teacher-dialogue autonomies that are guided by a combination of *context, meaning, the mathematics in action* and *critique*.

## Theoretical framework

The research is guided by Bakhtin's (1981) dialogic philosophy, which embraces the essence of the dialogic relationship between participants. Dialogue is therefore seen as on-going social process of meaning making that occurs between participants – students and teachers and between students themselves. Hence dialogism represents a methodological turn towards the reality of communication, in all its many language forms. Emphasis is simultaneously placed on the location of dialogue within the place where opposing concepts interact with each other to generate new meaning that goes beyond, and draws from more than one discourse alone.

Mathematics classroom is a complex environment (Hoyles, Noss, Kent & Bakker, 2010; William & Wake, 2007) but, through the lens of Bakhtin's dialogism, offers a novel way of meaningfully accessing the critical mathematical thinking skills of students and the interaction within students themselves, and with their teachers. Teachers and students now become subjects and the interactions and dialogue between them constitutes dialogism. The context and the mathematics is what 'feeds' the social process of students' critical mathematical thinking formation.

## Methods

The research was conducted in post-16 core maths classrooms between March and May 2015 in two sixth form schools and a further education (FE) college. Each school or college typically has three teachers that consist of a *host teacher* (the base for that particular lesson study) and two *visiting teachers* from other participating schools or college. Given the exploratory and complex nature of this research, a mixed mode and mixed method research (Johnson & Onwuegbuzie, 2004) within a case study design, was used to explore areas of interests.

The case study employed a Lesson study approach to data generation, with specific focus on the planning stage, the lesson delivery and post-lesson analysis. Qualitative data was collected through observations, audio recording, lesson artefacts and research notes from the researcher and visiting teachers. This data collection was within the planning stage, a two-hour lesson delivery stage and part of post lesson analysis stage that typically involves semi-structured interviews in a 45 minutes group interview session with the three teachers. Quantitative data on the other hand, was collected though questionnaires (students' and teachers') from the post lesson analysis stage. In all, seven teachers and 19 students from two different lesson study groups were directly involved in the study. MEI surveyed other teachers and students involved in other parts of the lesson study, bringing our total sample as follows: data

from interviews (N=7) and questionnaires (N=171). As such, two analytical methods were used: qualitative data was analysed thematically using Miles & Huberman's (1994) data analysis flow model of data reduction, data display and conclusion drawing. Additionally, since a pragmatic research philosophy was adopted, quantitative data analysis will be used to validate or explain the qualitative results.

## Analysis

The qualitative data was thematically analyzed using Miles and Huberman's (1994) data analysis flow model of data reduction, data display and conclusion drawing. The discourse focuses on students' critical mathematical thinking skills as informed by teachers' use of real-life contexts in mediating mathematics teaching and learning through different pedagogic practices.

### *Data reduction*

Data from observed lessons and other data collected in the study, we identified three overarching themes that we can organize our data around: *context and mathematics*, *CMT* and *pedagogy*. Codes relating to each theme have been established and mapped onto the data accordingly. The researcher is aware that codes are a starting point for analysis and can become complex as the data pool grows. The process began with an initial examination of data, based on recurring relative phrases/sentences and meaning with respect to the researcher's own interpretations of their relevance to the identified themes. Hence, the data reduction process involve in part, as I have described and serves as a useful strategy for organizing and summarizing data to reveal patterns and relationships from multiple data sources (see Table 1 below).

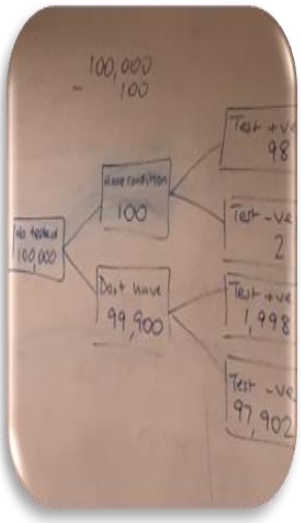
| **Themes** | **Codes** | **Data Sources** |
|---|---|---|
| Context | *Lie detector, leprosy, Medical screening, Pregnancy, Drug, DNA and Cancer tests.* | Audio-recordings; Lesson artefacts; Observations; Visiting teachers notes; Researcher's notes; Post-lesson analysis; |
| Critical Mathematics Thinking | *Only about 99.9% accurate; picks up heart rate doesn't necessarily mean it's true and that could even distort the results; 70 days without been diagnosed, 10 cases in the UK that have been left like that long with the disability because they've not been traced; their original result was false negative; The probability a random person's DNA would match, calculated to be 1 in 1 000 000; Potentially fatal; criticizes fatality; I think it's like 95% accurate; probability tree diagram;* | |
| Pedagogy | Teacher initiated context – question and answer, Student initiated context – students dialogue | |

Table 1: Data reduction process

### *Data display*

An analyzing matrix was used as an example data display in order to show how data was generated from the different methods as related to a particular theme. For example, it allows for the identification of pedagogic related practices in lessons with related contexts, and the ensuing CMT. Teacher generated contexts and students

ensuing critical mathematical reasoning, were used as a starting point for discussion. Then we subsequently discussed student generated contexts and their critical mathematical reasoning as a result. Please see table 2 below for how multiple-sourced information from different data sets have been identified through codes, which are then collated and organized to reflect the theme of 'critical mathematical thinking.

| **Theme: Critical Mathematical Thinking (CMT)** | | | |
|---|---|---|---|
| Coding similar phrases, meaning and patterns | | | |
| Data Source (i): Audio-recordings of lesson session with images of artefacts. | | Data Source (ii): Post-Lesson Analysis group interview with teachers | |
|  Student workings (Probability tree diagram) | Discussions on Screening: extract from lesson the introduction: *"The govt. has a screening program for a potentially fatal medical condition which is thought to affect 1 in a 1,000 of the population. If the test was 98% accurate, and 100,000 people are tested, how many would test 'false positive' that is test positive but be free of the condition?"* (Host Teacher). | *I meant the issue was that we were meant to be seeing whether they were talking maths.. .yeah they were talking maths. And there was a lot...I wrote down she talked about reliability of test, they brought in the lie detector which was significant.* (Visiting Teacher 2). | *They talked about pregnancy and DNA tests, which I thought has relevant meaning …they talked about testing for the right things* (Visiting Teacher 2). |
| *A potentially fatal medical condition; ….potentially fatal…; Yes keywords are they? We miss out keywords from questions; 'potentially' makes a big difference to 'fatal'..; You can have a potentially fatal car crash...but that doesn't mean you going to die...or you can have a fatal car crash and you can die...so that word potentially is pretty important...; doesn't* | *It's like a lie detector test; Only about 99.9% accurate; But just because they manage to pick up heart rate doesn't necessarily mean it's true…that could even distort the results*...(Student 2). *What about pregnancy test...I was like pregnant at the time…so many girl are pregnant lately; We were talking about how accurate a pregnancy test is;* | *It's certainly mathematical thinking….whether or not it's doing something calculation is a different issue entirely…; It is convincing students that maths doesn't have to expect numbers always...* (Visiting Teacher 1). | *...it's a discussion around 'the potential' that is part of the maths because it is how reliable... It's not black or [white] so when you say 98% Because you said you are going to die because you got it...and then they said well it is 98%...but* |

| | | | |
|---|---|---|---|
| *mean you're definitely going to die...; So give me an example of a potentially fatal condition?* (HT-S). | *Think it's like 95% .It's pretty high anyway*. (Student 1). | | *actually it is 98% of potentially fatal.* (Visiting Teacher 1). |

Table 2: Matrix of collated data from multiple sources

The matrix in table 2 shows synthesized data collated from multiple sources that include: lesson artefacts, audio recording of lessons, and audio recording from post-lesson analysis. This is to demonstrate relationships between context and mathematics, and pedagogy with critical mathematical thinking skills. Reorganizing and displaying data collected from multiple sources in this manner, provides high levels of meaningful information (phrases and patterns) that are related to the overarching themes and allows for conclusion drawing (Miles and Huberman, 1994).

### *Conclusion drawing and verification*

Miles and Huberman (1994) data analysis flow model was used as a qualitative analysis technique in the order to reduce and organize data into relevant themes. By employing this coding approach, the researcher hopes to reveal patterns of context and critical mathematics and then initiates conclusion drawing by discussing these patterns and the relationships as supported by the data. Also, meanings that began to emerge are then tested across the multiple data sources to confirm plausibility as table 3 shows the summary of findings replicated in the data generated from the lesson and post-lesson analysis sessions in order to identify the relationship between context and CMT as informed by students or teachers.

| **Theme: Critical Mathematical Thinking** | |
|---|---|
| **Teacher Initiated Model (TIM)** | **Student Initiated Model (SIM)** |
| 1. Teacher generated context based on their own life experiences<br>2. Based on questioning – question and answer sessions<br>3. Teacher heavily involved in the discussions and seen as the authorial figure<br>4. Practically controls the debate and hence, limiting students potential CMT skills<br>5. Limited discourse - monologue | 1. Student generated context based their own life experiences<br>2. Based on dialogue between students<br>3. Teacher mainly out of the discourse where students see themselves as equals – dialogue becomes personalized and internalized.<br>4. Students were able to generate more relevant contexts because of this parity and as such, critically mathematically minded<br>5. Rich discourse with a difference – dialogue |

Table 3: Critical Mathematical Thinking theme and conclusion drawn from relevant data

## Discussion and conclusion

Data from the lesson and post-lesson analysis sessions supports the emerging discourse in relation to students' development of CMT, in that the context is a critical part of the relationship. That is, the critical' in this 'critical mathematics' lesson did not arise from the 'mathematics' as such, but rather from the contextualized dialogue of the 'screening' contexts (some of which were introduced to the lesson by the

students themselves, e.g. pregnancy-testing). Bearing in mind that this research is positioned within a theoretical framework that discusses context mediated mathematical learning in a core maths classroom, as informed through dialogue. The context informs the mathematical dialogue between students in order for the development CMT. Hence, the dialogic contextualization of the medical screening context in this case was consequential for students' becoming critical mathematical thinkers. In effect, students make every day real-life connections to mathematics and maths becomes consequential to their lives. Dialogue becomes a profound and on-going activity that strengthens personality rather than being seen as an end in itself. It is within this difference (*monologism and dialogism*), and its altering potential, that the critical mathematical thinking meaning making, can be located.

## Acknowledgement

This paper was based on the researcher's PhD pilot study and the Mathematics for Education & Industry's funded core maths project, under the supervisions of Professor Julian Williams and Dr Maria Pampaka, both of the University of Manchester.

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