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Using digital tools in language diverse mathematics classrooms

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In this paper, interviews with teachers and preservice teachers are analysed to understand their views about using digital tools in mathematics classrooms, connected to language-diverse students': communication; potential for learning; and available identities. When digital tools were seen only as providing ways to utilise the home language so that existing mathematical knowledge could be used to complete tasks in the language of instruction, then language-diverse students' available identities were reduced to becoming like their non-immigrant peers. In contrast, when digital tools were considered as providing opportunities for utilising a wider range of their language resources, then preservice teachers broadened their views about language-diverse students' potentials for learning and available identities.

Keywords: Digital tools, multilingual classrooms, teachers, preservice teachers.

Introduction

Researchers have suggested that digital tools, both software and hardware, can facilitate language-diverse students learning mathematics (Le Pichon et al., 2021; Freeman, 2012). However, most research, such as that of Le Pichon et al. (2021) and Freeman (2012), used individualised computer programs, which provided instruction in the home language. The rationale for these studies was often based on teachers needing support in interpreting students' mathematical work, because with the "variety of languages present in the classroom, teachers do not always have the necessary tools and expertise available to appeal to every pupil's home language" (Van Laere et al., 2017, p. 98). These approaches raise two concerns: teachers became almost redundant in the teaching process; and only the student's home language was considered a resource for learning mathematics.

Yet, as Libbrecht and Goosen (2016) stated, "the introduction of ICTs into mathematics teaching brings different ways to express and perceive mathematical activities, concepts, and phenomena" (p. 217). For example, dynamic geometry programs, such as GeoGebra, are considered as providing easy manipulation of multiple representations, "the use of dynamic representations promotes geometric thinking and provides visual, algebraic and conceptual support for the majority of students" (Dockendorff & Solar, 2018, p. 67). Thus, digital tools could utilise language-diverse students' range of resources for learning mathematics, because the different modes, such as graphs and symbolic algebra, contribute to meanings about a mathematical idea being developed. Nonetheless, little is known about how teachers use digital tools to support language-diverse students to activate their repertoire of resources. In this study, we analyse interviews with teachers and preservice teachers about using digital tools to support language-diverse students to learn mathematics.

Knowing what teachers do and the possibilities that they see for using digital tools to teach mathematics in multilingual classrooms is important for designing appropriate teacher education courses and professional development experiences. In Norway, concern has been expressed that

teacher education is not providing adequate support for preservice and inservice teachers to incorporate digital tools into their teaching (Søby, 2013). A survey by Guðmundsdóttir and Hatlevik (2018) of newly-qualified teachers found that nearly half felt that their professional digital competency was poor because of poor initial teacher education. Yet, in the most recent Norwegian mathematics curriculum “digital skills” are highlighted as one of five “basic skills” for students, with programming being a required part of mathematics education in schools (Kunnskapsdepartementet, 2019). As well, concern has been expressed about mathematics teacher education, in Norway, providing adequate support for preservice teachers to facilitate language-diverse students to utilise their language resources (Rangnes & Meaney, 2021). Therefore, there may be a mismatch between what language-diverse students need from experiences with digital tools, both for learning mathematics and for later life, and with what teachers know how to provide. Thus, designing appropriate courses for preservice and inservice teachers is important based on what they already know as well as what they do not know.

In this paper, we explore how teachers and preservice teachers (PTs) consider digital tools could be used in multilingual mathematics classrooms. As so little research has been done in this area, there is a need to scope the field and identify what kinds of connections can be made between language-diverse students, digital tools and mathematics teaching and learning. The data is from five individual teacher interviews and one focus group interview with five preservice teachers. For the analysis, we use a theoretical model from earlier research (Rangnes & Meaney, 2021) to describe some of the complexity of teachers’ views.

Theoretical framework

The “multimodalities, signs and signs-maker in a social context” (MSSM) model was developed as part of a larger project exploring how preservice teachers learn about teaching argumentation for critical mathematics education (LATAACME) in multilingual classrooms. This model is designed to understand how respondents, such as teachers, describe the possibilities they see as being available to another group, such as students, when particular resources, such as dynamic geometry and Minecraft, are considered to be vehicles for carrying meaning – semiotic resources.

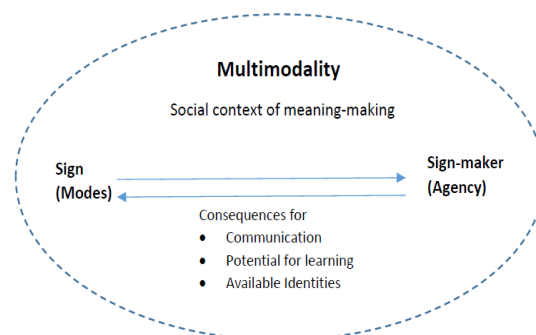


Figure 1: Multimodalities, signs and signs-maker in a social context (Rangnes & Meaney, 2021)

MSSM was built on Bezemer et al.’s (2012) work on multimodal social semiotics. In Figure 1, the oval symbolizes the social context, in which interactions, involving language-diverse students and digital tools, are embedded, as described by the (preservice) teachers. In any interaction, semiotic

resources carry meanings. The potential for semiotic resources to be considered as appropriate meanings becomes recognisable, as a result of previous interactions. Therefore, the interaction is not separated from the wider context. Kress and van Leeuwen (2001) described how semiotic resources carry extra meanings, through provenance and connotation. Provenance describes how meanings are imported with the use of signs/semiotic resources from one context (culture, social group, etc.) to another, such as when Minecraft is seen as a play activity in a mathematics classroom, because of students' home experiences. As a result, the kind of meanings that students consider that Minecraft can carry is limited to what is usual in the home situations. The connotations connected to a sign, such as a block house in Minecraft, through the use of a particular mode, the graphic representation, are the socio-cultural values and backgrounds that provide extra information, such as a house being associated with somewhere to live. Participants in an interaction use the meanings from the provenance and connotation of a sign to make interpretations in an interaction, even if the sign maker had not intended for it to be understood as having these extra meanings.

In Rangnes and Meaney (2021), preservice teachers described the sign makers' (the students') choice of modalities, such as spoken or written language, to produce and interpret signs that carried meaning for the students in mathematics lessons. Interpreting PTs' descriptions of the use of different modes in the interactions provided insights into how PTs considered the students' *communication, potential for learning* and the *available identities* affected and was affected by the social context of the mathematics lesson. *Communication* occurs in interactions between people and between people and artefacts. Communication is linked to *learning potential* as it is through interactions that there is a potential to meet and engage with new ideas. In our study, we analysed (preservice) teachers' views on how language-diverse students could produce mathematical meaning, using different digital tools as a way of identifying learning potential. Similarly, we consider *available identities* to be the kinds of identities that the teachers implied were available to language-diverse students, when making use of digital tools as semiotic resources.

Methodology

The data was collected as part of larger, Norwegian-wide, research projects that both authors participate in. The focus group interview with preservice teachers was done by project colleagues and the five individual teacher interviews were collected by master students. Both the preservice teachers and the teachers taught grades 5-10 in Norwegian schools. The semi-structured interviews used a similar set of questions about a wider range of topics to do with using digital tools in mathematics classrooms. In this article, we only investigate responses about multilingual classrooms, which came towards the end of both sets of interviews. The format of the interviews and the different interviewers means that although the questions about digital tools and multilingual classrooms were similar in intent, they were not the same. However, as our intention is not to compare the results but to identify issues of interest, we consider that the interviews are sufficiently compatible to do a similar analysis.

In the previous research with this model, the preservice teachers had discussed specific episodes where students engaged with mathematics outdoors (Rangnes & Meaney, 2021). In the interview data, the (preservice) teachers sometimes described specific examples, but often described the potential with digital tools at a general level. Therefore in the analysis, we considered how the

(preservice) teachers described aspects of modes, communication, available identities and potential for learning at a general level. The modes were the different kinds of representations that the (preservice) teachers identified as being important in multilingual mathematics classrooms. We identified comments to do with communication as those which talked about the purpose of communication in multilingual mathematics classrooms. Available identities were comments that (preservice) teachers made about language-diverse students as mathematics learners, while learning potential were comments about the kinds of learning that was made available in the mathematics classroom to language-diverse students. By considering how each of the aspects interacted together, we were able to consider how the (preservice) teachers considered the complex relationship between mathematics, digital tools and language-diverse students.

In the next section, we first describe our analysis of the teacher interviews and then the focus group interviews with the preservice teachers, by considering the modalities, the communication, the available identities and in the discussion and conclusion section, we discuss the results across the two data sets and what it means for teacher education programmes.

Teacher interviews

Modalities

The modes that the teachers highlighted in the interviews were mostly spoken and written language, including symbolic mathematics. Generally, mathematics was considered to be universal in these modes, “there are a few other words for things. But otherwise, it is exactly the same mathematics. It is generally valid” (Teacher2). As a result, the teachers focused on digital tools which translated instructions or translations of the students’ answers. This would be through audio input or videos in the students’ home language, which would enable the students to make sense of instructions illustrations and calculations, presented in Norwegian. T4 summarised that “the strength of the digital is that it is visual and a bit with being able to translate things”. The benefit of visualisation was mentioned also by T1 as good for developing students conceptual understanding, but here visualisation seemed to just be referring to watching a replacement teacher on a video, not visualisation as described by Dockendorff and Solar (2018). The focus on these modes may have been because the teachers expected students to learn from listening to a teacher and reading a textbook. These expectations, or provenance (Kress & van Leeuwen, 2001), produced from earlier experiences, of mathematics teaching could lead to the assumption that if the student was unable to understand the teacher or the textbook, then they would be unable to learn mathematics.

Communication

In the interviews, the teachers highlighted the purpose of communication as being to gain access to the mathematical meanings that the students conveyed in their written work, with an assumption that the teachers needed to evaluate it, “it is a pity that one (the student) does not get to show their mathematical competence just because it is the wrong language” (T4). T2, T3 and T5 described how they could talk with students who spoke English as a second language, but, as T2 stated, students who used Polish would be problematic because the teachers would not understand. Consequently, T2, T3, T4 and T5 valued translation programs, such as Google Translate, or the opportunities in Excel, GeoGebra to change the language, because the students were then able to demonstrate their

knowledge. For example, in written argumentation, the students could use translation programs to write in Norwegian well enough for the teacher to understand. To achieve this purpose, translation opportunities were highlighted by all the teachers, particularly when the students had limited Norwegian or English, which the teacher could understand.

The teachers also identified the purpose of communication as being for students to understand what was expected of them in class. Translation programs were considered as supporting this to happen, “it’s a bit like doing nothing to actually work” (T4). T2 provided a story about a successful mathematics student who used it to understand what he had to do. However, T2 also noted that translation programs were only useful, “if they can then write in their own language, then you have to be good at math, but weak in the language”, with “the language” referring to Norwegian.

Potential for learning

The teachers identified potential for learning as occurring when the students could follow the in-class teaching and completing textbook exercises. Digital tools were not discussed as supporting students’ mathematics learning except for the access they provided to material provided by the teacher or the textbook. As a result, digital mathematics textbooks were valued because they had less text (in Norwegian) than ordinary textbooks (T3), making them easier to follow for language-diverse students. T2 and T5 described how students could watch YouTube videos on a mathematical topic in their home language, “I do not know if they (on the video) do it right, but they (the student) can see the video and I can see the calculation” (T5). The written calculation allowed the teacher to evaluate the students’ learning. However, when language-diverse students had not previously learnt the same topics to the same degree as the other students in the class, then the potential for learning was limited. They considered that language-diverse students who had gaps, in relationship to what they were supposed to do in Norwegian classrooms, were not able to use translations programs or video lessons to bridge into the current mathematics classroom learning.

Available identities

The teachers were focused on bridging language-diverse students into existing classroom practices. Consequently, the students were described as having available identities either of being high achiever in mathematics from their previous countries or being low achievers with gaps in their understandings. As T5 stated, “to learn mathematics you have to have a foundation consisting of concepts and a language, and then be able to build on it”. The high-achieving group could benefit from using Google Translate. However, language-diverse students with gaps in their mathematics education and limited Norwegian, were unable to take advantage of translation programs and so digital tools were not considered to provide any possibilities for supporting their meaning making,

Often they are not necessarily bad in maths, they just have a lot of gaps and have to work with completely different things, things that they should have learned in 5th grade. Some have not got instant recall of basic facts to ten, then it becomes very difficult to add twelve and 18. It takes a long time (T2).

When language-diverse students came with such gaps, then digital tools were not considered as providing possibilities for supporting mathematical learning.

Preservice teachers focus group interview

Modalities

In the focus group interview, although they talked about different digital tools when they came to the questions on multilingual classrooms, the preservice teachers were asked specifically about programming. They described mathematics and programming as types of “language”, where language had an implicit taken-for-granted meaning of natural languages. However, there was no details about whether they considered written set of instructions as programming or the modes that were available when the programs were run.

Communication

The preservice teachers’ focus on mathematics and programming seemed to be about expressing ideas easily, “But as if there are people with both English and Norwegian, different word choices and in general. So I think it’s easier, maybe? With programming because it’s so distinctive” (PT2). Yet, what the meaning were that programming could provide were not discussed. Instead, programming was described as more precise and distinctive, making it easier to carry meanings. As well, the receivers of the meanings, expressed through programming, were not identified. It could be the teacher, or it could be other students who were the expected recipients of the communication.

Potential for learning

The preservice teachers discussed very generally what language-diverse students would learn from using programming. The preservice teachers had recently experienced learning programming and recognised that programming languages were unlike English or Norwegian, “so the language they use is also different. So, we became a little more aware of what that might mean” (PT3). As a result, they considered that programming, as another kind of language, was potentially easier for language-diverse students to learn. When they began programming, they used “a lot of trial and error”. As well, they had been in a classroom and saw that programming was well received by the students “So that they wanted more challenges, and then programming had to be good” (PT1). As learning programming could be done through trial and error, the preservice teachers considered that the students had agency to control what they were doing, in contrast to “complete all the tasks in class” (PT1). Therefore, the potential for learning could be seen as being on a metalevel, learning about learning strategies rather than about learning specific mathematics or programming skills.

Available identities

As with the teachers, the preservice teachers also considered language-diverse students to be students with “language difficulties” (PT2). Yet, the precision of the programming language meant that students, who were not fluent in Norwegian, or had “language difficulties” could be challenged to learn programming. As well, given that few students had experiences with it, then all students would be learning it on an equal level:

Yes, and so maybe most students are equal then, in programming. That not everyone has that much experience in it. So, one is in a way on an equal level, or, yes. It is equally unknown, equally known to all. And then you are not so outside. (PT2)

These reflections provided the PTs with the possibility to consider students as wanting to be challenged and not just complete tasks in the textbook and as having equal possibilities to learn programming.

Conclusion

Digital tools have been promoted as supporting students to learn mathematics by being able to convey meanings in a variety of ways (see for example, Dockendorff & Solar 2018). However, when the purpose of communication was to access students' mathematical knowledge, then the possibilities for using digital tools were reduced to having the students use translation programs. These programs provided the students with ways to show what they could do mathematically while they were learning the language of instruction. The use of translation programs provided opportunities to determine whether or not the students could become like the Norwegian students in the class, by showing they were capable mathematics students. On the other hand, using some digital tools, such as programming, allowed language-diverse students to be considered as capable learners, regardless of their fluency in the language of instruction. The features of programming language, although not discussed in any detail, seemed to provide opportunities to see language-diverse students as being similar to their classmates, in that they wanted to be challenged and they had the same capabilities to learn, perhaps more so because they had experiences of learning other languages.

The use of the MSSM to analyse the interviews provided insights into how the purpose of communication was connected to the potential for learning and the available identities for language-diverse students. However, it was more difficult to analyse the focus group interviews than it was to analyse the individual interviews because of the level of details provided by participants.

For teacher education, there are some not-so-simple findings from this research. The teacher interviews suggest that if programming is introduced into all classrooms, as the Norwegian curriculum (Kunnskapsdepartementet, 2019) now demand, and teachers only see the main role of communication in the classroom as interpreting and evaluating students' work, then it is unlikely that language-diverse students would be viewed in alternative ways. The provenance (Kress & van Leeuwen, 2001) connected to mathematics teaching, as being predominantly done through textbooks, would not allow for alternatives to be noticed. Similarly, even if learning programming does provide teachers with ways to see alternative identities for language-diverse students, but connections are not made to students' potential for learning mathematical content then the outcomes for these students will be limited. Unless teachers gain insights into how to make connections to mathematical ideas and value these connections, then programming can take on the connotation (Kress & van Leeuwen, 2001) of being game-like and so not a legitimate way for teaching mathematics to any student, including language-diverse students.

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