

Restructuring the university course Mathematics for All: An action research



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Abstract: *The purpose of this educational action research was to understand how we can restructure the course Mathematics for All, a graduate-level course taught at the University of Iceland. Data was gathered and analysed thematically and cyclically with an open questionnaire at the end of the course and individual interviews a year later. Findings show that the course influenced participants' understanding of mathematics education and their professionalism. The interviewed participants were able to utilise problem solving and discussions in their classroom but faced challenges and needed ongoing support to implement their learnings in class.*

Introduction

Inclusive education is the school policy in Iceland (Compulsory School Act No. 91/2008). This policy is based on international standards of social justice, democracy, human rights and the participation of all (Ainscow, 2020). These fundamental principles focus on schools working to remove barriers to participation and all learners have the right to inclusive compulsory education where the educational and social requirements of each student are met in the learning community of a common local school (Ministry of Education, Science and Culture, 2014). The national curriculum recognises that compulsory school learners are diverse and their needs varied. The curriculum is based on competence criteria for all subject areas and in mathematics those focus on process and skills (Ministry of Education, Science and Culture, 2014).

Mathematics for All is a 10 ECTS graduate-level course that we (Ósk and Edda) teach at the School of Education, University of Iceland. The course focuses on theories and research on how children learn mathematics, the challenges they encounter and how to design and adapt the mathematics curriculum to diverse groups of learners. Additionally, the focus is on course participants developing an under-

standing of themselves as mathematics learners and users. In the course we, as teacher educators, have found it important to model inclusive teaching practice as course participants need to experience learning mathematics in an environment that reflects the environment they are expected to create for their own learners in mathematics (Moore, 2005).

We – the teachers of the course – have different strengths and academic backgrounds. Both of us were schoolteachers before coming to work in academia: Ósk has taught mathematics at all school levels and Edda was a special needs teacher for 20 years, focusing on working with the challenges learners encounter in learning mathematics. We see our different experiences and expertise as a strength for the course, as Ósk focuses on mathematics pedagogy and creativity while Edda focuses on inclusive education and working with diverse learners.

Through the years, the course Mathematics for All has been restructured and developed through action research (Óskarsdóttir & Guðjónsdóttir, 2004; Guðjónsdóttir & Kristinsdóttir, 2006; Guðjónsdóttir et al., 2009; Guðjónsdóttir & Kristinsdóttir, 2011). Continuing in this tradition, the purpose of our action research is to gain an understanding of how the course can be restructured to influence teacher professionalism and mathematics teaching. The aim is to investigate how the course has influenced participants' teaching practice and understanding of teaching mathematics to diverse groups of learners. Our research question is: How can we restructure the course Mathematics for All to empower teachers to teach mathematics to diverse groups of learners?

Conceptual framework

The conceptual framework consists of the ideas emphasised in the course Mathematics for All. The foundation is inclusive education and practices that are fundamentally based on the ideology of social justice, democracy, human rights and full participation of all (Ainscow, 2020). At the heart of the course ideology lies the premise that individuals have different requirements for achieving the same goals. This means that teachers need to be positioned and empowered to provide effective mathematics learning environments based on equity and access (Tan & Torius, 2018). The challenge of providing a quality mathematics education for all goes beyond the classroom level and involves a rethinking of the systemic and institutional structures which mediate both teaching and learning (Lisenbee & Tan, 2019; Roos, 2019). The focus is not only on how to assist learners experiencing difficulties in learning mathematics, but also how to structure mathematics education such that it no longer disables and alienates so many learners in mathematics.

According to Luria et al. (2017) equity can be increased in a mathematical classroom through various methods such as employing open-ended problems, modelling

and discussions of mathematical concepts and incorporating cultural awareness and creativity into curricula and the classroom environment. Thus, teachers who aim to include all learners in mathematics need to be responsive, competent and able to express and explain mathematics in various ways (Lindenskov & Lindhardt, 2020; Roos, 2023). According to Scherer and Bertram (2024) there is a need in mathematics teacher education to create situations that support teacher students to reflect on their mathematical knowledge and course activities must be discussed openly to investigate differences in how people learn mathematics.

To support learner understanding in mathematics, it is important for the mathematics teacher to create an inclusive learning community in the class, where the primary focus is not on “right or wrong” solutions but rather to discuss different ways of approaching a given mathematical task (Boaler, 2016). In general, classroom practice should encourage students to explain and reason about solution strategies, along with considering solution strategies and associated reasoning (Scherer et al., 2016). Boaler (2016) argues that a growth mindset and flexible interaction with numbers can support students to become better learners in mathematics. Those with a fixed mindset believe that people are either good at mathematics or not and those beliefs can hinder learning, while those with a growth mindset believe everyone can improve in their learning, which can support them to exert themselves and enjoy their learning (Boaler, 2016).

An important factor in working with diverse groups of students is to focus on discussions (Valero et al., 2008). Discussions about problems and concepts can support learners towards developing their mathematical understanding in a collaborative learning community (Yeh et al., 2017). There should be a mathematical goal driving the discussions. For discussion to be successful, teachers need to be role models and communicate that everyone is a sense-maker as they support learners in deciding how and what to share, as well as to be oriented to one another and to the mathematical ideas (Kasemi & Hintz, 2014). Presenting mathematics visually with hands-on projects can also support students to think flexibly and develop mathematical understanding (Boaler, 2016; Luria et al., 2017).

The course context

The course Mathematics for All is taught at a master’s level and participants are student teachers and practising teachers who teach at all levels of the education system, together with special needs teachers and social educators. The course was originally aimed at special education teachers, and it focused on difficulties that learners have in mathematics, how to analyse those problems and how to teach accordingly. As the idea of inclusion has developed to incorporate all learners, so has the focus of the

Table 1. *An overview of the course themes, emphasis and assignments*

Theme	Emphasis	Graded assignments
The conceptual background of the course	Research on mathematics learning and the development of children's understanding. Theories of inclusion, equity, creativity, growth mindset and universal design for learning in mathematics.	1. The ideology (20%), individual project. Writing a synopsis based on selected articles and book chapters (from a list) related to the subject of Mathematics for All.
The learner in mathematics	Tasks for all learners. A sociocultural view of learning and how it takes place in the classroom community. Difficulties in learning mathematics. Cognitively guided instruction and problem solving. Promoting high-quality mathematics and visual learning. Mathematics learning in multicultural/multilingual settings.	2. Field observation (20%), collaborative project. Students choose between: a. Set and analyse a mathematical task for learners and discuss solutions with them. b. Observe teaching and conduct an interview with a teacher. c. Interview with a learner about their experience of learning mathematics.
The teacher in mathematics	Teaching methods that are suitable for diverse learners. Building optimal learning environments and powerful classrooms. Using dialogue and formative assessment in the mathematics classroom.	3. Final project (30%) related to the course themes (collaborative project). 4. Self-assessment (9%) of what participants have learnt in the course (individual task).

course changed. Now the emphasis is on how to support course participants to work with diverse learners in developing their mathematical thinking and skills, and on the teacher's ability to evaluate and promote learning through exploring their own understanding of mathematics.

The course content is based on the conceptual framework of the study and organised into three themes: the conceptual background that the course builds on, the learner in mathematics and the teacher in mathematics. Table 1 provides an overview of the course, the emphasis and graded assignments under each theme.

Reading material and a recorded lecture are made available to participants a few days before the class meets. In class we begin by discussing the reading material and lecture whereafter participants are given a mathematical task to work on, either in small groups or individually, using hands-on material. The emphasis is always on discussing the different methods participants used to solve the tasks, although they

come to the same conclusion. Our aim is to act as role models for participants, so they learn about how to conduct open discussions about mathematics, how to create an inclusive space for talking about different ways of approaching mathematical tasks and to see how differently people think in mathematics.

Methodology

Action research is an umbrella term encapsulating many ways of researching practice. We understand it as being teacher or practitioner research (Cochran-Smith, 2005) that places the practice at the centre in order to find out how to improve it. Because of this focus on practice, action research is small-scale and the intention is to improve or change practices and report on that development. The research topic arises from the practitioners' questions or ponderings about their practice, and the goal is not to report facts of knowledge but to improve practice and add to what was known previously (Baumfield et al., 2013; McNiff, 2013).

The purpose of this action research is to gain an understanding of how the course Mathematics for All can be restructured to influence teacher professionalism and mathematics teaching. Participants in the study include us – the two teachers of the course – together with 20 participants who attended the course in the autumn term of 2022. All ethical procedures were adhered to: teachers gave informed consent and pseudonyms were used to hide their identities (Siðareglur háskólanna, e.d.).

This action research is based on three cycles of inquiry in which the outcomes of earlier cycles influence subsequent thinking and understanding. In the first cycle participants completed an online questionnaire with open questions at the end of the course in December 2022. Of the 20 course participants, 12 completed the questionnaire. In the second cycle three participants were interviewed individually in January and February 2024. The interviews were semi-structured and focused on participants' descriptions of their views and experiences of the course and the influence on their teaching. The third cycle of the research focused on reflecting on and analysing all the data as well as implementing changes in our Mathematics for All course that will be next taught in autumn 2024. Throughout the research we have written research notes and journal entries that also form part of the data. Table 2 provides an overview of research cycles and the data collected.

Data was analysed using inductive thematic analysis. For each cycle we first analysed the data individually and then together. By analysing the data both individually and together we achieved triangulation that added to the trustworthiness of the study (McNiff, 2013). In the individual analysis we used colours to search for codes, categories and themes inductively. In our collaborative analysis we compared our categories and themes and agreed on the ones that were most descriptive and would

Table 2. *Research cycles and data*

Research cycle	Data
First cycle	An online questionnaire with open questions about participants' learning from the course asking participants to reflect on: <ul style="list-style-type: none"> • Own learnings and achievement of learning outcomes • The usefulness of the course for teaching • Wishes for future learning and development as a mathematics teacher for all
Second cycle	Individual interviews focusing on participants' views and experiences a year after attending the course: <ul style="list-style-type: none"> • Embla, third grade teacher (Nov 2023) • Sif, fifth grade teacher (Nov 2023) • Jóna, special needs teacher in fourth and fifth grades (Feb 2024)
Third cycle	Summary of the findings from the first and second cycle and collaborative review of all data with the aim of making sense of the participants' experiences.

support us in answering the research question. The themes that developed are explained in the findings.

Findings from the first cycle

The first cycle findings are based on the analysis of the end-of-course questionnaire that 12 participants completed. The replies to the questionnaire were in the form of written reflections and statements. Three core themes came out of our analysis from this cycle: participant understanding of mathematics learning, understanding one's own professionalism and teaching practice and learning from each other. We will discuss each of those themes below, providing examples of how participating teachers described their own experiences.

Participant understanding of mathematics learning

All participants were clear in their statements that the course material and projects had improved their understanding of their own mathematics learning and that of students. Anna, a preschool teacher, discussed what she learnt about fixed and growth mindsets in the course and wrote the following: "I have discovered that I have a fixed mindset in mathematics – I have now consciously tried to change to a growth mindset." She shows how she was actively reflecting on her own mindset in mathematics and made a connection to creating "a meaningful learning environment" for her students.

Bjarni, who was studying to be an upper secondary school teacher, commented

that he would be able to use a great deal of what he had learned in the course, “for example about drilling and to place emphasis on quality rather than quantity of practice”, thereby showing that he was changing his understanding of how people learn mathematics and wanted to focus on understanding rather than mindless repetition of many problems.

Sigrún, also an upper secondary school teacher, commented on her own improved mathematical understanding:

“One thing I remember was [...] about the equal sign and [how I learned in the course] that it means you have to do the same on both sides but not just to move the numbers and change the other signs => it is not the same thing. This was an ‘Ah-HA!’ moment for me.”

Sigrún’s reflection is a testament to her growing understanding of mathematics. Her educational background was in sciences, where she had learned substantial mathematics but had not understood the equal sign and equations in this way prior to the course. She takes this as an example of how the course supported her to develop her own understanding of mathematics.

Understanding one’s own professionalism and teaching practice

There were several participants who explained how the course had influenced their professionalism and teaching practice. Not all of the participants were teaching at the time of the course, such as Embla, a seasoned teacher at the comprehensive level who was on study leave, who wrote:

“This course has increased my self-confidence in teaching maths: I have more tools than before and more knowledge and ways to work with learners. I want to use more diverse teaching methods, and work from the curriculum goals but not just the textbooks. I’m finishing the course full of good intentions!”

Embla’s experience was that the course improved her confidence in teaching and gave her tools and knowledge. Through her words the emphasis on working from textbooks in mathematics lessons is evident. However, she clearly wishes to use more diverse teaching methods and she further states that she left the course full of hope and wanting to apply what she had learned.

Hanna, also a teacher at the comprehensive school level, stated: “I have learnt incredibly many things, both about all kinds of tasks and about creativity that I can use in my teaching. I have read lots of interesting research on mathematics teaching.” From Hanna’s comment it is clear that the focus on reading research in the course is important for teachers developing as professionals.

Learning from each other

The diversity of the class participants, in terms of teaching experience, school level, age and background, was a strength and course participants with different backgrounds felt that their needs were met. Anna, a preschool teacher, stated:

“I learned that number sense is the foundation for mathematical learning for children. The goal was to add accessible shapes, numbers and games in my class. I made a shopping game where the product prices were marked and the children paid with money, a fun game where children learn by experimenting and playing.”

Anna explained how she, as a preschool teacher, learned practical methods for her teaching of young children and emphasised number sense. In the survey Bjarni wrote: “I have been introduced to diverse teaching methods that I can use as a teacher, also for other subjects. I realize better which challenges students face and what ways there are to work through those challenges.” This implies that Bjarni, as a secondary school teacher, experienced that he could apply his learning to teaching young people and understand the challenges that they face in mathematics learning.

Linda, a primary school teacher, stated:

“I have learned a lot, but now the importance of discussion to solve problems comes to mind, I mean the lessons in which we have collaborated on solutions. I have seen how much I can really learn from others, and I take that with me into my own teaching where I emphasize that students describe how they solve problems with the aim of supporting other students’ learning. I feel I have acquired a new vision of mathematics education.”

The point that Linda makes here about learning from others resonates with what we have experienced when teaching the course: that the diversity of the group was a strength. Course participants with different backgrounds, experience and age employ various ways to solve problems assigned in class and they learn from each other. An example of this was a problem with two unknown numbers where one of the teachers studying to be a secondary school teacher solved it with an equation whereas a primary level teacher used blocks. Both found a way to solve the problem and as they discussed and shared their solutions, they learned about each other’s methods and gained insight into how differently one can approach mathematics.

Findings from the second cycle

The findings from the second cycle are based on the analysis of three semi-structured individual interviews. The participants who we interviewed all worked in teams in

their schools and shared the responsibility of teaching mathematics with other teachers. Embla taught third grade, Sif was a fifth grade teacher and Jóna was a special education teacher in grades four and five. The next sections are organised according to the teachers' individual stories, as their unique experiences provide an insight into how teachers work with Mathematics for All.

Embla's experience

Embla relates that she took on a new class in the autumn with a very diverse group of students and that a great deal of her time has been focused on classroom management. She said that because of this and in relation to problems with class schedules and collaboration with other teachers, her teaching has been more conventional than she had hoped for. She did, however, explain that she and the other teachers in her team had weekly rotating stations with different projects for their students. In those, they worked with hands-on assignments, and she believed that this represented quality time for the students and were the "best lessons".

When she finished the course she was full of enthusiasm and good intentions, and what she found most interesting was watching videos of students' discussions in class and explained how they were thinking. As Embla was on leave from work to focus on her studies when she attended the course, she noted that there were many instances that it would have been great to have been teaching at the time. She believes that what she learned was so connected to practice that it is important to be able to incorporate it straight away in the classroom.

Sif's experience

Sif shares that she always tries to approach teaching in a lively and interesting manner. She states: "After the course I was fascinated by the ideas presented there and I wanted to support number sense through play, games and using manipulatives." However, she mentioned that she does not have access to the manipulatives she needs, as in her school "those are only available for the youngest grades, even if older students could also benefit from hands-on work." She explains that she uses different games in her lessons and that she makes an effort to have those accessible.

For Sif, learning about cognitively-based instruction was the highlight of the course and last year she used that in weekly lessons with problem solving. She wants to engage students in discussions about their solutions and says: "I find it remarkable that even when they have difficulties with mathematics, they can explain very well how they find a solution." She explains that in her experience, the students learn from listening to others sharing their solutions. Sif wishes to emphasise problems and discussions more and shares that she would like to learn more about how to create problems that deal with different mathematical concepts.

Sif explains that her main challenge is to work with teachers who are not familiar with these ideas of mathematics education and are not ready to change their way of teaching mathematics. She also mentions that the diversity of the student group is a challenge and that it can be hard to not get too attached to the textbooks. She is clear that she wants all the students to work with the same learning materials, though she emphasises meeting the needs of each and every one. She believes that it is not good if students get stuck in special education away from the class for many years, which she thinks is too common. She shares that sometimes the students lose faith in their abilities, but she explains to them that learning takes time and even if they do not know something, they will always get another chance to learn it better.

Jóna's experience

Jóna is an experienced special educator. She works collaboratively with the class teachers in fourth and fifth grade, some of whom have not taught at this school level before. She sometimes takes a group of students to her classroom but she also works in the students' classroom, although the classroom schedules can be a challenge. Jóna mentions problem solving and discussions as her main learnings from the course. She emphasises flexibility in her practice.

Jóna is concerned that at times the textbooks control the lessons, and she wishes to focus more on curriculum competence criteria from the national curriculum rather than pages in the book. However, she and her co-teachers sometimes do hands-on projects that help students learn and understand concepts better through collaboration, as well as to focus on discussions and problem solving. She shares an example of this: "Recently we did a collaborative project in geometry where the students were to design a case for a rubber. They had to describe the form, measure it, and count small squares." She feels that these kinds of projects are too rare, but these lessons are the ones where the teachers can check whether the students are meeting the curriculum competence criteria.

Jóna states that the students in the special education classroom usually work individually as they are at different places in their mathematics learning, and some are also new to the language. She has tried to have students collaborate and work on problem solving and she wants to have more variety in her teaching.

"Sometimes I want to discuss a certain topic in mathematics, even if they are not all in the same place. Students have a hard time listening and participating if they are not at the same place. So we give those who are slower a discount, so that they do less. Then we are all able to discuss the same material."

Being at the “same place” seems to refer to where the students are in the textbook, illustrating the fact that the textbook affects the learning process more than the competence criteria of the curriculum.

Findings from the third cycle

Through the findings participants describe how the course has empowered them and gave them inspiration for wanting to employ their learning in school as they reflected on what could be improved and what they wanted to change in their practice. The participants in cycles one and two all mention that the course pushed them to use dialogue in their mathematics classroom. They aspired to emphasise problem solving as a method of learning after studying it in the course. The teachers described how useful and important they had found using manipulatives in the course and wanted to use these in their teaching. They aimed to teach according to their vision and the national curriculum competence criteria but felt that the textbooks often dictated the learning process.

Various challenges were mentioned as participants incorporated the lessons learned from the course into their teaching. The diversity of the student group was a challenge. Another challenge was connected to collaboration with co-teachers, who were inexperienced or had a different view of how to teach mathematics and were not ready to change their teaching practice. Organisational factors were also mentioned as a challenge. These include conflicts in the class schedule, having large groups of students in class and lacking access to manipulatives.

Discussion and conclusion

This action research project has aimed to find an answer to the research question: How can we restructure the course Mathematics for All so that participants are empowered to teach mathematics to diverse groups of learners? The findings show us that overall, the participants have found the course helpful for developing their professionalism and views of teaching mathematics. The participants were clear that the joint learning experience of seeing and valuing the different ways to solve problems assisted them in realising that there are different ways to learn mathematics. Furthermore, to support all students, teachers need to be open to different ideas and solutions and help their students to embrace such a manner of working.

Our interviews with the three teachers, which were held a year after they attended our course, show that they seem to have equity and student access to mathematics at heart as they discuss their practice (Ainscow, 2020; Tan & Torius, 2018). They aim to be responsive and want to express and explain mathematics in various ways

(Roos, 2023; Scherer et al., 2016) and focus on problem solving and discussions about mathematics in class (Boaler, 2016; Lindenskov & Lindhardt, 2020; Luria et al., 2016). However, it seems that the structure and culture of schools restricts their resolve so that their teaching is often based on following the textbooks (Roos, 2019).

In answering our research question on how we can restructure our course with the aim of strengthening teachers' understanding and empowering them to teach mathematics to diverse groups of learners, the findings provided valuable insights. The questionnaire provided us with information on how the participants experienced the course, whereas the interviews shed light on how teachers utilised their learning for their teaching.

The strengths of the course, as our findings unveil, are the elements that empower and inspire participants to make changes in their mathematics teaching. As we restructure the course, we need to make sure these elements are still in place. However, we have learnt that an added focus is needed on how to organise mathematics lessons, with a balance between using textbooks and modelling tasks and methods. The findings have given us an insight into the importance of placing an even stronger emphasis on the role of collaboration, discussions, open problem solving and diverse activities for diverse learners.

According to the findings, participants seem to have adopted a new way of thinking about mathematics teaching and learning. Those teaching in schools intended to make changes in their teaching but encountered various obstacles, as we learned in the second cycle. To support the participants in overcoming these hindrances an assignment is called for where we give them structured feedback on how they can further develop their ideas of teaching in collaboration with others. This assignment could be a reflective journal that runs through the whole course, where participants document their experiences, their successes and challenges. We would then encourage teachers to continue writing this journal after they complete the course to understand and enhance their teaching.

The various structural challenges that teachers face in schools are often not in their power to change and are out of the scope of our course, but nonetheless need to be discussed to enable teachers to develop their teaching practices (Lisenbee & Tan, 2019; Roos, 2019). Thus, we see a need for further research focusing on how teachers are empowered and supported to work in inclusive ways at the school level, with an emphasis on effective, quality mathematics education for all.

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Dansk abstract

Formålet med denne pædagogiske aktionsforskning var at forstå hvordan man kan omstrukturere kurset matematik for alle, et kursus der undervises i på kandidatniveau på Islands Universitet. Data blev indsamlet og analyseret tematisk og cyklisk via et åbent spørgeskema ved afslutningen af kurset og via individuelle interviews et år senere. Resultaterne viser at kurset påvirkede deltagernes forståelse af matematikundervisning og deres professionalisme. De interviewede deltagere var i stand til at bruge problemløsning og diskussioner i deres klasseværelse, men stod over for udfordringer og havde brug for løbende støtte til at implementere deres læring i klassen.