Bringing Nordic mathematics education into the future – a review of the papers presented at the NORMA20 conference

Janne Fauskanger[1], Margrethe Naalsund[2], Hans Kristian Nilsen[3], Guri A. Nortvedt[4], Guðbjörg Pálsdóttir[5], Päivi Portaankorva-Koivisto[6], Jelena Radišić[4], Jóhann Örn Sigurjónsson[5] and Anna Wernberg[7]

[1]University of Stavanger, Norway, janne.fauskanger@uis.no; [2]Norwegian University of Life Sciences, Norway, margrethe.naalsund@nmbu.no; [3]University of Agder, Norway, hans.k.nilsen@uia.no; [4]University of Oslo, Norway, g.a.nortvedt@ils.uio.no, jelena.radisic@ils.uio.no; [5]University of Iceland, gudbj@hi.is, johannorn@hi.is; [6]University of Helsinki, Finland, paivi.portaankorva-koivisto@helsinki.fi; [7]Malmö University, Sweden, anna.wernberg@mau.se;

The NORMA conferences held triennially gather academics from the Nordic area and beyond. The conferences offer a window into the key topics and outcomes of Nordic mathematics education research. This paper presents an analysis of the 73 regular papers presented at the NORMA20 conference held in Oslo in June 2021 and published in the conference pre- and proceedings. The analysis yields research questions, methods, and key findings for the educational levels spanning kindergarten through to higher education. The majority of the papers present research from primary school-level and pre- and in-service teacher education. Across the educational levels, teaching methods and classroom discourse emerged as the most frequent topics, dominated by empirical studies that applied qualitative methods.

Keywords: Nordic mathematics education, review, educational level, programming, Nordic model

Introduction

Research within the field of mathematics education is a young field within the Nordic community compared to other countries (Grevholm, 2021; Rønning, 2019), and few sources exist that identify what characterises this field. Among the early sources are the edited volumes *Matematikdidaktik i Norden [Mathematics education in the Nordic area*], edited by Björkqvist in 1994, and *Matematikdidaktik–ett nordiskt perspektiv [Mathematics education–a Nordic perspective],* edited by Grevholm in 2001. Both these volumes comprise chapters written in the Nordic languages as well as English, discussing central aspects of Nordic mathematics education in an international perspective. In 2010, the Nordic sourcebook, edited by Sriraman et al. (2010), presented current research from each of the five Nordic countries. According to Sriraman (2010), the aim of this publication was to make Nordic research known and available outside the Nordic community. Since then, a few publications have been published, mainly journal articles, attempting to review the field of Nordic mathematics education research, for instance Grevholm (2021) and Rønning (2019). Rønning (2019) aimed to describe the development of the field of mathematics education as a research domain in the three Scandinavian countries, Denmark, Norway, and Sweden. Linking this to the development of the national school and teacher education systems, Rønning (2019) showed that the research profile and orientation differs across the three countries; however, in all of them, the aspects related to

inclusive education (e.g., learning difficulties, misconceptions, and gender issues) and problem solving are central.

In addition to the edited volumes and journal articles, conference proceedings from the Swedish Madif conferences held biannually since 1999 and the NORMA conferences held every third year since 1994 might provide additional insights into research in mathematics education in the Nordic region. The NORMA conferences are mainly attended by researchers from the Nordic countries, and as such, the conference proceedings provide accounts of the current research in the Nordic area (c.f. Grevholm, 2021; Rønning, 2019).

Recently, Grevholm (2021) reviewed the 32 research papers from the Nordic and Baltic countries in the proceedings from NORMA17, revealing that the majority of papers came from Norway and that most papers reported empirical studies applying both qualitative and quantitative methods. Rønning (2019), however, claimed that the majority of mathematics education researchers (and research) in the Nordic region, are from Sweden. Theoretical papers were rare in NORMA17. The empirical papers mostly reported the outcomes of interventions, including teaching approaches and experiments, while some papers reported studies of learning and cognition, including problem solving.

The purpose of the current paper is to add to the insights about research in the Nordic area by reviewing the regular papers presented at the NORMA20 conference that were accepted for publication in the conference pre- and proceedings (Nortvedt et al., 2021; Nortvedt et al., 2022). We argue that these publications might provide a snapshot of the status of Nordic mathematics education research. The conference had two main themes; however, the researchers could relate to Nordic mathematics education in general.

The first theme concerned the Nordic model, as described in Blossing et al. (2014) and Oftedal Telhaug et al. (2006), who claim that the educational systems in the Nordic countries share some characteristics, which is particularly the case at the compulsory education level. For example, the Nordic countries all have a high level of school autonomy, national curricula, inclusive classrooms, and formative grading at the primary school level, in contrast to education systems that have little school autonomy, grading in primary schools, streaming, and tracking. Within the Nordic countries, mathematical competence (e.g., Niss & Højgaard, 2019) is at the core of compulsory-level curricula and lately, all the countries have implemented programming in their national curricula as part of the mathematics subject. Although the Nordic countries have implemented various national-level policies over the past 10 years, and the educational systems are becoming more diverse, a Nordic model is still the focus of discussion (Blossing et al., 2014). In contrast to the similarities at the compulsory school level, higher education in general and teacher education in particular are organised differently across the Nordic countries. In Iceland, Finland, and Norway, teacher education includes a master's degree, whereas in Denmark and Sweden, teacher education lasts for four years and does not include a master's degree. However, it might be argued that even at this level, there are strong similarities, as all countries offer free higher education.

Since the Nordic educational systems have such strong similarities, the emerging issues in educational research might be expected to be similar. The aim of this review is to analyse papers representing different educational levels to identify the key themes, research methods, and outcomes that may

highlight the emerging issues within Nordic mathematics education. In this process, our focus is on the whole Nordic area rather than on comparing research representing the individual countries.

Methods

The current study reviews 73 regular papers presented at the NORMA20 conference and included in the pre- and proceedings of the conference (Nortvedt et al., 2021; Nortvedt et al., 2022). The review can be characterised as an overview, with the purpose of describing the characteristics of the research papers presented at NORMA20, following the procedures in Grant and Booth (2009).

Due to the COVID pandemic, NORMA20 was first postponed for one year, and in 2021, it was held as a virtual conference. In 2020, however, the International Programme Committee decided to host a second round of submissions and publish the conference proceedings in two volumes: the preceedings consisted of accepted papers originally submitted in the first round, and the proceedings comprised papers originally submitted in the second round. This process resulted in 36 papers published in the NORMA20 preceedings and 37 papers published in the NORMA20 proceedings. All papers had at least two rounds of peer review.

Data analysis procedures

The data analysis followed a three-step procedure. First, a database was constructed comprising the titles, authors, abstracts, and keywords for each paper. Next, the themes, educational levels, methods, framework(s)/orientations, findings, and implications were categorised and added to the database. All authors of this current review article were involved in the categorisation of the papers. This first overarching classification of the papers shares some aspects with Grevholm (2021), who draws on Niss (2013), for instance in including the research questions, design, and findings. While Grevholm (2021) used Niss's (2013) categories of research study paradigms, the current study focuses on research orientation.

Second, the papers were divided into groups according to educational level, resulting in nine groups of papers (see Table 1). Of these, 31 papers addressed more than one educational level, for instance research on both teachers and students. If one of the educational levels (e.g., students) was the main focus of the paper, the paper would only be included in the analysis of the corresponding group. The categorisation was checked during this phase. Further, the papers belonging to each group were analysed to identify common themes. This analysis was concerned with what characterises the content of the papers at each educational level. Third, the author team discussed the analysis to identify emerging themes across the education-level analysis, which included clarifying the issues related to the categorisation to ensure consistency.

Table 1. Number of papers identified across educational levels

Educational level	Papers (n)
Kindergarten	6
Primary school	27
Lower secondary school	9
Upper secondary school	8
Higher education (mathematics)	5
Pre-service teacher education	15
In-service teacher education	27
Teacher educators	3
Other	6

Results

In total, the analysis included the 73 papers included in the NORMA20 preceedings and proceedings ((Nortvedt et al., 2021; Nortvedt et al., 2022). Of these, 68 papers were empirical and six theoretical, of which two papers had an empirical example. Regarding the research methods applied in the empirical papers, 58 of the accepted papers used a qualitative approach, seven used a quantitative approach, and three used mixed methods. In the next sections, the characteristics of the research papers within each of the educational levels are presented and further discussed.

Kindergarten

Of the accepted papers, six concerned kindergarten,[25] all of which reported some aspect of interaction in mathematics learning, mainly by applying case-study methods or video analysis. For instance, the research questions asked what tasks the teachers might be faced with in leading mathematical discussions in the kindergarten context; how the processes of mathematical inquiry unfold among the collaborating children (and adults) engaged in mathematical activities in kindergarten; and which challenges and opportunities are observed in classroom interactions when the kindergarten class teacher is teaching mathematics. The research foci on the teaching practices and interactions between children and adults may be due to a novel interest among the authors regarding the kindergarten curriculum.

[25] By the term "kindergarten", we refer to the educational level preceding formal education (primary school). We also consistently use the term "students" rather than "pupils" to refer to those enrolled in education at all levels ranging from kindergarten to higher education.

Primary education

Overall, 27 of the papers concerned primary-level education. The majority of these papers reported classroom studies, with a focus on communication and conceptual understanding. Qualitative research methods were mainly applied, including interviews, video analyses, field studies, content analysis, and design research. The authors studied students, teachers, and student teachers in field practice, focusing on a few participants, individuals, or groups of participants. Three of the papers were analyses of textbooks and curricula. Several papers reported numeracy at different grade levels, while others examined beliefs, reasoning, cultural aspects, and societal issues. Further, some papers focused on programming, the use of ICT for testing, and computational thinking by applying different resources. There were also papers about various teaching approaches and their implementation. In the studies on teaching approaches, the emphasis was on communication between teachers and students and the structure of the lessons. In many papers, the researchers worked with the teachers, analysing the teaching and learning from experience with the goal of improving the teaching. Several papers were aimed at developing and trying out research instruments, both regarding data collection and analysis.

Lower-secondary level

Nine papers, all empirical, focused on lower secondary mathematics. Although the qualitative approach dominated the papers—with one offering a mixed study—various analytical frameworks were employed (e.g., Schoenfeld's TRU framework, Bishop's mathematical activities, and semiotic mediation theory). Topically, the papers showed variety, but some commonalities were also visible; for example, several papers investigated dialogue and managing classroom discussions and the process of students' engagement during an activity. Two studies focused on digital tools and how these mediate both teachers' and students' mathematical competencies. The enactment of mathematics through teachers' reflections and particular tasks was the focus of two other papers, one of which focused on exams in Norwegian lower secondary schools, while the other examined North Sámi mathematical records within the context of a particular teaching unit. Despite this topical range, some common themes were found in the conclusions across these studies. These included the importance of "infrastructures" and language register in building students' mathematical (communication) competence, how real-life objects are utilised to support mathematisation and modelling, and the fine line between intended and enacted teaching, which is modulated by teacher beliefs and the particular demands of the activity itself.

Upper-secondary level

Eight out of nine papers involving upper secondary schools were empirical. Based on an instrumental approach, the theoretical paper dealt with evidence for tasks as instruments for developing mathematical competence in calculus. The link to tertiary education and transition from secondary to tertiary education was discussed through the possible construction of such tasks. Tasks and the transition issue were also relevant in an empirical paper focusing on students' metacognition as revealed in integral-area tasks. Two papers directly addressed teaching approaches. One of these, based on data from Chile, focused on the teaching practice linked to a critical approach to statistics. The second paper dealt with inquiry-based mathematics teaching and pointed to mathematical pathologies as a possible starting point for inquiry-based teaching. One paper presented an

exploration of the interdisciplinarity between physics and mathematics, concluding that the mathematical emphasis in physics often focuses on the technical use of mathematics rather than its structural use. Vocational students were the focus of attention in two papers, one of which highlighted students' experiences with linear equations, while the other considered how vocational students' goal achievement could be identified in the teachers' descriptions. Digital technology and other potential aspects of mathematical thinking competency that could be offered by vocational experiences were the focus of one of the papers. Lastly, one paper discussed the collaborative learning process among teachers and how this leads to teachers' choosing or rejecting tasks for further development.

Pre-service teacher education

Altogether, 15 papers focused on pre-service teachers. Of these, there was one quantitative study and one theoretical paper, while the others were empirical and qualitative studies. Several methods were adopted in these studies: three studies used video-analysis and observation studies, two studies employed surveys and interviews, while think-aloud protocol and reports, group discussions, reflection papers, and a group-designed survey were used in the other studies.

The themes of all the papers addressing pre-service teacher education varied, but some common threads were found. Most of the studies concentrated on how to incorporate different aspects of mathematics teaching into mathematics classrooms, for instance by surveying preservice teachers' understanding of mathematics teaching. Mathematical modelling with pre-service teachers was highlighted and discussed in three of the papers. These papers concentrated on how to support pre-service teachers in mathematical modelling to recognise students' representation levels and ask appropriate questions at various structural categorical stages, how to help primary teachers in their planning of mathematical modelling activities, and the kind of experiences that preservice teachers and students gain in the context of mathematical modelling. Historical aspects and the use of the history of mathematics in mathematics teaching were dealt with in two of the papers. In addition to modelling and history, learning mathematical concepts, using interactive mathematical maps, integrating programming into mathematics education, Sámi pre-service mathematics teachers traditional body measuring in their teaching, and pathologies as starting points for inquiry-based mathematics education and preservice teachers' fraction representation transformations were studied.

In-service teacher education

Of the 27 in-service teacher education research papers presented at the conference, 25 were empirical papers. One of the remaining two was theoretical, whereas the other was coded as both theoretical and empirical, as it used empirical cases to illustrate theoretical perspectives. Only one study used a quantitative design, and another used a mixed design with both qualitative and quantitative approaches. A total of 25 papers were qualitative studies, in which video observation and interviews were the most prominent methods of data collection. Most papers focused on primary (n = 9) or secondary (n = 8) teacher education. One focused on both primary and secondary education, whereas six explored preschool or kindergarten teacher education. For the rest of the papers, educational level was not relevant or not indicated. In-service teachers' views on programming as part of the mathematics curriculum were explored in two papers, and the collaboration between leaders of professional development (PD) for mathematics in-service teachers and schools was the focus of one of the papers.

The challenges and opportunities related to classroom interactions, with a simultaneous focus on children's mathematical inquiry, were the main focus across the kindergarten in-service teacher education papers. These challenges and opportunities were mainly related to teachers' tasks in general and, more specifically, to teaching practices, such as teachers' noticing, or to classroom interactions. Only one paper focused on toddlers, as the oldest children in kindergarten were the main focus in the few studies from kindergarten in-service teacher education presented at the conference.

In the nine papers reporting on research from primary in-service teacher education, the focus of attention varied to a large extent. Thus, it was difficult to group the papers into categories. Five of them, however, reported research exploring discourse or communication in one way or another. The remaining four papers reported research on primary in-service teacher education exploring socio-mathematical norms, the challenges of translating central words in the mathematics curriculum from Norwegian to Sámi, teachers' knowledge about what constitutes problem solving, and the interplay between original resources and GeoGebra.

Further, in two out of the eight papers focusing on secondary school in-service teacher education, studies of PD supporting teachers in managing classroom communication were reported. One paper focused on the challenges and opportunities of a dialogic approach to mathematics teaching, and the second one was on how teaching guidelines might support teachers in managing classroom discourse. Two papers explored secondary teachers' knowledge or competencies, and two focused on the implementation or enactment of tasks and activities. The remaining two papers that explored secondary in-service teacher education focused on how problem solving using whiteboards might contribute to students' mathematical problem solving process and how teachers relate to their experiences of attainment grouping.

In conclusion, the in-service teacher education research presented at the NORMA20 conference mainly reported qualitative empirical studies from primary and secondary teacher education. Across grade levels, the focus of attention varied to a large extent. However, the challenges and opportunities related to classroom interactions seemed to have received the most attention.

Teacher educators

Three papers presented at the conference focused on teacher educators. All three were empirical with a varied approach, including cross-sectional and longitudinal studies, both quantitative and qualitative. Among the topics studied, two focused on professional development and the idea of a "community of learning", using a different setup. One study examined the interplay between programme innovators, schools, and school heads while observing dominant discourse practices as the programme unfolded, whereas the other questioned the concept of "project forums" in setting up the playground for a learning community to evolve. The last study in this group took a more didactical approach, examining how definitions are used in mathematics teaching. From the perspective that definitions are there to help students learn and understand the meaning of a new concept, the paper discussed the tensions between the required and preferred features and how practice aligns with the broad recommendations provided within the mathematics education literature.

Higher education

In total, five of the submitted papers presented research conducted in higher education, three of which addressed different mathematical aspects, such as students' understanding of linear regression. The

remaining two papers addressed the role of tasks in developing mathematical competence and the relationship between motivational beliefs and values. The first four papers adopted a qualitative approach, using (task-based) interviews and observation, while the last paper employed a quantitative approach, using a survey.

The red thread: teaching approaches and communication

Across education levels, the majority of the papers concerned different aspects of teaching practices and classroom communication. These are not novel topics; rather, they represent a long-standing research tradition seen not only in the NORMA conferences but also internationally. Many papers addressed tasks and activities related to developing mathematical competence, especially focusing on inquiry-based activities for teaching and learning. This often included collaboration and mathematical discourse, such as researching how students communicate about chance (Julien & Iversen, 2021) and exploring how the signifier 25 × 12 was realised in a discursive classroom when teaching multiplication (Gautam & Bjuland, 2021). As these two examples show, the research that might be grouped into a category such as "discourse" or "communication" varied to a large extent. While some papers focused on students, and some on teachers or pre-service teachers, many addressed both teachers and students. In total, seven of the papers focused on programming, one of the two main themes of the conference, and are therefore explored and used as an in-depth example herein. Few papers used the concept of "the Nordic model", the second main theme, although they addressed topics under this "umbrella" concept, for instance "mathematics for all" (c.f. Rønning, 2019; UNESCO, 1984).

Programming

Four papers discussed programming as part of mathematics teaching and learning. One of these papers explored teachers' (n = 20) views on programming and mathematics by applying semi-structured interviews. The researchers found that teachers were convinced that programming would be a potentially powerful tool in learning mathematics, including promoting computational thinking, if only students knew how to use it (Kilhamn et al., 2021). The teachers also claimed that students find programming interesting and engage better with programming tasks than with traditional mathematics tasks. Another of these papers used a survey to collect 445 pre-service and in-service teachers' views on the usefulness of programming in different areas of mathematics (Kaufmann & Maugesten, 2022). The analysis indicated that the respondents were less convinced of the usefulness of programming in the case of geometry than in other mathematical topic areas. Accordingly, the authors claimed that in- and pre-service teachers might need additional competence and experience in programming generally, both in the context of mathematics and in teaching programming. The remaining two papers discussed programming as part of mathematics teaching. One paper introduced two ways of approaching programming (Bergqvist, 2022). The narrow interpretation manifested activities based on learning to write codes, while the broader interpretation yielded activities in which the focus was on learning how to solve problems by applying programming as a tool. The last paper reported on teachers' experiences after participating in an intervention study in which the Use-Modify-Create approach to programming was introduced. Participants stated that they used this approach because it has a low threshold for programming, supports mathematical discussion, facilitates problem solving, and strengthens the relationship between programming and mathematics (Maugesten et al., 2022).

Three papers reported classroom studies in which students worked on mathematical problems, two of which focused on the same project, which was introducing Scratch to the students. In this project, the researchers noticed that the students gained power over the language, skills, and practices of using and applying mathematics to different degrees and took ownership of the project (Hauge et al., 2021). Even though the students displayed different levels of mathematical language and understanding of mathematical ideas, they moved towards generalisation and algorithmic thinking. Moreover, in the second paper, which was based on a case study of two students, the authors argued that programming might promote critical learning and productive struggle (Herheim & Johnsen-Høines, 2021). The third paper presented a study on student collaboration while attempting to make a square using a micro:bit. The authors found that most of the student groups struggled in their collaborative problem solving due to a lack of communication while formulating hypotheses in the debugging process (Kaufmann et al., 2022).

A common narrative in the papers focusing on programming is that programming can contribute to mathematical learning, fostering computational thinking and problem solving. However, some obstacles exist, perhaps related to how programming is introduced and scaffolded by the teacher, for instance in supporting collaborative work. Still, the main hurdle might be the teacher's belief that students need to learn to code before they can use programming rather than recognising that the students can change the existing code in their introduction to programming.

The Nordic model

Inclusive education in diverse classrooms is one of the main characteristics of Nordic classrooms and can be seen as one element in a Nordic model of mathematics education (Räsänen et al., 2019). Few papers addressed this specifically; however, many papers addressed whole-class teaching, for instance focusing on discussions (Julien & Iversen, 2021; Manshadi, 2022), exploratory talk and argumentation (Lekaus & Lossius, 2021), or developing teaching design and trying out ideas (Justnes & Mosvold, 2021; Säfström & Sterner, 2021). These and other papers included analyses of student learning that were cognizant of the learning and challenges faced by students at different proficiency levels. As such, the idea of inclusive mathematics education was embedded in most of the NORMA20 research, a few papers addressed students at a specific proficiency levels or non-diverse classrooms. We may argue that identifying what it takes to facilitate learning for all students becomes more challenging when adapted education is not at the forefront. Regarding programming, for instance, students are often asked to write the same code for the same problem, and in this case, little differentiation is included in the task. At the same time, applying problem solving strategies (Buchholtz & Singstad, 2021), and enquiry-based teaching approaches, prominent foci of the NORMA20 papers, offers richer opportunities for differentiating and adapting tasks.

Nordic classrooms are becoming more linguistically and culturally diverse, and within inclusive mathematics education, all students should have the best opportunity to learn mathematics. This includes using contexts that students find familiar and engaging, which has been a main concern in previous research on mathematics teaching in Nordic classrooms (Rønning, 2019). This, too, seemed somewhat hidden in many of the NORMA20 papers. A few exception can be found, for instance papers addressing translation issues related to translating curriculum or mathematics education concepts to North Sámi, which show an awareness of culturally responsive teaching (Norkild et al., 2022; Varjola et al., 2022).

Discussion

Judging by the topics addressed and the research methods applied in NORMA20, a driving force in the NORMA community is the need to improve mathematics education across educational levels. What may not be emergent in the presentation of educational levels, however, is the closeness between schools and research, something that might be inferred also from the analysis performed by Rønning (2019), who discussed the emergence of mathematics education as a research field in the light of the development of the school and teacher education systems in the Scandinavian countries. Regarding the NORMA papers, the authors did not offer an outsider perspective on teaching and learning mathematics; rather, they showed much awareness of the characteristics of the different educational levels. This might not be surprising regarding research on teacher education, as the majority of the NORMA community are teacher educators themselves and thus insiders. However, the same tendencies are seen in studies that reported student learning, in which the research often took a student perspective. However, being a teacher educator involves working with schools, students, and in- and pre-service teachers. This might be a feature that characterises researchers in mathematics education in the Nordic countries, and hence a quality in Nordic research.

Across the levels, many researchers designed and implemented new tools to improve their research while simultaneously improving mathematics education. This represents a willingness to develop as a researcher and to further the research field, and it might be one of the underlying reasons why the majority of studies presented at NORMA are qualitative research. Further, we observed a lack of quantitative-oriented studies, which might allow us to generalise the research findings to a larger population. This is not a novel observation; a similar observation was made by Grevholm (2021), who claimed that the NORMA17 papers were mainly empirical and qualitatively oriented. In order to bring Nordic mathematics education into the future, our research field needs to build on and extend previous research in our field to a larger extent. In addition, when the driving force is to contribute to the improvement of mathematics education, our research needs to reach decision makers such as teachers, school leaders, and teacher educators to provide evidence that they might utilise in their daily work. Moreover, we need to deliver take-home messages to decision makers, for instance by providing evidence that supports our recommendations for mathematics education.

The group of researchers in NORMA20 is diverse, with Ph.D. students and experienced researchers working together or as individuals to investigate different content in mathematics and mathematics education. Some of the papers reported studies that were part of larger projects developed by larger groups of researchers. In the future, we recommend that we, as a community, build on each other's research foci and outcomes to a larger degree while engaging in more mixed methods studies in order to facilitate theoretical discussions that can bring Nordic mathematics education forward by developing theoretical groundings about Nordic mathematics education. Part of this movement could be to continue to grow the collaboration within the NORMA community and within and across institutions and countries.

Compared to the papers reviewed by Grevholm (2021), NORMA20 shows that the NORMA society is growing, based on the number of papers presented. A majority of the papers were Norwegian, while many were Swedish, with only a few contributions from the reminding Nordic countries. This might be seen as a limitation regarding our interest in reviewing the current state of research in Nordic mathematics education.

The tradition of the NORMA conferences has been to bring together researchers in mathematics education from the Nordic and Baltic areas. Interacting, communicating, and sharing ideas has been an important instrument in shaping Nordic research. However, at the last conference, the papers presented and included in the preceedings and proceedings represent fewer countries, and as such, our analysis cannot be extended to the full Nordic area. Hence, bringing Nordic mathematics education research forward involves nurturing the NORMA community, not only with respect to our research methods and foci but also with regard to a diverse representation of the regions and communities across the Nordic and Baltic areas.

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