

Multilingual issues in Nordic mathematics education – What is achieved and where to go next?

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This NOMAD special issue provides eleven highly interesting insights into current research and development projects in mathematics education on multilingual and multicultural issues. It shows the diversity of approaches currently adopted in the Nordic Countries with an impressive richness of perspectives and ideas. I am grateful to have had the opportunity to read and discuss the papers carefully as I learned a lot. In this commentary, I compare and connect the papers with each other and the international state of research and to suggest some directions for further research and development. The commentary is structured in the following steps: Different implicit and explicit conceptualization of languages are identified in the articles (first section); different research approaches are summarized with a need to strengthen Design research (second section); and different instructional approaches for activating multiple language resources for mathematics learning and further enhancing both languages (third section).

Implicit or explicit conceptualizations of languages

As the overview in table 1 shows, the papers deal with a large diversity of language contexts:

- Almost all major Nordic majority languages appear: Danish, Swedish, Finnish and Norwegian.
- The minority languages which appear are either immigrant languages (such as Russian, English, Arabic) or native minority languages (such as Greenlandic, Sami and Kven).

Interesting enough, multilingualism in all these papers refer to *languages as langues* (national or ethnic languages), but only one to different language registers such as everyday or school academic language

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Table 1. *Overview on the language contexts investigated in the papers of this issue*

Authors	Language context of the article	Language of instruction	Home languages	Further dimension in view
Pettersson	Monolingual assessment of newly and early arrived immigrant students	Swedish	Multiple Immigrant Languages (not in view)	Curricular learning opportunities before immigration
Ahlholm & Portaan-korva-Koivisto	Monolingual assessment of multilingual immigrant students	Finnish	Russian as immigrant language	Mental processes
Fyhn et al.	Intellectualization of native minority languages	Sami and Norwegian	Sami and Norwegian	Universal activities as cultural traditions Challenges of translation from Norwegian as lingua non-franca
Hjelmberg & Fleischer	Indigenous language use in teaching and learning mathematics	Danish and Greenlandic	Greenlandic and Danish	Monolingually educated mathematics teacher as emergent bilinguals
Huru et al.	Language revitalization for native minority languages in immersion classrooms	Norwegian and Kven	Norwegian and Kven	Cultural artefacts and traditions as source for tasks
Lange & Meaney	Enhancing multilingual children's math and language-integrated multilingual learning by parents discussing with them about digital games	Norwegian but also multiple European languages	Norwegian but also European languages	Family discussions as learning opportunities. Differential parental resources for supporting the informal learning
Lembrér	Language not the category in view, instead: Parents' mathematical activities at home and in pre-school	Swedish pre-school and Polish homes as learning places	(Polish and Swedish)	Parents' views on learning opportunities: Polish parents' assimilation leaves multicultural chances behind
Sjöblom	Enhancing students' discourse competence and their mathematics learning	Swedish (and rarely one of the nine, mainly unshared immigrant languages)	Multiple immigrant languages and perhaps Swedish	Design of productive classroom discussions
Norén & Sevansson Källberg	Conceptualization of newly arrived students as language learners in policy documents	Swedish (and multiple immigrant languages as resources)	Multiple immigrant languages	Policy Dimension: Tension of social construction of multilinguals' need for help and multilingual resources
Svensson Källberg	Multilingual students and their low socio-economic status	Swedish (and multiple immigrant languages)	Not relevant in the article	Identity formation in a socially vulnerable urban area
Eikset & Meaney	Language Diversity as a Content in Mathematics Teacher education	Norwegian (and possibly multiple other languages)	Norwegian and multiple other home languages	Revealing obstacles in teacher education associated with teaching linguistic diversity, provides opportunities for change.

(Schlepppegrell, 2010; Cummins, 2000). Hjelmberg and Fleischer (in this issue) discuss everyday conversational language and formal academic registers in Greenlandic and Danish. As well, at least two papers refer to

these differences implicitly when emphasizing the distance between the morphologic and lexical demands in PISA items and students' competencies (Ahlholm & Portaankorva-Koivisto, in this issue) or the discursive competencies to be enhanced (Sjöblom, in this issue), which are both also relevant for monolingual students, but not necessarily part of the everyday language. In future research, it might be relevant to consider differences and connections also between registers within one language more systematically.

More important than the focused *languages* themselves are differences in the conceptualizations of language which are implicitly or explicitly adopted in the different papers. Figure 1 tries to sketch a (necessarily rough) map of conceptualizations, including the most important further dimensions beyond language which are in view of the papers.

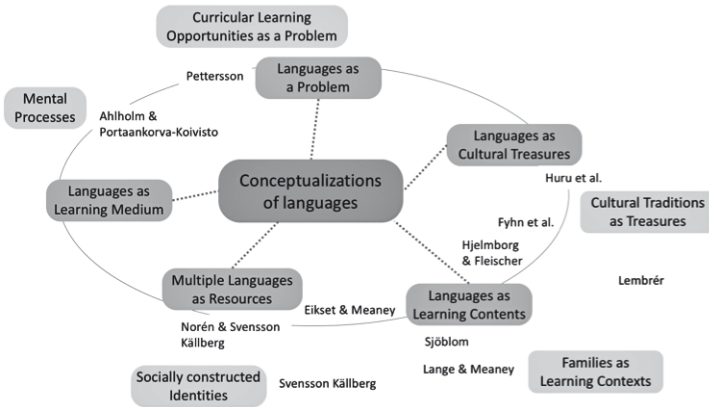


Figure 1. Map of conceptualizations of languages implicitly or explicitly adopted by the papers

Two papers mainly treat the existence of multiple *languages as a problem* when investigating multilingual students' struggle with monolingual assessments (Petterson, in this issue; Ahlholm & Portaankorva-Koivisto, in this issue). However, both papers also address aspects which go beyond the deficit-oriented view.

- Petterson (in this issue) compares the test achievements of newly and early arrived second language learners and shows that in some topics (e.g. structure sense), the newly arrived students outperform the second language learners who were completely schooled in Sweden. This addresses the dimension of possibly different curricular learning opportunities and perhaps even of difficulties of the

Swedish school system to foster second language learners' mathematics achievement. These results resonate with other studies which have shown that language limitations in the learning processes of resident monolingual and multilingual students mainly affect the higher cognitive and conceptual demands, not the procedural skills (Prediger et al., 2018).

- Ahlholm & Portaankorva-Koivisto (in this issue) investigate Russian immigrants when solving Finnish PISA items in an interview study. They can show that language demands on the lexical, syntactical and discursive level can be highly intertwined and the Finnish language especially poses highly complex morphemic demands with its 17 grammatical cases and the tight connection to different mental processes. Beyond conceptualizing language as a problem, the investigated processes provide evidence that the students can use their Finnish as learning medium for meaning making even if the grammar is not perfect. These findings resonate with early results from Adler (2001).

In contrast, three papers treat *languages as treasures* and stem from language contexts in which native minority languages are revitalized in order to preserve the cultural and linguistic traditions of the minorities, the Greenlandic language (Hjelmborg & Fleischer, in this issue), the Sami language (Fyhn et al., in this issue) and the Kven language (Huru et al., in this issue). This important work reminds the international community of the revitalization activities conducted with the Maori (Barton, Fairhall & Trinick, 1998).

- Hjelmborg & Fleischer (in this issue). In order to provide bilingual classrooms in these revitalization contexts, the mathematical register must be re-translated into the endangered languages Greenlandic and Sami, and challenges appear in these processes. Greenlandic as a highly poly-semantic language creates meanings by complex morphemic constructions, the register analysis however shows that in these constructions, the mathematics vocabulary carries the meanings much more directly than the Danish language. This is interesting as it might provide a promising pathway for Greenlandic being the better learning medium for meaning making processes (Moschkovich, 2007). Translation is never only translation, but also transformation, this is also evidenced by the second example.
- Fyhn et al. (in this issue). When trying to translate Bishop's (1991) universal activities into the Sami language, Fyhn and colleagues

report on the need for a culturally-responsive transformation rather than adaptation: locating in the North Sami culture needed to be split into two activities. Future papers will be able to trace the learning processes from these culturally bound universal activities towards also the formal mathematical concepts.

- Huru et al. (in this issue). For Kven revitalization, the tension between learning the language of origin and getting access to mathematics which has often been discussed for the South African context (Setati, 2005a) is crucial to policy issues in the Kven context. Huru and colleagues suggest to dissolve the tension by mathematics- and language-integrated classrooms which systematically refer to the cultural tradition of the cultural to be revitalized. By adopting this typical ethnomathematical approach (D'Ambrosio, 1985; Gerdes 1996), the group of authors can combine the different purposes. For a future study, it would be interesting to see how these cultural artefacts are also connected with the standard-Western mathematics curriculum and how it influences the uses of language.

In all these three language revitalization contexts, the minority languages are also conceptualized as a critical *learning content* which requires extra attention in immersion classrooms. This is different to the other articles in which the *languages treated as learning contents* are mainly the majority languages, such as Swedish (Sjöblom, in this issue; Norén & Svensson Källberg, in this issue).

When these articles also refer to the home languages, they mainly conceptualize the *languages as resources* to be activated for mathematical learning. However, treating multiple languages as resources for mathematics learning seems to have only very little attention in the current projects (mainly in prescriptive demands in Norén & Svensson Källberg, in this issue, and Eikset & Meaney, in this issue), although this conceptualization is highly recommended on the international level (Beacco et al., 2010; Planas & Setati, 2014; Schüler-Meyer et al., 2017). This might suggest a further direction for future research.

The main reason why all languages should be treated as resources is that language is always an important *learning medium* (Pimm, 1987). Language as a *learning medium* appeared in nearly every project (but mostly as a second or third conceptualization, that is why they are not visible in figure 1), e.g.,

- language can serve as a learning medium in the interview study of Ahlholm & Portaankorva-Koivisto's (in this issue), even if the grammar is not perfectly developed;

- language could serve as a learning medium for meaning making, especially when Greenlandic provides the better links to constructing meanings, after having managed the complexities of the morphemic constructions (Hjelmborg & Fleischer in this issue);
- family languages are expected to be the medium for parent-child discussions about digital games in the proposal of Lange & Meaney (in this issue);
- active language use for establishing mathematical discourses is deliberately fostered by Sjöblom (in this issue).

Summing up, the papers address and combine different conceptualizations, which shows a particular strength of many papers. For the future, also treating languages as resources might be strengthened in the design activities.

Whereas some (of the so far mentioned) papers show how language is connected to cultural issues, two papers leave language behind and mainly focus on other multicultural aspects. Svensson Källberg (in this issue) investigates the identity construction of immigrant students from failing schools; their identity formation seems to be highly shaped by social marginalization, not by language concerns. Lembrér (in this issue) investigates Polish parents' views on mathematical activities in preschool and at home. She reveals that the Polish parents have aligned with the preschools' priorities and criticizes that by this assimilation, potential multicultural resources from the mathematically strong Polish culture might be left unused. Both studies show that multilingual children live in multicultural contexts in which *national* differences and similarities are not the major factor anymore. Instead, their life is shaped by the superdiversity (Vertovec, 2007) of modern European societies. These societies still need to learn to take their multicultural nature as a resource for learning, future research could elaborate on this idea.

Multiple research approaches and research aims

The eleven papers cover an impressively wide range of research approaches. Some concern the analysis of circumstances or backgrounds:

- theoretical analysis of policy documents (Norén & Svensson Källberg);
- theoretical linguistic register analysis (Hjelmborg & Fleischer);
- surveys with parents (Lembrér; Lange & Meaney);

- large-scale assessment (Pettersson);
- interview study on students' identities (Svensson Källberg);
- interview study with think aloud protocols (Ahlholm & Portaankorva-Koivisto);
- report from researcher and teachers' challenging discussions in regard to translating theoretical considerations into Sami (Fyhn et al.).

Some more directly address students' learning processes and the design:

- design activities for introducing Bishop's six universal activities into a culture-responsive Sami curriculum (Fyhn et al.),
- collaborative design and implementation (Huru et al.),
- qualitative analysis of video-taped discussion of professional development sessions (Eikset & Meaney), and
- design research with video-based analysis (Sjöblom).

The first set of research approaches are interesting to understand students' challenges (Pettersson, in this issue; Ahlholm & Portaankorva-Koivisto, in this issue) and the underlying language demands (Ahlholm & Portaankorva-Koivisto, in this issue; Hjelmberg & Fleischer, in this issue) or other highly relevant background factors such as parents' culturally influenced perspectives (Lembrér, in this issue; Lange & Meaney, in this issue), identities shaped by socio-economic status (Svensson Källberg, in this issue) or policy influences (Norén & Svensson Källberg, in this issue). All these studies can help to describe and understand the circumstances and backgrounds of multilingual classrooms. However, they cannot inform the *design* of teaching approaches and hence the concrete learning opportunities of these students as the research was too distal from the concrete learning processes.

In contrast, the other studies can provide a contribution to improving teaching practices. Whereas reporting on translators' experiences (Fyhn et al., in this issue) and on collaborative design and implementation (Huru et al., in this issue) can contribute to reflective practitioners' knowledge, the two other studies (e.g. Eikset & Meaney, in this issue) and especially the *Design research* project (Sjöblom, in this issue) take the generated teaching learning processes as their new research focus and thereby systematically contribute to an empirical foundation of teaching approaches for multilingual classrooms. For all the open questions mentioned ideas for future research and design efforts, these kinds of research approaches might have an interesting potential.

Design research is a well-established research approach which combines both, (1) developing innovative learning opportunities as contributions to practical problems and (2) providing deep insights into the initiated teaching learning processes with the aim of contributing to a successive theory building (Gravemeijer & Cobb, 2006). In the context of fostering language learners' mathematics learning, Design research has proven to be valuable in several projects.

- Sjöblom (2015) improved the quality of small group discussions and documented the students' learning processes.
- Smit (2013) and Pöhler & Prediger (2015) developed teaching units according to the design principle of macro-scaffolding (Gibbons, 2002) in which students can successively learn to master all language demands occurring while acquiring conceptual understanding of diagrams or percentages, respectively.
- Prediger & Zindel (2017) showed how Design research can allow the researchers to identify language demands occurring in the details of topic-specific learning of the concept of functions, or deductive reasoning, respectively.
- Meaney et al. (2012), although not explicitly situating in the Design research methodology, document a Design research project promoting indigenous students' mathematics learning. The book is an excellent example showing how solving practical teaching problems and contributing to theory building can convincingly be intertwined.

These examples show that Design research approaches can substantially contribute to developing an empirically founded didactics of language-responsive mathematical classrooms by

- reconciling different language conceptualizations by not stopping with seeing languages as a problem, but developing them as learning medium and learning content in a consequent and systematic manner;
- testing and optimizing instructional approaches;
- specifying language demands very near to the mathematical topic;
- gaining theoretical knowledge of multilingual learning processes.

For suggesting further directions, I therefore advise to continue all the wonderful projects in the direction of Design research.

Finally, the paper of Eikset & Meaney (in this issue) shows the complexities of mathematics teacher educations when the mathematics teacher educator (the second author) intends to prepare the preservice teachers for linguistically diverse mathematics classrooms. The current state of theory building for a didactics of multilingual mathematics classrooms is still much too far from providing a frame in which the teacher educators' reflections and decisions could be embedded and typical tensions be treated. This again shows that more systematic Design research on multilingual mathematics classrooms is required.

Different instructional approaches for activating multiple language resources for mathematics learning and further enhancing both languages

Although most of the presented paper adopted a more fundamental research stance aiming at providing understanding for specific circumstances, they implicitly or explicitly work with ideas for different instructional approaches for enhancing the mathematics learning for monolingual and multilingual language learners:

- integrating mathematics- and language teaching and learning rather than letting them compete for the learning time (Huru et al., in this issue; Norén & Svensson Källberg, in this issue), which is totally in line with current research results (Gibbons, 2002; Moschkovich, 2013);
- focus on students' constructions of meanings as a major step for developing conceptual understanding (Hjelmberg & Fleischer, in this issue), which is again in line with current efforts in many places (Setati, 2005b; Prediger & Zindel, 2017);
- building upon the multilingual language repertoires as an important resource for constructing meanings (Hjelmberg & Fleischer, in this issue; Norén & Svensson Källberg, in this issue; Schüler-Meyer et al., 2017);
- constructing meanings from culturally-responsive universal activities (Bishop, 1991; Fyhn et al., in this issue);
- referring to the parents' resources to use family discussions for developing the multilingual language repertoires and the mathematical ideas (Lange & Meaney, in this issue; Lembrér, in this issue);

- enhancing students discourse competences (here concretely the posing of questions) by focused learning opportunities (Sjöblom, in this issue);
- starting from mathematically rich artefacts which are language-neutral and can be used in two languages, in preschool and at home (Lange & Meaney, in this issue). This is, in my view, a highly interesting new idea which should be elaborated as quickly as possible.

The most striking features of all these approaches are that they have the potential to connect different languages and registers and overcome unnecessary splits of worlds. This is what makes them most strong. I am looking forward to reading about the continuation of the projects in which these approaches are further explored and systematized!

References

- Adler, J. (2001). *Teaching mathematics in multilingual classrooms*. Dordrecht: Kluwer.
- Barton, B., Fairhall, U. & Trinick, T. (1998). Tikanga reo tātai: issues in the development of a māori mathematics register. *For the Learning of Mathematics*, 18 (1), 3–9.
- Beacco, J.-C., Byram, M., Cavalli, M., Coste, D., Egli Cuenat, M. et al. (2010). *Guide for the development and implementation of curricula for plurilingual and intercultural education*. Strasbourg: Council of Europe. Retrieved from <http://www.coe.int/lang>
- Bishop, A. J. (1991). *Mathematical enculturation. a cultural perspective on mathematics education*. Dordrecht: Kluwer.
- Cummins, J. (2000). *Language, power and pedagogy: bilingual children in the crossfire*. Clevedon: Multi lingual Matters.
- D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics*, 5 (1), 44–48.
- Gerdes, P. (1996). Ethnomathematics and mathematics education. In C. K. Bishop A.J., Keitel C., Kilpatrick J. & C. Laborde (Eds.), *International handbook of mathematics education* (pp.909–943). Dordrecht: Kluwer.
- Gibbons, P. (2002). *Scaffolding language, scaffolding learning. teaching second language learners in the mainstream classroom*. Portsmouth: Heinemann.
- Gravemeijer, K. & Cobb, P. (2006). Design research from a learning design perspective. In J. van den Akker, K. Gravemeijer, S. McKenney & N. Nieveen (Eds.), *Educational design research: the design, development and evaluation of programs, processes and products* (pp. 17–51). London: Routledge.
- Meaney, T., Trinick, T. & Fairhall, U. (2012). *Collaborating to meet language challenges in indigenous mathematics classrooms*. Dordrecht: Springer.

- Moschkovich, J. (2007). Using two languages when learning mathematics. *Educational Studies in Mathematics*, 64 (2), 121–144.
- Moschkovich, J. (2013). Principles and guidelines for equitable mathematics teaching practices and materials for English language learners. *Journal of Urban Mathematics Education*, 6 (1), 45–57.
- Pimm, D. (1987). *Speaking mathematically. Communication in mathematics classrooms*. London: Routledge.
- Planas, N. & Setati-Phakeng, M. (2014). On the process of gaining language as a resource in mathematics education. *ZDM*, 46 (6), 883–893. doi: 10.1007/s11858-014-0610-2
- Pöhler, B. & Prediger, S. (2015). Intertwining lexical and conceptual learning trajectories – a design research study on dual macro-scaffolding towards percentages. *Eurasia Journal of Mathematics, Science & Technology Education*, 11 (6), 1697–1722. doi: 10.12973/eurasia.2015.1497a
- Prediger, S. & Zindel, C. (2017). School academic language demands for understanding functional relationships: a design research project on the role of language in reading and learning. *EURASIA Journal of Mathematics, Science and Technology Education*, 13 (7b), 4157–4188. doi: 10.12973/eurasia.2017.00804a
- Prediger, S., Wilhelm, N., Büchter, A., Gürsoy, E. & Benholz, C. (2018). Language proficiency and mathematics achievement – empirical study of language-induced obstacles in a high stakes test, the central exam ZP10. *Journal für Mathematik-Didaktik*, 39 (3). doi: 10.1007/s13138-018-0126-3
- Schüler-Meyer, A., Prediger, S., Kuzu, T., Wessel, L. & Redder, A. (2017, online first). Is formal language proficiency in the home language required to profit from a bilingual teaching intervention in mathematics? A mixed methods study on fostering multilingual students' conceptual understanding. *International Journal of Science and Mathematics Education*. doi: 10.1007/s10763-017-9857-8
- Setati, M. (2005a). Power and access in multilingual mathematics classrooms. In M. Goos, C. Kanes & R. Brown (Eds.), *Proceedings of the fourth International Mathematics Education and Society Conference* (pp. 7–18). Gold Coast: Griffith University.
- Setati, M. (2005b). Teaching mathematics in a primary multilingual classroom. *Journal for Research in Mathematics Education*, 36 (5), 447–466.
- Sjöblom, M. (2015). *Promoting student-to-student interactions in mathematics: a study in a multilingual upper secondary classroom* (Licentiate thesis). Malmö: Holmbergs.
- Smit, J. (2013). *Scaffolding language in multilingual mathematics classrooms* (PhD thesis). Utrecht: Freudenthal Institute.
- Vertovec, S. (2007). Super-diversity and its implications. *Ethnic and Racial Studies*, 30 (6), 1024–1054.

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