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Digital technologies & linguistically and culturally relevant pedagogies: where do we stand?

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ABSTRACT

This special issue highlights research mainly conducted from 2020 to 2023 in Canada, France, Germany, the UK and Finland. Each of these studies presents the affordances and constraints of using multilingual digital tools to address the deficit orientation to the education of newcomer students that still exists in many contexts. This includes the underestimation of the potential of multilingual students as well as the exclusive focus on using the language of the school for teaching and learning. It highlights the crucial role of teachers in supporting newcomer students and emphasises the innovative nature of using digital technology in STEM education. The six articles that make up this special issue focus on linguistically and culturally relevant online learning resources and curricula designed to support inclusive learning in STEM subjects. Focusing on teachers and their ideologies as well as teacher training, the articles highlight the varying degrees of effectiveness of multilingual technology in providing new ways of integrating newcomer student perspectives into curricula and promoting inclusive STEM education.

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Multilingual learner; digital technologies; linguistically and culturally relevant pedagogies; STEM education; English as a second language; teacher training

Poor academic achievement among multilingual learners continues to be the focus of international debate, particularly in countries with a high influx of newcomer and refugee students, such as Canada, France, Germany, Sweden, Finland or the United Kingdom. Among the proposed causes, proficiency in the school language is a key factor. Multilingual learners need at least five years to catch up with their peers in school (e.g. Collier, 1987; Cummins, 1981; Levin & Shohamy, 2008). During this time, multilingual learners invest a substantial proportion of their efforts in learning the school language, while struggling with the academic language demands of content subjects. As a result, some fall behind academically (Collier & Thomas, 1989; Cummins, 1989, 2000; Le Pichon et al., 2023; OECD, 2016). Another challenge is that assessments conducted upon arrival are almost always carried out in the host country's dominant language (Le Pichon, 2020). This is likely to negatively affect the assessments of skills, where proficiency in the target language is necessary for obtaining a reliable assessment of the skill (e.g. numeracy). As a result, the academic skills of multilingual learners may

often be underestimated (Callahan et al., 2021; Kanno & Kangas, 2014). In fact, the latest results from standardised math tests across Canada speak for themselves: only 34% of English Language Learners in Ontario reached the provincial standard, compared to 64% before the pandemic (¹EQAO, 2023). Is the language of the school solely responsible for these students' failure on tests? And if not, what are the other factors? And above all, are there any solutions in sight to enable these students to perform at their actual level of ability? Interestingly, studies have reported that multilingual learners performed better in math when assessed in their home language (Attar et al., 2020), even when they had never been taught in that language (Le Pichon & Kambel, 2016). These and other findings (Cummins, 2017; Dendrinos, 2019; Morgan, 2020) suggest that the assessment of academic skills in multilingual learners is very likely confounded by their linguistic level in the language of the assessment which prevents them first from comprehending, then elaborating and finally communicating the solution (Callahan et al., 2021; Lidz, 1991). In addition, in order for multilingual learners to integrate into their new academic environment, they need to acquire socio-cultural norms related to the institution such as doing homework. Furthermore, numerous countries, including Canada, have adopted a digital testing system that necessitates students to possess the skills to navigate and utilise these digital assessments.

In summary, the underestimation of their academic potential, the delay caused by the process of catching up with the school language and the acquisition of socio-cultural norms and digital skills are all potential important factors explaining their observed academic underperformance (e.g. August & Hakuta, 1997; Cummins, 1989). There are additional aspects of academics that likely challenge all students but may be particularly taxing for multilingual learners. For instance, in STEM subjects, students need to become familiar with technical language, polysemic concepts, math symbols and general academic vocabulary (Cummins & Takeuchi, 2019; Freeman & Crawford, 2008; Le Pichon et al., 2021; Song & Coppersmith, 2020). Moreover, in the general population a decline of interest in mathematics and sciences in the middle grades is observed, as well as reduced opportunities to practice science and math outside of school hours (Savelsbergh et al., 2016). Although these trends are general, they are likely to affect multilingual learners in particular, making it difficult to make sufficient academic progress in these subjects in a timely manner (Allexsaht-Snider & Buxton, 2016).

According to the Ontario Ministry of Education (2008), all teachers should be able to support multilingual learners. However, teachers are typically prepared to work with an imagined monolingual homogeneous group of students and therefore not provided with the necessary knowledge to cope with high levels of linguistic diversity in the classroom (Allexsaht-Snider & Buxton, 2016; Song & Coppersmith, 2020). This is unfortunate as a powerful strategy for facilitating multilingual learners' integration into their new educational and social environment is to engage their home languages to maximise the transfer of academic content. This strategy is supported by a host of studies showing its advantages (e.g. Cenoz & Gorter, 2013; Creese & Blackledge, 2010; Cummins, 2017; Garcia & Wei, 2014; Reljić et al., 2015; Westernoff et al., 2021). One promising way forward involves the use of multilingual digital tools that focus on academic content. Although such tools are available to support student learning in some content areas, they are not yet widely available. In addition, teachers need to learn how to use and implement these novel multilingual digital tools

to support multilingual student learning and get important insights into their multilingual students' true academic skills across subject areas.

Research has shown that digital technologies have the potential to enhance the engagement of students independent of the setting (Stacy et al., 2017). Online and computer-based tools have recently been gaining traction as promising and appealing strategies to assist teachers. Of particular relevance to this special issue, digital technologies can incorporate different languages, which provides a unique opportunity for students to access content in their home language and for teachers to assess their skills. Such technology can provide a more accurate impression of their knowledge and skills in these domains (Haertel et al., 2012). However, computer-based tools developed thus far to engage students in a sustainable way, have not exploited the option of using multiple languages or if they have, they did not adopt a game-like interface (Le Pichon et al., 2021; Van Laere et al., 2016).

Additionally, the closure of schools across countries during the COVID-19 pandemic has exposed significant gaps in the educational provision for both 'mainstream' and 'vulnerable' school populations. Teachers in elementary and secondary schools (K-12) have struggled to find learning resources that connect with the curricula they are mandated to teach. Furthermore, until the pandemic, most teachers had minimal opportunities to develop their expertise in delivering curriculum using online technologies and find learning resources that connect with the curricula they are mandated to teach. The challenge has been daunting even in the case of students who have access to computer technology at home. However, the challenges are even more acute for students who could be classified as at-risk as a result of their families' precarious socioeconomic situation, the recency of their arrival in host countries, or the fact that neither parents nor children may speak the language of schooling.

In this special issue, we brought together studies of innovative linguistically and culturally relevant online learning resources within STEM subjects. The main objective is to understand what lessons can be learned from their use in terms of addressing the challenges of educational continuity and the effectiveness of these multilingual tools. The distinctiveness of this special issue lies in its nearly exclusive focus on teachers and teacher education or professional development in each article, with the exception of the first article, which also incorporates the perspectives of parents and communities. With this emphasis, we wish to underscore the critical role teachers play as essential catalysts for learning. In the realm of digital technology, teachers assume the pivotal role of decision-makers, determining whether and how these tools should be incorporated into the learning environment. Teachers have, perhaps, been overlooked in their training and unfairly implicated when learning challenges arise. The question arises: What measures are in place to support them, and are they adequately equipped through training?

Five out of the six articles report on studies conducted in Canada, France, Germany, and Finland, that explore the capacity of the innovative Binogi resource to instigate a dialogue among pre-service teachers, in-service teachers and families regarding the need to reassess STEM education in recognition of students' plurilingual skills. These articles reveal that an approach rooted in deficit thinking, centring on students deemed at risk of failure, results in the neglect of plurilingual resources and practices. In contrast, an asset-based approach fosters innovative practices and establishes spaces for STEM

engagement among families, teachers, and, ultimately, students. The findings of the sixth article, stemming from research conducted in a teacher education programme in England, align with the conclusions drawn in the previous five articles but utilise distinct online technologies. All findings underscore the significance of reimagining STEM education, emphasising the need for a reevaluation of teacher preparation and professional development practices.

The first article of the special issue by Le Pichon, Naji, Cha, Ye Jia, and Tariq – *Towards linguistically and culturally sensitive curricula: the potential of reciprocal knowledge in STEM education* – delves into the challenges of supporting the education of multilingual students across diverse curricular landscapes. The study explores the implementation of the multilingual digital tool, Binogi, as a means to understand students' diverse backgrounds and prior knowledge in STEM fields. Employing a critical interculturalism approach, the research challenges implicit cultural assumptions and power dynamics related to social justice, promoting a positive perspective on newcomer students as enriching the host school system. The authors analyzed math and science curricula from various countries for grades 6–9, including Syria, Afghanistan, Pakistan, China, Korea, and Ontario. This analysis allowed them to identify similarities and differences between the curricula, leading to the creation of programme maps and concept lists that connect scientific and mathematical concepts in each language. The study explored linguistic and cultural transfer, focusing on the meaning of concepts in different languages used in a variety of contexts. Activities in various languages were developed to assist teachers in leveraging students' linguistic and cultural resources in conjunction with the digital resource Binogi. The findings were disseminated through workshops involving teachers, parents, and communities, and results of these workshops showed that language and culture-based resources for STEM education enhance the inclusion of students with diverse linguistic backgrounds. The findings also showed that improved teacher understanding, parental navigation of the educational system, and validation of students' prior learning, contribute to a more inclusive educational environment. In conclusion, the authors highlight the potential for teachers to leverage the diversity of students' funds of knowledge, adapting curricula through language friendly pedagogy to address the needs of students within the framework of reciprocal knowledge.

The second article of this issue, by Cavalcante, Gagné, and Le Pichon, explores the nexus of language friendly pedagogy and mathematics education. Titled *Mathematical benefits of a language-friendly pedagogical tool: a praxeological analysis of teachers' perceptions and practices*, the study focused on preparing teachers to work more effectively with multilingual students learning mathematics. Both in-service and pre-service mathematics teachers experienced using the Binogi online platform, which provides STEM instructional videos in multiple languages. The study employed the Anthropological Theory of the Didactic (ATD) to investigate the mathematical benefits perceived by the participants. Data collection involved responses from in-service and pre-service teachers regarding their experiences with language friendly pedagogy and the Binogi platform. The analysis, guided by open-ended questions, delves into perceptions of multilingual instruction, the potential use of Binogi in and beyond the classroom, and recommendations for training resources. The findings revealed contrasting praxeologies among teachers, with some viewing mathematics as a universal concept independent of language, while others recognised the value of multilingualism in learning mathematics. Teachers embracing a

language friendly approach supported open-ended, inquiry-based explorations, fostering higher engagement and ownership of learning for all students. Conversely, some viewed multilingual platforms as remedial tools rather than opportunities to enrich learning through diverse cultural and linguistic lenses. The article concludes by emphasising the urgent need to support mathematics teachers in adopting and implementing language friendly pedagogies. The authors call for a shift toward a new epistemology of mathematics in teacher education, highlighting numeracy as a human practice embedded in social groups.

Multilingual pedagogies and digital technologies to support learning STEM in schools in France and Canada by Auger, Sauvage, Le Pichon, Fleuret, Rempel and Dalle, investigates the facilitative role of multilingual pedagogies and digital technologies in promoting STEM education within the educational frameworks of France and Canada. The study provides an overview of the distinct educational contexts, setting the stage for examining the impact of the Binogi online platform on students' language proficiency in science and mathematics.

The project, conducted amidst the challenges posed by the COVID-19 pandemic, aimed to familiarise students with the language used in STEM subjects and bridge language gaps for recently arrived and multilingual students. In Canada particularly, the challenges of online instruction were heightened due to long school closures and unpredictable schedules. Despite the differing circumstances, both sets of teachers engaged in the study, contributing valuable insights into the implementation and use of Binogi in their educational settings. Qualitative data informed the analysis, revealing convergent experiences of French and Canadian educators. Overall, the introduction of Binogi facilitated the adoption of translanguaging practices in STEM subjects, with teachers applying targeted pedagogical differentiation, catering to the language needs of diverse student groups. In both countries, teachers highlighted the usefulness of the monitoring feature of the online platform that allowed them to keep track of their students' progress and gain insight into their learning. The article emphasises the platform's versatility which allowed teachers to integrate the videos and related online resources into different stages of their lessons. The article concludes by highlighting the impact of reflective activities that prompt students and teachers to prioritise language as a crucial objective within STEM subjects and to understand that multilingual practices can contribute to enhanced language awareness and a deeper understanding of scientific content.

The article titled *Crossing linguistic and disciplinary boundaries? Linguistic practices in STEM/S.T.E.M. classrooms, or how a multilingual habit does not make a multilingual monk*, by Melo-Pfeifer offers valuable insights into the integration of multilingual pedagogies in the context of STEM practices. The paper explores the complexities of implementing multilingual STEM pedagogies, emphasising the dual challenge of crossing linguistic boundaries while simultaneously bridging subject-specific knowledge. One of the key takeaways from this paper is the recognition of the complex interplay between teacher beliefs, school context, and the perceived role of languages in education. The study emphasises the importance of raising awareness about intralinguistic diversity and the specific needs of STEM students in teacher education programmes. Additionally, it highlights the need for teacher education to promote responsiveness to language proficiency, heritage language maintenance, and interdisciplinary knowledge construction to enhance cognitive justice and epistemological diversity in the classroom. Such

perspectives can open doors to innovation in teacher education programmes, potentially involving the co-teaching of interdisciplinary modules by experts from various fields. In conclusion, this article contributes to the ongoing discourse on multilingual pedagogies in STEM education and underscores the need for a nuanced understanding of the challenges and opportunities in bridging linguistic and disciplinary boundaries. It encourages teacher educators and policymakers to consider the dynamic relationship between teachers' beliefs, school context, and language ideologies in shaping pedagogical practices in multilingual settings. The findings also highlight the importance of fostering awareness, responsiveness, and interdisciplinary perspectives in teacher education programmes to better prepare educators for diverse and multilingual classrooms.

In *Finnish pre-service teachers' understandings of the role of language(s) in learning mathematics*, Alisaari, Heikkola and Harju-Autti make a significant contribution to our understanding of the importance of language friendly pedagogy in mathematics education. The study delves into the experiences of Finnish pre-service primary school teachers as they engage with the role of language in mathematics learning and the impact of a practical teaching period. The findings reveal a growing awareness of linguistic challenges and the significance of students' home languages in the learning process, which aligns with the broader discourse on the importance of linguistic diversity in education. However, the study also uncovers the persistence of monolingual ideologies among some participants, underscoring the need for continued efforts to promote multilingual pedagogies. The research highlights the importance of providing pre-service teachers with research-based information on multilingual pedagogies and the benefits of strong home language skills in supporting the learning of both language and content. The authors underscore the eagerness of pre-service teachers to explore and implement multilingual pedagogies, suggesting the potential for meaningful change in mathematics education. This article, therefore, offers valuable insights for educators and policymakers seeking to enhance the role of language in mathematics instruction and promote inclusive education practices, not only in the Finnish context but also in other educational settings worldwide.

Benson presents in the article *Using a functional multilingualism framework and online learning to develop professional repertoires and racial literacy for trainee mathematics teachers in London England*, a narrative case study that holds great importance for this special issue on language friendly pedagogy in mathematics and science education. It examines the language provisions for a diverse group of trainee mathematics teachers undertaking a Postgraduate Certificate in Education in London, England. By integrating concepts such as Functional Multilingualism, Academic Literacy in Mathematics, and digital multimodal literacies, this study underscores the significance of embedding professional and academic literacies alongside mathematics pedagogies. It not only addresses the development of professional language repertoires for mathematics teaching but also fosters a safe space for trainees to discuss issues related to diversity and inclusion. The article's innovative approach over a four-year period demonstrates how to prepare teachers to work effectively in super-diverse classrooms, challenging language deficits among both teachers and students. It emphasises the importance of critical language awareness and a multimodal approach, including the use of digital resources in mathematics teaching, which enhances meaning-making processes and promotes critical reflection. Moreover, it contributes to building a creative professional identity capable of managing the challenges and opportunities in teaching. The article presents implications for teacher education in England and

serves as a valuable reference for exploring how such strategies are implemented in teachers' early careers and planning for multimodal literacies that promote critical language awareness. It highlights the importance of creating safe spaces for discussing issues of race, gender, and sexuality in schools throughout the teacher education period, making it a highly relevant and insightful contribution to this special issue.

As each of the authors explored how innovative digital tools allowed for linguistically and culturally relevant pedagogies, they considered their propensity to support students' academic progress, increase parent engagement, and strengthen teachers' digital skills in STEM. By demonstrating the benefits of these resources, this special issue provides evidence that teachers can use multilingual platforms and other digital resources to support their multilingual learners regardless of location or language. In order to provide instruction that is tailored to the individual needs of each student, it remains crucial to equip teachers with versatile digital tools as well as support them in learning to use these to their full potential in meeting the needs of their multilingual students (Alleksaht-Snider & Buxton, 2016; Benson, 2010; Bunch, 2013; Cummins, 2012; Lyon, 2017). Unfortunately, until the pandemic, schools often underestimated the importance of digital technologies and teachers were not prepared to use them to teach. It is therefore equally important to identify innovative practices to support teachers in adopting novel resources (Cenoz & Gorter, 2017; Cummins, 2017; Garcia & Wei, 2013; Song & Coppersmith, 2020; Westernoff et al., 2021). Identifying these tools and validating them can foster innovative multilingual teaching practices.

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Note

1. <https://www.eqao.com/wp-content/uploads/2023/08/highlights-provincial-results-2023-g3.pdf>

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