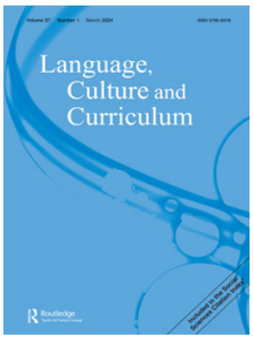

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Towards linguistically and culturally responsive curricula: the potential of reciprocal knowledge in STEM education

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ABSTRACT

From the perspective of host country education system and, in light of a normative view of academic development, school systems have too often viewed the academic profiles of newcomer students as deficient despite a curriculum in Ontario (Canada) that mandates culturally relevant and responsive pedagogy. In this project, we view the mobility of these students as an enrichment of the host school system through the lens of reciprocal knowledge. The online STEM resources created are based on an understanding of the students' funds of knowledge from the curricula of the families' home countries. The results show that these resources contribute to the inclusion of multilingual students by allowing their teachers to better understand them, helping parents to understand the educational system of the country in relation to their own. However, such an approach requires curriculum change to include these transcultural perspectives and to train teachers to open their classrooms to reciprocal knowledge.

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Linguistically and culturally relevant and responsive pedagogy; curriculum; funds of knowledge; digital technology; newcomer students; reciprocal knowledge

Conversation between a researcher and a Grade 9 student translated from Dari

I: How long have you been in Canada?
B: 3 months.
I: […] What grade are you in?
B: 9th grade, but 7th and 8th grade for math. […] after we took the test, we were told to start math from 7th and 8th grade.
I: How do you feel about math at this level? Is it easy or hard, or is it good?
B: Very easy.
I: How? Had you learned these lessons before in Afghanistan?
B: Yes, we had studied them in Afghanistan.
I: Did you tell your teacher that the lessons are easy for you? […]
B: No. The problem here is that I only learned some lessons, not all of them in Afghanistan. I mean, some lessons are totally new to me. […] Area, theorem, etc. […] I mean the language is a challenge, but I deal with it by looking up the translation of new words in google translate. […] The Google translation is not accurate either. This makes the program very difficult.

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1. Introduction

This conversation took place in April 2022 during a focus-group session with students. It was conducted in Dari and facilitated by one of the research assistants. The dialogue highlights the challenges faced in welcoming newcomer students and sheds light on the evaluation of students' academic skills and their orientation to a corresponding level. The student not only communicates her struggle with the language of instruction, but she reveals the lack of alignment of educational programmes and the resulting issues. This conversation, in essence, exemplifies common educational misunderstandings that can occur when welcoming newcomer students in the Canadian context (see also Antony-Newman & Niyozov, 2023). More often than not, differences in curriculum and language between home and host countries are main sources of challenges for these students (Le Pichon, Naji, et al., 2023). The ESCAPE research project, derived from the French acronym 'Enseigner les Sciences aux Elèves Plurilingues' (Teaching Science to Multilingual Students) and sponsored by a Canadian Federal grant (SSHRC), aims to assist teachers in developing a better understanding of the needs of students and families by addressing their funds of knowledge through language and curriculum. Specifically, the objectives include:

(1) Assisting teachers in empowering students by creating opportunities for them to utilise their own languages during the learning process;
(2) Supporting teachers in building upon students' previous learning by minimising the language demands;
(3) Engaging parents and families in their children's academic journeys, fostering a collaborative partnership between home and school.

In this article, we focus on the latter objective. We first present a review of the literature on the topic of culturally relevant and responsive pedagogies and the potential of digital technologies to enable better communication between families and schools, particularly in the Canadian context. Then, we introduce the STEM resources that were developed in the framework of the ESCAPE projects on the basis of an existing multilingual online resource and an in-depth study of the curricula of the students' countries of origin. We describe some of the activities we conducted to introduce them to teachers and parents in order to promote dialogue and encourage reciprocal knowledge. Finally, we evaluate the impact of these activities on parent and teacher satisfaction and the ideal conditions for their implementation.

1.1. Canada

In 2022, Statistics Canada released a document stating that 'over 1.3 million new immigrants settled permanently in Canada from 2016 to 2021, the highest number of recent immigrants recorded in a Canadian census' (Statistic Canada, 2022, p. 2). Taking these statistics into account, the Ontario Ministry of Education recommends that teachers use students' cultures as a tool for learning through connections with their 'background, language, family structure, social or cultural identity' (Ontario Ministry of Education, 2022). This pedagogy thus aims to encourage teachers to consider the funds of

knowledge that students bring with them (Gay, 2018; Ladson-Billings, 1995; Ladson-Billings, 2009; Moll et al., 1992), rather than emphasizing their lack of knowledge of the host country's curriculum. Too often, school systems in host countries consider the academic profiles of newcomer students as deficient (Dryden-Peterson, 2016; Ogilvie & Fuller, 2016). Many teachers lack a comprehensive understanding of their new students' prior educational experiences, and the necessary resources to obtain this information (Antony-Newman & Niyozov, 2023). These experiences are frequently concealed from schools due to factors like language differences and cultural misunderstandings (Dryden-Peterson, 2016). In this research, we aim for a positive approach that sees the mobility of these students as an enrichment of the host school system, to the extent that teachers take into account the funds of knowledge of their students and are aware of their transcultural experiences of mobility (Cummins et al., 2015; Freeman & Crawford, 2008; Le Pichon, Cole et al., 2020; Le Pichon, Siarova et al., 2020; Wattar & Le Pichon, 2022). We seek to understand how the continuity of students' schooling can be supported despite language and curriculum differences, particularly in STEM. We posit that it is urgent to give teachers and families the means to better understand each other and that digital technologies offer many opportunities for teachers to better understand the needs of their students and parents to support their children in their school journey (Cenoz & Gorter, 2017; Cummins, 2017; García & Wei, 2014; Song & Coppersmith, 2020; Westernoff et al., 2021).

1.2. Culturally relevant and responsive pedagogy and digital resources: A holistic approach to languages

As established above, the immigrant population in Canada continues to grow at a significant rate. Therefore, teachers, and STEM teachers in particular, need to adopt a more inclusive pedagogy by addressing the challenges of their newcomer students to counteract the gradual disinterest of teenagers in STEM (Savelsbergh et al., 2016) and, ultimately, STEM dropout in high school (Callahan, 2013). However, English as a second language teachers may not necessarily cover STEM topics in their classrooms, and STEM teachers may feel inadequate in supporting students who are still learning the language of instruction (Freeman & Crawford, 2008; Le Pichon, Naji, et al., 2023; Wattar & Le Pichon, 2022). As a result, their approach to teaching is primarily monolingual. The traditional belief of the monolingual principle is based on the 'maximum input hypothesis' (Krashen et al., 1982). Yet this theory is only meaningful when the language is at least partially comprehensible to the learner (Lin, 2015). From this point of view, translation of the target language would help these students to process the text, to perform better on assessments, and to enhance their motivation to learn (Attar et al., 2020; Beauvais & Ryland, 2021). The last 10 years have seen the flourishing of pedagogies, including the culturally relevant and responsive pedagogy recommended by the Ontario Ministry of Education, and including the target language centred around translanguaging and multiliteracies. Based on the idea that students will benefit from a pedagogical practice that takes into account all of their language resources, there has been a growing awareness of the need to develop their literacies in these languages (Batyi, 2022). Multiliteracies pedagogy would allow learners to explore the human experience and understand the nature of language from a cultural and social perspective (Menke & Paesani, 2019), while the

culturally relevant and responsive pedagogy is meant to (1) value students' culture and language as assets and (2) recognise students' identities as highly contextualised by their lives, experiences, and backgrounds (Babaci-Wilhite, 2022; Chang & Viesca, 2022). Taken together, these theories argue for pedagogical approaches that combine the inclusion of students' languages and cultures. The language versatility of digital resources, such as the resource Binogi, which lies at the heart of this research, helps activate students' prior knowledge by translating the material to be learned (Le Pichon, Cummins et al., 2021).

1.3. Digital game-based resources

Digital learning platforms are growing in the educational sector and the COVID-19 pandemic has been the catalyst to accelerate the investment in and development of online learning resources to meet the high demand from both private and public educational institutions and families (Stracke et al. 2022). They provide abundant resources that are accessible and flexible: learning is self-directed, and, importantly, enjoyable through gamification (Le Pichon, Cummins et al., 2021). While the digital element contributes its perks to positive learning experiences, the game-based component has also been effective due to its reinforcement of various skills including problem-solving, collaboration, communication skills (Dicheva et al., 2015) and encouraging both extrinsic and intrinsic motivation. Extrinsic motivation is gained through points, badges, and winning against peers. Intrinsic motivation, meanwhile, derives from challenges, control, curiosity, interest, and concentration (Dicheva et al., 2015; Fulya Eyupoglu & Nietfeld, 2019; Le Pichon, Cummins et al., 2021). Digital game-based learning resources have been analysed from behaviourist, cognitivist, and constructivist perspectives (Becker, 2017; Tammets et al., 2022). These three approaches are connected through social aspects that are mediated by technology, where learning occurs in a social and interactive setting with peers (Becker, 2017). While the behaviourist perspective shows the activation of extrinsic motivation through digital game-based resources with appropriately presented materials, the constructivist perspective emphasizes the activation of funds of knowledge to construct, transform and apply new knowledge. The cognitivist perspective shows that digital game-based resources promote meaning-making.

Accessibility is another key characteristic of digital learning platforms. It allows for learning to go on beyond the school walls, thus increasing the chance of parental and community involvement. Through online resources, families and communities have access to their child's learning content, allowing them to discuss content, and share their knowledge and their ways of knowing with their children and with the teachers of their children. To promote the fluidity of exchanges of information, it is necessary to develop strategies to facilitate the passage of these funds of knowledge from one context to the other and bridge the gap between community and schools. Unfortunately, collaboration between school and home is scarce. For newcomer parents, challenges lie in communicating with their child's teacher, sometimes due to limited language proficiency in the school language (Zaidi et al., 2021). Addressing the critical communication gap between parents and teachers is crucial for providing effective and successful support to newcomer students.

1.4. Parental involvement and culturally relevant and responsive teaching

In recent decades, many relevant studies have been conducted on helping teachers cultivate asset-based teaching practices when educating newcomers. In the early eighties, Cummins (1986) examined the reasons behind the failure of several initiatives aimed at integrating minority languages in schools. The study revealed that a crucial determinant of successful and sustainable inclusive programmes was the extent to which schools established strong connections with newcomer families and communities. The value of this connection is evident in the work of Antony-Newman (2022), who stressed the importance of the relationship between parental attitudes towards language use and their children's plurilingual practices. To understand their students, teachers need strong ties with students' families. Moll et al. (1992) found that students who regularly interact with their heritage culture's communities have access to unique and valuable contexts for experiential learning, which greatly augmented their funds of knowledge. Haneda (2006) and Sleeter (2011) both stressed the positive impact of culturally responsive instruction via community engagement in the education of newcomer students. Building bridges between schools and newcomer students' homes not only cultivates fertile soil for 'reciprocal practice' (Moll et al., 1992, p. 134) in creating unique learning contexts, but also renders attempts at developing equitable teaching practices more sustainable (see also Zaidi et al., 2021). Heineke et al. (2012) emphasize the role of 'positive communication' in fostering 'trusting relationships' (p. 141). Recent research demonstrates the value of collaborative spaces that involve teachers, researchers, and families, highlighting how they can work together to develop an understanding of instructional approaches tailored to students' needs (Harman et al., 2020 for science). This exemplifies the importance of including all members of the school community in the process (Zaidi et al., 2021). In this research, by promoting dialogue between the different actors of education, we aim to promote a more equitable and inclusive approach that values diverse perspectives and experiences.

2. Methodology

2.1. The ESCAPE projects (**www.escapeprojects.ca**)

2.1.1. Binogi

These projects are based on a collaboration with Binogi (www.binogi.ca), a company that provides online learning resources (in Canada for grades 6–9) that exploit the multilingual resources of digital technologies. The Binogi platform offers engaging video lessons lasting 5–7 min, accompanied by quizzes. A noteworthy aspect of this resource is its capacity to offer users a wide selection of predetermined languages, including Dari, Tigrynia, or Arabic, for both video playback and the addition of subtitles in their desired language. Additionally, users have the flexibility to personalise the language of the quizzes based on their individual preferences. While teachers receive students' quiz results in the school language, the platform informs them about the language chosen by the students. Essentially, this feature provides teachers with the opportunity to allow their students to make progress in the subjects being taught, even if they haven't yet attained the required proficiency in the language used at school (Le Pichon, Cummins et al., 2021). Our projects seek to investigate how educators utilise

these resources to support 'vulnerable' students who encounter obstacles due to factors like low socioeconomic status, recent immigration to Canada, or communication barriers while adapting to the new educational system. These transitions involve not only relocating from one country or school system to another but also transitioning between home and school environments on a daily basis (Le Pichon, 2013). Within the broader scope of our multifaceted research, this specific study focuses on exploring the firsthand experiences of educators and families in three distinct schools. It examines their implementation of Binogi and the multilingual resources developed by our research team to enhance STEM (Science, Technology, Engineering, and Mathematics) learning.

2.1.2. Transcultural analysis of the curricula of the different countries

Building on our previous research examining math curricula in Syria and Ontario (Wattar & Le Pichon, 2022), we extended our analyses with an in-depth examination of STEM curricula in grades 6–9 in eleven countries, including Syria, Afghanistan, China, Iran, India, Egypt, Iraq, Lebanon, Pakistan, South Korea, and Jordan (see also Le Pichon, Naji, et al., 2023). These countries were chosen to represent the diverse backgrounds of the students. We compared these curricula with each other (see Table 1). We identified similarities and differences between the programmes in terms of curriculum organisation, language(s) of instruction, curriculum content, pedagogy and assessment.

The objective, as articulated by Eco in 2011, is not to interpret these differences as shortcomings within the respective curricula, but rather to identify and assess their divergences from the proposed framework. By doing so, we aim to explore the extent to which these curricula can enhance our comprehension of one another. For each of these categories, we added original documents as well as excerpts from the curricula. Finally, we used this information to create curriculum maps and concept lists that link science and mathematics concepts in each of these languages. We paid particular attention to the meaning of the concepts and how they were integrated in each national context.

2.1.3. Development of multilingual posters

Based on the Binogi videos, we created multilingual concept lists that include the key science or math concepts and their definitions in both the school language and an additional language. Each concept is accompanied by an infographic (see Table 2). The selection of languages for the concept lists was based on the student demographics of the participating schools, (Arabic, Bangla, Chinese, Korean, Persian, Pashto, and Urdu). When translating these concepts, special consideration was given to the cultural relevance of the concepts within the respective language contexts.

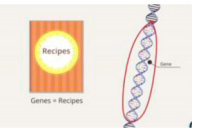
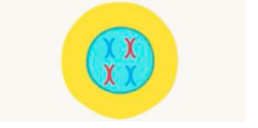
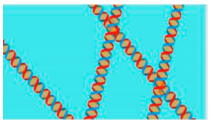
In the field of taxonomy, living organisms are classified using a hierarchical framework based on shared characteristics. This classification begins with the highest rank, domain, followed by kingdom, phylum, class, order, family, genus, and species. The Arabic word for family is الفصيلة, which translates to platoon in English. Similarly, the Arabic word for order is الرتبة, which means 'rank'. This example illustrates that emphasizing a distinct facet of a concept can broaden the semantic comprehension of that concept, even among students who may not understand Arabic. An additional example pertains to the Arabic word for 'virus', which is phonetically identical to its English equivalent but written in Arabic letters as 'فيروس'. This similarity in sounds allows students to make connections with their own language, utilising their existing knowledge. These comparisons can be extended to

Table 1. Comparing science curricula: the example of Syria (www.escapeprojects.ca).

	Science strands				
Grades	Life systems	Matter & energy	Structures & mechanisms	Earth & space systems	STEM skills & connections
6	Relationships between Living Things; Food Chain; Ecosystems; Human Excretory System; Vertebrate Excretory Systems; Urinary System Organs and Diseases; Skin; Sexual and Asexual Reproduction in Plants; Agriculture; Reproduction in Humans; Pregnancy/Birth; Health/Family Planning; Reproduction in Vertebrates; Carbon/Nitrogen Cycles	Molecules; Law of Conservation of Matter; Astonishing Phenomena; In Motion and Stationary	Forces in Nature; Inclined Plane; Lever; Pulleys; Wheel and Axle; Machines	Earthquakes; Tsunami; Space; Earth through Time	Operating Systems: Windows; Software, Applications; Programming (Scratch)
7	Biology: The Cell; Origin and Development of Living Things; Life of Plants; Health	Chemistry: Matter and Heat; Matter and Energy	Physics: Motion and Dynamics; Pressure and Archimedes' Principle	Earth Science: Environment (Organization of Living Things; Ecosystem; Environmental Balance)	Computer Structure: Physical Components; Operating Systems, File Types; Application Software; Malware Software; Algorithms; Information Security; Website Components, Advanced Searches, social media; Numeral Systems; AI, PLC2, Robots
8	Biology: Plants; Animals; Origin and Development of Life (Origin and Development of Life on Earth; Cell Theory; Classes of Nutrients); Adaptation and Behaviour	Chemistry: Structural Chemistry	Physics: Movement and Forces Unit; Electricity; Light	Earth Science: Origin and Development of Life (Earth through Time; Atmosphere)	Computer Structure; Operating Systems; Adobe Photoshop, Video Creation/Editing Application Software; Programming language; Action Script, Building Information Modelling; Information Security; Networks and the Internet; Numeral Systems; Smart Home, Smart City, Electronic Trades

Note. Table 1 compares the Syrian science curriculum (for grades 6, 7, 8) and the Ontario curriculum science strands. The Ontario science curriculum is presented as objectives and guidelines and organised into strands (https://www.dcp.edu.gov.on.ca/en/curriculum/science-technology/context/strands). The Syrian curriculum is textbook based, with specific topics covered in each grade (http://moed.gov.sy/site/cur). The table highlights the main topics taught under each strand in the Syrian curriculum.

Table 2. Chromosomes and traits: English-arabic bilingual concept list.

Gene(s) The part of a cell that determines its development, appearance and functions and is the basic unit by which genetic information is passed from parent to offspring.	المورثة هي الجزء من الخلية الذي يحدد تطورها ومظهرها ووظائفها وهي الوحدة الأساسية التي يتم من خلالها توريث المعلومات الجينية من جيل إلى آخر (من الأهل إلى الأبناء).	
Chromosome(s) A structure in the cell that is made up of long double spirals of DNA, where our genes are found. Upon cell division, the chromosomes are separated.	الكروموسوم (الصِبْغي) بنية في الخلية تتكون من حلزونات مزدوجة طويلة من الحمض النووي، حيث توجد جيناتنا. عند انقسام الخلية، يتم فصل الكروموسومات.	
DNA (Deoxyribonucleic Acid) Molecules that carry genetic information. They act like a blueprint for the structure of all organisms.	الحمض النووي (حمض نووي ريبوزي منقوص الأكسجين) الجزيئات التي تحمل المعلومات الوراثيـة. إنها بمثابة مخطط لبنية جميع الكائنات الحية.	

Note: This bilingual concept list features definitions in English and Arabic and includes visuals from the Binogi video 'Chromosomes and Traits' (https://app.binogi.ca/l/chromosomes-and-traits) to enhance comprehension.

mathematical terms across different languages. Chinese often features self-explanatory terminologies. In Korean, a similar pattern is observed, with majority of the mathematical and scientific terms derived from Sino Korean (Kim & Shin, 2016). For example, number words up to 99 are constructed by combining words for one to ten, resulting in a literal translation of 89 as 'eight-ten-nine' in English. This pattern extends to larger numbers, incorporating words from one to ten with classifiers for hundred, thousand, and beyond. In addition, Sino-Korean numbers are primarily used for counting extensive quantities, measurements, or monetary amounts. However, Koreans use Korean numbers to count smaller quantities and express time. These examples illustrate the pivotal role that teachers can play in raising students' awareness of the similarities and differences between languages. By leveraging students' existing knowledge and facilitating understanding, teachers empower students to build upon and broaden their existing knowledge.

2.2. Data collection

To ensure accessibility for teachers, students, and parents, the resources were uploaded to the Project Website (https://escapeprojects.ca). Teachers were individually notified via email regarding the updates and informed of the resources relevant to the topics they were teaching. Large-format concept lists, tailored to the students' languages, were printed and displayed on classroom and library walls. Furthermore, the created resources were shared through workshops conducted for in-service teachers, parents, and communities. Data were obtained through field notes, surveys and focus groups.

2.3. Participants

In 2022, three schools organised workshops for parents: a private (Junior Kindergarten to Grade 10) school (school 1), a secondary public school (school 2) and an elementary (Junior Kindergarten to Grade 8) (school 3). School 1 is a private school in Ontario that

operates as a non-profit organisation. Established in response to the influx of refugees escaping the Syrian war, this initiative has provided a welcoming environment for Arabic-speaking students from diverse backgrounds for a period of five years. Some of the students were born in Canada, with only some knowledge of Arabic, while other students were born in an Arabic-speaking country and were learning English. Students' proficiency in both languages varies significantly, and teachers consider their students' language abilities in all subjects. The families of the students come from Syria, Lebanon, Palestine, Iraq and Egypt. The teachers come from various countries including Syria, Lebanon, Iraq, Pakistan, India, Somalia, and Sri Lanka. The school, whose two languages are represented in Binogi, participated in the research project with three, and then five teachers (see also Wattar & Le Pichon, 2022). School 2 is a public high school that welcomes newcomer students for periods of up to one year. The primary goal of the school is to expedite the students' transition into their preferred high schools by equipping them with the requisite English language skills and fundamental academic knowledge necessary to pursue their high school diplomas. At the time of our visit, the school had 93 students who had lived in Canada for 2 years or less, and 38 students who had lived in Canada for a maximum of 5 years. School 3 is a public primary school in Ontario (Junior Kindergarten to Grade 8). According to their website, the school has more than 500 students coming from over 29 countries.

3. Results

3.1. In-service teachers' workshop School 1

We organised a workshop in school 1 for STEM teachers (grade 6, 7, 8, 9). Three of them were already familiar with Binogi. The objectives of the workshop were to understand teachers' perspectives on their students' background and prior learning, to gauge teachers' perception and understanding of different curricula and to introduce them to multilingual online resources. All five teachers acknowledged their students' prior educational experiences. A teacher shared how she had noticed that some of her students were 'more familiar with scientific concepts in Arabic than in English'. Another teacher noted: 'Many of the students express that they have come across content we discuss in class in previous grades/countries'. The workshop allowed teachers to communicate their students' accomplishments in their home language more than their academic shortcomings, and their responses were formulated positively.

Teachers highlighted some of the differences between the curricula in terms of structure and guidelines and brought their own learning experiences into their responses. One teacher reported: 'Curriculum documents in Ontario are very detailed in comparison to curriculum back in my country or Kuwait where I have been teaching' or 'Canadian curriculum is more application based than the Syrian one'. Two other teachers reflected on their own experiences regarding differences in curricula between countries, contrasting pedagogical approaches and assessment.

> Teacher B: "I studied from grade 1 till grade 7 in Syria and then from grade 8 till grade 12 in Lebanon. It was a huge shift for me as I needed to prepare and study the whole summer before I entered grade 8. Not only the language shift but also the way the material is presented and the assessment way as in Syria, they focus on

memorizing whereas in Lebanon they focus more on analyzing and integrating the information in different ways."

Teacher M: "Both curriculums, Syrian and Ontarian, are strong in the amount and level of information as I felt I had a pretty good background when entering a science program at a Canadian university."

Teachers also noted differences in the sequence and depth of topics taught in each grade and across grades.

Teacher W: "In science and social studies, the Ontario curriculum units across different grades (1–8) are different each year. Whereas back home, we would study all the topics/units but go deeper each year."

Thus, the comparison charts not only prompted them to think about their students' educational journeys, but also to critically reflect about their own educational journeys. Teachers listed textbooks, online videos, and several online platforms that they used in their math and science classrooms. However, none of the tools they mentioned included multilingual options to support multilingual students. In sum, this first comparative approach to STEM curricula allowed teachers to identify their students' prior knowledge and to value the different curricula, often taking a step back from their own learning and teaching.

3.2. Family workshop in School 1

Building on the initial workshop's positive outcome, the school hosted a similar workshop tailored for families. More parents than expected participated in this event. The workshop programme closely resembled the one conducted for teachers. However, the perspective differed, as teachers typically concentrate on the curriculum they teach, whereas parents draw from the curriculum they are familiar with – the one they were taught during their own education. After working on sample questions in Arabic and then in English, the parents were able to better understand the challenges of moving from one language and culture to another in STEM content. The workshop served as a platform for knowledge sharing and meaningful dialogue between the research team and parents. One parent voiced concern about the use of Arabic in the classroom, stating that their primary objective was for their child to learn English. In contrast, other parents expressed their enthusiasm and interest in the multilingual resources that bridge STEM content taught in English in Ontario with STEM concepts in Arabic, aligning with their familiarity with the subject. To show their gratitude to the team, the parents collaborated to create a short film showcasing the workshop. The video demonstrated how much the parents valued the opportunity to gain a deeper understanding of what their children were exposed to, considering their own funds of knowledge and experiences.

3.3. Family workshop in School 2

A team of four researchers, proficient in Dari/Farsi, Korean, Arabic, English, and/or French, conducted a parent workshop at School 2. The school staff was positively surprised by the number of parents present (around 40), as it was the first face-to-face meeting since the pandemic. The workshop was attended by the principal, vice principal, librarian, head of mathematics, and STEM teachers. Among the families, spoken languages included Dari,

Bengali, Arabic, Spanish and Tigrinya. Families arrived at the event ahead of time. Interpreters and students provided assistance during the workshop. Student ambassadors, identified by their teachers through accumulated points in Binogi and language background, welcomed the families while wearing Binogi badges. These ambassadors played a vital role in orienting parents to the school and introducing them to the Binogi resource. The school successfully cultivated student leadership by leveraging the gamified aspect of the resource, using point accumulation to stimulate extrinsic motivation. After a welcome word by the vice-principal, the team circulated key concept posters in different languages, and a poster on how to sign onto Binogi in the various languages of the communities; they displayed large, laminated posters: 'cell bilingual concept list' or 'label the cell in your languages'.

The team introduced Binogi, along with the mathematics and science curricula, followed by hands-on exploration of Binogi using computers or tablets. Additionally, one-on-one conversations with parents regarding the curricula were conducted.

3.1.1. Resistance to culturally relevant and responsive practices

A researcher spoke with a Jordanian mother, who was accompanied by an interpreter. While the mother acknowledged the potential benefits of the resource for her children, the interpreter expressed the view that students should primarily focus on English and learn subject content in English. This experience, akin to the parents who expressed resistance in the previous workshop, shed light on the potential challenges faced by teachers when using linguistically responsive pedagogies. These pedagogies advocate for building on students' diverse funds of knowledge, including their own language, to enhance learning. However, some parents may initially perceive this approach as counter-intuitive, believing that maximum exposure to the language in question is key to optimal learning. This experience also underscored the significance of fostering dialogue between families and teachers to better understand these resistances and to articulate the educational principles underlying linguistically and culturally responsive and relevant pedagogies.

3.1.2. Online resources as a source of empowerment for families

A researcher presented curriculum comparisons to Dari-speaking families, specifically focusing on STEM guidelines. During the discussion, a father from Afghanistan, who had previously worked as a US Army interpreter, shared that his 18-year-old son had not been able to attend high school. The father expressed his satisfaction with the teaching and curriculum resources provided, emphasizing that they would enhance his ability to support his son's education. This testimony highlights the potential significance of parents of children with limited or interrupted formal education as valuable partners in their children's school education. The outcomes of these workshops, as well as subsequent ones, were highly promising. Families expressed their appreciation for the provided resources and valued the opportunity to share their experiences in a multilingual space where written and human resources were mobilised to facilitate communication. The presence of the students during the workshop added a meaningful dynamic as they not only assisted with translation, but also actively engaged in discussions with their parents about the learning content. One unexpected result was the renewed enthusiasm among the teaching staff who decided to organise weekly meetings with the parents on topics such as, for instance, libraries or community services.

3.2. How teachers appropriated key concept posters in Schools 1, 2 and 3

In School 1, a bilingual teacher used the Arabic and English concept posters as assessment tools, printing them out, asking students to explain the concept and/or rephrase the explanation in their own language. She then collected these lists and graded them. She introduced assessments on lists of concepts to motivate her students to focus on the language of mathematics, targeting their vocabulary development. In School 2, during a network meeting with teachers working on Binogi, a librarian suggested thinking about how libraries could help produce digital resources in collaboration with subject teachers. To her, concept lists could be converted into digital flipbooks, creating longer-term formative assessments that would allow students to develop their own learning trajectories, thereby promoting interdisciplinary collaboration. Similarly, teachers in the third school collaboratively created documents in OneNote 'to allow students to access it any time'. They asked students to integrate audio components explaining and/ or translating the concepts in their own language. These teachers were mindful of their students who had oral skills in their own language but not necessarily reading and writing skills. Their objective was to build on students' background knowledge and increase higher level comprehension. One of the teachers showed the team an example created by a student in the Oromo language, a language from Ethiopia. In summary, each team took ownership of the concept lists to develop their own learning resource, each with a slightly different learning objective. All of them mentioned the formative assessment aspect that underlined the need for assessment tools adapted to these students.

4. Discussion

Following Heineke et al., 2012, our research results show that implementing a culturally responsive and relevant pedagogy is effective. Through the lens of reciprocal anthropology, we challenged the notion of the observer's perspective as external and superior to that of the observed (Laplantine, 2017), introducing linguistically and culturally responsive resources, that were tailored not to pre-established needs, but rather to align with the diverse funds of knowledge of the students' families. The results showed how these efforts enabled us to engage in dialogue with families and teachers, encouraging them to share their own journey and to consider alternatives for their students/children. In doing so, we responded to Erll's call to 'complicate the notion of single memory culture' prevalent within the education system (Le Pichon, Cole et al., 2020; Erll, 2011, p. 8). Additionally, it is worth noting that the curriculum of Ontario mandates a culturally relevant and responsive pedagogy, omitting the *linguistic* aspect of this pedagogy. In our research, the development of resources in the language of the families, through in-depth research of the curricula of some of the countries from which the families come, has shown the importance of developing culturally *and* linguistically appropriate resources on which teachers can build.

These resources which we call 'language friendly' (Le Pichon & Kambel, 2022) made it possible to initiate and generate a transcultural dialogue, including all members of the educational community (Heineke et al., 2012; Zaidi et al., 2021). In 2017, Brown highlighted the importance of 'Culturally sensitive teachers' in validating 'students by acknowledging their family and community funds of knowledge' particularly in science

teaching, emphasizing the 'transformative and emancipatory natures' of these approaches (Brown, 2017, p. 1147). The findings presented in this study support these assertions. Moreover, our results underscore the symbolic significance of family languages, which, when openly acknowledged and visible, validate their potential for conveying knowledge. Additionally, our research confirms the empowering impact of a linguistically and culturally responsive approach for students and their parents. Typically, parents feel linguistically and culturally disconnected from educational content in the host country (Antony-Newman, 2022). However, language and culture can serve as powerful tools to enable their participation as education partners.

Furthermore, similarly to Moll (2019), we confirm the importance of a transcultural communication approach aimed at reciprocal knowledge. Teachers and parents, through reflecting on their own educational journeys, have gained a deeper understanding of their students' and children's trajectories, as well as the significance of their unique knowledge and experiences. In this research, through an extensive study of the school curricula of some countries of origin of the students' population, we took Moll's proposal (Moll, 2019) a step further: by offering parents and teachers the opportunity to discover the local school curriculum through their own language and the curriculum of the country from which they originate, we fostered a reciprocal discovery process. This approach helps mitigate unintentional power imbalance that often exists between schools and (newcomer) families.

The use of informed multilingual resources, including Binogi, has played a crucial role in helping teachers identify resources and address student needs. Leveraging digital technologies, these resources have been created and shared effectively. By providing training for teachers and school administrators on utilising these resources, teachers are empowered to take ownership of them for teaching and communication with families. Identifying these resources and validating them can foster innovative multilingual and multimodal teaching practices (see also Babaci-Wilhite, 2022). Yet, as some of our data show, the introduction of each of these resources was subject to intense negotiation among participants and then by individual teachers in their own classrooms. A single instance of rejection experienced by a teacher, whether from a parent or a language interpreter, as observed in two of the family workshops, can easily destabilise a teacher. In such situations, the teacher may opt to remove a resource from the entire class rather than risk causing frustration or dissatisfaction for a single student or parent.

Taken by themselves, the linguistic and innovative elements of these resources pose a challenge for teachers, requiring them to step out of their comfort zones – i.e. the strict teaching of mandated content related to their discipline and the content of the books used in class. In our research, the three schools we reported about were led by individuals who were familiar with educational research, either through their own learning experiences or their involvement as scholars in research. In each school, these leaders played a crucial role in the implementation of the approach. The vice-principal at School 1, a former refugee who arrived in Canada at the age of 12, acknowledged the ongoing issue of a mismatch between the curriculum and students' languages and funds of knowledge. This recognition prompted his active participation in our monthly network groups with teachers and led him to organise the parent workshop. In School 2 and School 3, this same role was played by two administrators who were/had been researchers themselves.

Their enthusiasm further strengthened the trust and collaboration among researchers, teaching staff, and parents involved in the educational process. The research highlighted significant disparities among teachers and emphasized the significance of fostering a sense of belonging within a teaching team to enact what Hélot and Ó Laoire (2011) refer to as a 'pedagogy of the possible'. In this study, this involved the development of a STEM curriculum integrating students' languages and lived experiences as essential components.

5. Conclusion

The project aimed to utilise STEM resources from Binogi and the ESCAPE projects to foster dialogue between teachers and families, challenging implicit biases and providing effective support to students throughout their educational journey. The research objective was to examine the impact of these resources on implementing linguistically and culturally relevant pedagogy, considering various contexts of resource utilisation. Overall, the results showed that the development of linguistically and culturally appropriate resources for science and mathematics helps build trusting relationships with families (Heineke et al., 2012). These resources allow teachers to better understand their students' funds of knowledge and parents to understand and share their own understanding of school and schooling. Technology facilitates this work both in terms of creating and disseminating these resources, enabling teachers to take ownership and extend their use beyond the provided resources. Furthermore, international curriculum mapping has demonstrated its effectiveness in addressing the scarcity of tools that teachers require to transcend local curriculum content and establish connections with their students' funds of knowledge. However, our findings highlight that resources alone are insufficient in accomplishing this objective. Consistent with the findings of Lucas and Villegas (2013), we found that teachers require training and ongoing support to effectively address the needs of their students. In STEM, a language-friendly pedagogy (Le Pichon & Kambel, 2022) engages teachers and parents in 'crossing boundaries' (Haneda, 2006) of language, culture, and science. The active participation of a team of multilingual researchers and various stakeholders, along with the organisation of inclusive meetings involving the entire school community, played a pivotal role in the success of this initiative. By fostering informed and valued partnerships, parents can reclaim their pivotal role as primary partners in their children's academic journey.

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