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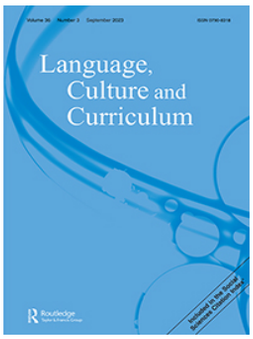

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Finnish pre-service teachers' understandings of the role of language(s) in learning mathematics

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ABSTRACT

We examined Finnish pre-service primary school teachers' understandings of the role of language(s) in learning mathematics and how these understandings developed during a period of teaching practice. We also examined how the participants experienced the usefulness of the ready-made multilingual digital material *Binogi* and how the teaching practice period influenced their thoughts on multilingual pedagogies. Our results indicate that the teacher training period increased awareness of linguistic challenges and of the importance of students' L1s in learning. However, some participants' views reflected monolingual ideologies, especially regarding the conditional use of L1s. Regarding linguistic support, the participants reported using visual supports and explaining vocabulary and structures. Although many participants perceived *Binogi* as beneficial and motivating, less than half used it. Some participants emphasised that the practice period reinforced their understanding of the importance of multilingual pedagogies. It is important to critically reflect on the language policies and practices of Finnish teacher education and support the dialogue between research and practice regarding a shared understanding of valuing linguistic diversity in teacher education.

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1. Introduction

The Finnish core curriculum (National Agency for Education [EDUFI], 2014) determines the operating culture of basic education in Finland. A key concept of the curriculum is language awareness (see Association for Language Awareness [ALA], 2022). Schools are seen as places where students' languages and identities meet, and students are encouraged to use and develop their entire linguistic repertoire. The curriculum requires that teachers understand language and its use, language-related attitudes, and the importance of language for learners' identities and socialisation (EDUFI, 2014). However, these actions require more than just language awareness – they require linguistically responsive teaching (Lucas & Villegas, 2013). Principles of

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linguistically responsive teaching can be seen in the Finnish curriculum for basic education; teachers are required to actively support students' language use and learning in general (see, e.g. Alisaari et al., 2019b). For example, according to the curriculum, every student is entitled to their own language and culture, and multilingualism is seen as a natural part of every school (EDUFI, 2014).

Globally, language issues are becoming increasingly important in education. PISA studies have shown a significant gap in learning outcomes between immigrant-background students and majority language speakers in many contexts. In Finland, this gap is alarming (OECD, 2019). In response, the curriculum for basic education emphasises language awareness and recommends multilingual pedagogies (EDUFI, 2014), thereby supporting both language and content learning and the development of subject-specific language (see also Cummins, 2016; Lucas & Villegas, 2013). However, previous studies have shown that although Finnish teachers have positive attitudes toward multilingualism, their practices concerning the use of students' linguistic resources for learning are still developing (Alisaari et al., 2019a; Harju-Autti & Sinkkonen, 2020; Heikkola et al., 2022; Lehtonen, 2021; Repo, 2020). It is important to investigate how future teachers are prepared to implement multilingual pedagogies. In this study, the participants used the digital multilingual platform *Binogi* as a tool for implementing multilingual pedagogies. Our aim was to investigate pre-service teachers' understanding of the role of language(s) in learning mathematics and how this understanding developed during a period of teaching practice. We also examined how the participants experienced the usefulness of *Binogi* and their perceptions of how the teaching practice period influenced their thoughts on multilingual pedagogies.

This study was guided by the following research questions:

1) How do pre-service teachers understand the role of language as a medium for learning mathematics, and how does this understanding develop after a period of teaching practice?
2) What do pre-service teachers know about learners' linguistic repertoires as resources for learning mathematics, and how does this knowledge develop after a period of teaching practice?
3) Which teaching strategies associated with linguistic support do pre-service teachers recognise before and after a period of teaching practice?
4) How did the participants perceive the usefulness of the ready-made multilingual digital material *Binogi*, and how did the teaching practice period influence their understanding of multilingual pedagogies?

1.1. Linguistically responsive teaching and teaching mathematics

Linguistically responsive teaching (LRT) emphasises teachers' active responsibility in guiding language learners' learning processes (Lucas & Villegas, 2013). The LRT framework encompasses teachers' awareness and understanding of language and its role in learning, as well as teachers' pedagogical skills and responsibilities, more consistently than *language awareness* (see, e.g. ALA, 2022). It provides a holistic view of teaching that aims to support language learners to the maximum extent possible.

The LRT framework consists of two parts: teacher orientations and pedagogical knowledge and skills. These can be considered as basic prerequisites for successful LRT (Lucas & Villegas, 2013). The orientations of linguistically responsive teachers, according to Lucas and Villegas (2013), include being sociolinguistically aware; understanding that language, culture, and identity are intertwined; and understanding that language use and language education are always embedded in a wider socio-political context and power relations. Linguistically responsive teachers value linguistic diversity and encourage students to use all the languages they know as a resource for learning in the classroom, and they advocate for students' learning opportunities (Lucas & Villegas, 2013).

According to the LRT framework (Lucas & Villegas, 2013), pedagogical knowledge and skills include an understanding that knowing learners' backgrounds, experiences, and abilities makes teaching meaningful for learners and more responsive to their needs. Moreover, a linguistically responsive teacher understands how language develops and which features of the language of instruction may pose challenges to learners, and they use this information to plan and implement pedagogical practices that support learning (Lucas & Villegas, 2013). Academic language differs noticeably from everyday social language (e.g. Beacco, 2017; Cummins, 2021), and its development requires practice (Carlson et al., 2018). Teachers must provide linguistic support and scaffold instruction so that students can accomplish academic assignments at cognitive and language levels that are slightly higher than their current level (Gibbons, 2015; Tharp et al., 2000; Vygotsky, 1986). Attention to language and its structures in the teaching of different subjects is associated with improved learning outcomes for migrant-background students (Kieffer & Lesaux, 2012).

Linguistically responsive teachers understand that they are models for subject-specific language. The subject-specific language of mathematics is challenging for all learners due to the rich use of concepts and specific textual practices (Ahlholm & Portaankorva-Koivisto, 2018). The language of mathematics consists of a special vocabulary and contextual vocabulary – words representing the context of an assignment. Specific structures are also used, for example, complex question formulations and passive constructions (see Ahlholm & Portaankorva-Koivisto, 2018 for more details).

According to the National core curriculum (EDUFI, 2014), expressing mathematical thinking and understanding mathematical concepts and structures form the basic elements of learning mathematics in grades 3–6. Teachers play a key role in supporting students in engaging in mathematical discussion and articulating mathematical thinking. Teachers should actively support students in developing mathematical language, participating in cognitively challenging discussions, and understanding tasks (see also Ahlholm & Portaankorva-Koivisto, 2018; Carlson et al., 2018). When teachers are aware of the connection between language and learning, they are more capable of providing linguistic support for learners and pedagogically justifying their practices (Alisaari & Heikkola, 2020; Heikkola et al., 2022).

1.2. Benefits of multilingualism and strong first languages

A part of the LRT framework is valuing different languages and advocating the use of multiple languages as a resource for learning (Lucas & Villegas, 2013). This could be seen as

implementing multilingual pedagogies, wherein students' languages are perceived as tools for learning in the classroom (García et al., 2016).

Several studies have shown the cognitive benefits of bilingualism (see Adesope et al., 2010 for a review), and children of immigrants who have maintained their L1s perform better in education and the labour market compared to those who mainly use the majority language of society (Agirdag, 2014; Glick & White, 2003; Lutz & Crist, 2009). Migrant-background students who primarily use their L1s with their parents sometimes achieve better learning outcomes than those who only speak the language of society at home (Agirdag & Vanlaar, 2018). Strong L1 skills are positively associated with learning the language of instruction and other subjects (e.g. Eunjung Relyea & Amendum, 2019; Ganuza & Hedman, 2019). Moreover, some studies suggest that L1 use at home may prevent dropping out of school (Feliciano, 2001) and support socio-emotional well-being (Chung et al., 2019).

2. Materials and methods

In this section, we present the participants and the data collection (Section 2.1), as well as the data analysis (Section 2.2).

2.1. Participants and data collection

The participants included 20 pre-service teachers undergoing teaching practice in teacher training school. All 20 responded to the pre-test and 14 responded to the post-test. The participants were mainly 4th year master's students in a teacher education programme aiming to become primary school teachers. The teaching practice lasted seven weeks (five weeks of active teaching), consisting of 40–54 h of teaching. The students planned and implemented lessons in different subjects for these classes. Before the practicum, as a part of their teacher studies, all the pre-service teachers had participated in classes focusing on didactics in Mathematics.

The data collection instrument was developed in Germany (Carlson et al., 2018); it was translated and modified to correspond to the Finnish context by the first author and a university mathematics teacher (see Alisaari et al., in press). For this study, the Finnish version piloted by Alisaari et al. (in press) was shortened after an analysis of a first round of responses; questions that did not produce relevant data were excluded. The original Finnish questionnaire included questions regarding (1) developing skills for learning in the language of instruction; (2) knowledge of language, grammar, and semiotic symbols; (3) providing linguistic support; and (4) L1 as a tool for learning. There were 14 closed questions (yes/no) and 15 open-ended questions covering all four dimensions. In this study, questions regarding knowledge of language, grammar, and semiotic symbols were omitted, and questions related to pre-service teachers' knowledge of language awareness and multilingual pedagogies were added. In the post-test, questions regarding *Binogi* and the teacher practice period were also included.

The survey was administered to pre-service primary school teachers at the beginning and end of a training period, with two months between the tests. Both sessions were conducted via Zoom. Immediately following the pre-test, the participants were offered a training session on using *Binogi,* a multilingual digital learning environment comprising

animated educational subtitled videos in 15 different languages that are based on curriculum content, with an emphasis on mathematics and the natural sciences. Meanwhile, they were introduced to multilingual pedagogies and the importance of acknowledging students' linguistic resources as tools for learning. The presentation was held by the first author and a representative of *Binogi*; it lasted 45 min and included detailed instruction on how to use the platform.

2.3. Data analysis

The data were first analyzed qualitatively (thematic content analysis) and then quantitatively (frequencies, chi-square, Cramér's V, and *z* tests). A data analysis rubric created for the original survey was adapted for the Finnish instrument by all the authors (Alisaari et al., in press). Authors 1 and 2 first analyzed the open-ended items independently, then discussed the analysis of each item until consensus was reached. The first author coded the multiple-choice questions as having correct or incorrect answers. The questions regarding the role of language(s) in learning (pre- and post-tests) and their scoring are presented in Table 1.

Participants were asked to reflect on the difficulties multilingual learners may have with contextual vocabulary compared to mathematical vocabulary and to give examples of challenging words, sentences, or structures (Table 1, Question 1). The responses were qualitatively analyzed and scored (0–2 points), and the differences between the pre- and post-test scores were investigated using chi-squares, Cramér's Vs and *z*-tests.

The responses were then analyzed for the extent and different types of linguistic support participants would offer multilingual learners (Table 1, Question 2). The responses were first qualitatively analyzed (scored 0–2 points), then the multiple response set function in SPSS (version 28) was used to examine the frequencies of the different types of linguistic support. The possible differences between the pre- and post-test scores (0–2 points) and the different types of linguistic support were investigated using chi-squares, Cramér's Vs, and *z*-tests.

Next, the participants responded to a question about the link between mathematical and linguistic skills (Table 1, Question 3). The responses were qualitatively analyzed and scored (0–2 points). Chi-squares, Cramér's Vs, and *z*-tests were used to investigate possible differences between the pre- and post-test responses.

The participants were then asked to justify their responses to four statements (Table 1, Question 4). The responses were qualitatively analyzed and scored (0–2 points) to reflect the depth of understanding (Table 1, Question 4A). The responses were analyzed as 0 or 1, reflecting the participants' understanding and valuing of multilingual learners' L1s (Table 1, Question 4B). Finally, the pre- and post-test scores were compared using chi-squares, Cramér's Vs, and *z*-tests.

In the post-test, the participants were also asked questions regarding their use of multilingual pedagogies, particularly *Binogi*. The questions concerned the frequency of the use of *Binogi* (from 1 = never to 5 = every lesson), the reasons why and the ways in which the participants used the material (open-ended questions), and their perceptions of the usefulness of *Binogi* for teaching (1 = I didn't use *Binogi*, 2 = weak, 3 = relatively weak, 4 = relatively good, 5 = good). The participants were asked an open-ended question about

Table 1. Presentation of the survey questions and their qualitative scoring.

Survey questions	Scoring	Responses for specific scores
Question 1		
Contextual and mathematical vocabulary		
The following assignment is in a fifth-grade mathematics textbook (*Tuhattaituri 5a*): 'In a dog agility competition, the distance between two poles on the straight weave-pole[a] trajectory is always 60 cm. The distance from the first pole to the last pole is 6 m 60 cm. How many poles are on the straight weave-pole trajectory in total?'		
A) Why does the contextual vocabulary (e.g. *agility*, *competition*) pose more difficulties for multilingual learners than mathematics subject-specific vocabulary (e.g. *total*)? Name at least one other difficult word and justify your answer. (0–2 points)	2 points	Mention of at least one difficult word AND explanation of why contextual vocabulary might be more challenging than mathematical vocabulary (e.g. the notion that life experience influences the development of contextual vocabulary)
	1 point	Mention of one difficult word OR an example of why contextual vocabulary is more challenging than mathematical vocabulary
	0 points	No mention of a difficult word OR suitable line of reasoning regarding vocabulary
B) What other difficulties might the assignment cause for a multilingual learner at the sentence and text levels? (0–2 points)	2 points	Mention of concrete, challenging words/ grammatical features OR discussing difficulties on an abstract level
	1 point	No mention of concrete, challenging words/structures OR of the task being too long
	0 points	No mention of challenging words/structures OR an inappropriate response
Question 2		
Linguistic support		
A) What kind of linguistic support would you offer multilingual learners either before or during the assignment to make the assignment easier to understand? Name at least two. (0–2 points)	2 points	Mention of at least two of the following reasons: • Ensure students understand challenging words/phrases/concepts • Break the sentence into fragments • Use sentence/summary frames • Provide visuals that correspond with the word problem • Rewrite the question to be less linguistically complex/give students the formula/ simplify the vocabulary/use imperatives • Strategy (e.g. use translators or Google)
	1 point	Mention of at least one of the reasons listed above
	0 points	No mention of the reasons listed above
B) Different types of linguistic support listed by the pre-service teachers based on their responses to question 2A.		The first three listed by the participants were included in the analysis.

(*Continued*)

Table 1. Continued.

Survey questions	Scoring	Responses for specific scores
Question 3		
Link between mathematical and linguistic skills		
What is the link between mathematical skills and linguistic skills? Explain. (0–2 points)	2 points	Understanding and explaining the link between mathematical and linguistic skills
	1 point	Naming the link between mathematical and linguistic skills
	0 points	Vague response not naming the link between mathematical and linguistic skills
Question 4 Use of L1s		
A) Importance of L1s		
A) I would restrict conversations in first languages during lessons to ensure that multilingual learners develop their basic and academic language skills in Finnish. (0–1 points) B) First languages should be used in classrooms, but only when the teacher also knows the language(s). (0–1 points) C) I would encourage multilingual learners to use their first languages to understand content in different subjects more easily. (0–1 points)	1 point	Understanding the importance of multilingual learners' L1s
	0 points	Not understanding the importance of multilingual learners' L1s
B) Justify your response to the following statements:		
A) I would restrict conversations in first languages during lessons to ensure that my multilingual learners develop their basic and academic language skills in Finnish. (0–2 points) B) First languages should be used in classrooms, but only when the teacher also knows the language(s). (0–2 points) C) I would encourage multilingual learners to use their first languages to understand content in different subjects more easily. (0–2 points) D) Name reasons why it may be good for multiple languages to be present in different subject classes. (0–2 points)	2 points	Mention of at least two of the following reasons: • L1s are appreciated • Learners' identities as multilingual individuals are strengthened • Some learners have more courage to contribute during a lesson (e.g. group work) if they are can use their L1 • Learners can understand the lessons' content (e.g. a task was understood) • Learners' L1s should be used as a resource • Language contrasts can highlight linguistic structures • Highlights awareness of languages • Helps build community in the classroom • Learning is encoded in L1 • Encourage maintenance of L1 • Building communities through L1
	1 point	Mention of at least one of the reasons listed above
	0 points	No mention of the reasons listed above

[a]A weave-pole is an agility obstacle consisting of a series of poles, and it is traditionally used in dog agility training and competitions.

whether their thoughts or experiences regarding multilingual pedagogies or their significance changed during the practice period.

3. Results

3.1. Linguistic challenges in the classroom

When asked about the possible linguistic challenges of a specific mathematical task (Table 1, Question 1), in the pre-test, more than half of the participants (11/20) were already aware of the reasons contextual vocabulary might cause more challenges for multilingual students than the vocabulary of mathematics (Table 2). In the post-test, almost all (12/14) indicated the same awareness.

There were significant differences in the responses, with a deeper understanding reflected in the post-test responses ($p < 0.05$). The participants reported that subject-specific vocabulary is frequently repeated during lessons, whereas contextual vocabulary might be completely new to learners who are unfamiliar with the context.

> The task requires a lot of knowledge and language skills outside the mathematical world. To solve the task, students also need to know the meaning of 'weave poles and what a 'pole' is. #8 pre

When asked what other difficulties the assignment could cause multilingual learners at the sentence and text levels, 5/20 of the pre-test responses and 8/13 of the post-test responses included concrete examples of words, grammatical features, or the abstractness of the assignment (Table 2). There were significant differences between the pre- and post-test responses, with more 0 and 2 responses in the post-test and more 1 responses in the pre-test ($p < 0.05$). Thus, although some of the respondents' post-test answers were more superficial than those of the pre-test, most had gained a deeper understanding of the language demands of mathematical tasks during the teacher training period. For example, the participants were able to identify that long sentences, infrequent vocabulary, and unfamiliar phenomena increased the abstraction of the assignment. Some of the participants also identified the relationship between mathematical problem-solving and language skills.

Table 2. Contextual and mathematical vocabulary: response frequency and comparison or pre- and post-tests.

	Pre-test ($n = 20$)	Post-test ($n = 13$[a])	Comparison pre-test vs. post-test
1. Contextual and mathematical vocabulary			
A) Why does contextual vocabulary pose more difficulties than mathematics subject-specific vocabulary?	0: 5% 1: 40% 2: 55%	0: 0% 1: 7.7% 2: 92.3%	$X^2 = 5.3$, $df = 2$, $p = 0.07$, Cramér's V = 0.4 0 : ns. 1: pre > post* 2: pre < post*
B) What other difficulties exist on sentence and text levels?	0: 0% 1: 75% 2: 25%	0: 23.1% 1: 15.4% 2: 61.5%	$X^2 = 12.7$, $df = 2$, $p = 0.002$**, Cramér's V = 0.6 0: pre < post* 1: pre > post* 2: pre < post*

[a]1 missing answer.
* significant at 0.05.
** significant at 0.01.

> The task becomes easier if you can figure out the trickier words and concepts, such as spacing, distance, etc. The more difficult the situation, the more difficult the concept of 'pole to pole' is, and not everyone will understand it just by knowing the vocabulary. When the vocabulary is challenging, students lack the opportunity to concretize the problem being asked, and as a result, mathematical thinking and grammar become more challenging. #19 pre

> In general, any task can be difficult if a student's vocabulary is not sufficient. In addition, the task requires an understanding of word conjugation [from pole (kepiLTÄ) to pole (kepiLLe), expressed with suffixes in Finnish]. #13 post

The participants whose knowledge of the differences between the challenges of contextual and subject-specific vocabulary was still developing (9/20 in the pre-test, 5/13 in the post-test) mainly discussed the challenges of lexicon in general but did not indicate that the challenges could be caused by infrequent or subject-specific vocabulary. Thus, some participants' understanding of academic language related to mathematics instruction seemed relatively superficial, even after the teacher training period, which indicates that this content could be better covered during the teacher training.

> It is a long word, unknown to many, and difficult to read and pronounce. Another tricky concept would be 'weave pole,' which is a term used in this hobby but not in everyday use. #5 pre

> Lots of difficult words and difficult sentence structures. #7 post

There were no statistically significant differences between the pre- and post-tests regarding participants' awareness of possible links between mathematical and linguistic skills (Table 3).

Nevertheless, when looking at the frequencies, the participants' awareness of the link between linguistic and mathematical skills was deeper in the post-test.

> Language affects how meanings are formed. Specifically in math, concerning verbal tasks. #10 post

> During the training, I discovered the importance of languaging in developing mathematical thinking. Being able to verbalize a calculation or formula helps students think mathematically. #4 post

3.2. Learners' linguistic repertoires as resources for learning

Regarding the use of learners' linguistic repertoires as resources for learning, the participants reported more supportive attitudes in the post-test, indicating a deeper awareness of the importance of students' L1s in learning (Table 4). However, monolingual ideologies were also reflected, and some participants reported that restricting students' L1 use was

Table 3. Link between linguistic and mathematical skills: response frequency and comparison of pre- and post-tests.

	Pre-test ($n = 20$)	Post-test ($n = 13$[a])	Comparison pre-test vs. post-test
3. Link between mathematical and linguistic skills	0: 26.3% 1: 15.8% 2: 57.9%	0: 9.1% 1: 0% 2: 90.9%	$X^2 = 3.9$, $df = 2$, $p = 0.15$, Cramér's V = 0.36 ns.

[a]1 missing answer.

Table 4. Justification of responses and the importance of L1s: Response frequency and comparison of pre- and post-tests.

	Pre-test ($n = 20$)	Post-test ($n = 13$[a])	Comparison pre-test vs. post-test
4A. Understanding the importance of L1s (multiple choice – right vs. wrong)			
A) Restricting L1 use during lessons	right: 50% wrong: 50%	right: 91.7% wrong: 8.3%	$X^2 = 5.8$, $df = 1$, $p = 0.02$**, Cramér's V = 0.43 0 – ns. 1 – pre < post * 2 – pre > post *
B) L1s should be used in the classroom if the teacher knows the language	right: 90% wrong: 10%	right: 100% wrong: 0%	$X^2 = 1.4$, $df = 1$, $p = 0.24$, Cramér's V = 0.2 ns.
C) Encourage L1 use for better content understanding	right: 100% wrong: 0%	right: 100% wrong: 0%	ns.
4B. Justify your response to the following statements (open responses):			
A) Restricting L1 use during lessons	0: 55.6% 1: 11.1% 2: 33.3%	0: 36.4% 1: 9.1% 2: 54.5%	$X^2 = 1.3$, $df = 2$, $p = 0.53$, Cramér's V = 0.2 ns.
B) L1s should be used in the classroom if the teacher knows the language	0: 12.5% 1: 18.8% 2: 68.8%	0: 10% 1: 30% 2: 60%	$X^2 = 0.4$, $df = 2$, $p = 0.8$, Cramér's V = 0.1 ns.
C) Encourage L1 use for better content understanding	0: 20% 1: 13.3% 2: 66.7%	0: 0% 1: 33.3% 2: 66.7%	$X^2 = 2.9$, $df = 2$, $p = 0.24$, Cramér's V = 0.35 ns.
D) Reasons why it is good to have multiple languages in subject classes	0: 5% 1: 0% 2: 95%	0: 8.3% 1: 0% 2: 91.7%	$X^2 = 0.1$, $df = 1$, $p = 0.7$, Cramér's V = 0.07 ns.

[a]1 missing answer.
* significant at 0.05.
** significant at 0.01.

crucial for developing their Finnish language skills. In the post-test, some answers were more conditional or strictly against using students' L1s at school. The difference between the two tests was significant ($X^2 = 5.8$, $df = 1$, $p = 0.02$**, Cramér's V = 0.43), with stricter responses in the post-test.

> The language of instruction is Finnish, and every moment is a moment to learn Finnish. Every student should understand what others are saying. #6 pre

> It is important for students to learn to speak Finnish. School is probably the only place where it can be learned, so requiring Finnish in lessons is an absolute minimum. #13 post

In some post-test answers, participants reflected more carefully on the positions and roles of different languages when they were asked whether they should restrict the use of students' L1s:

> Yes and no. If I knew the same language myself and could be sure that students were talking about the right thing and teaching each other in their own language. #6 post

> Yes, but restricting does not mean prohibiting. Adequate practice and reinforcement of Finnish language skills are certainly necessary in every lesson, but, for example, ensuring understanding or discussing a given topic in your own language in addition to Finnish is certainly useful. #14 post

Concerning the importance of teachers' knowledge of all the languages in a classroom, the participants were almost unanimously of the opinion that L1 use should not depend on teachers' language skills in these languages:

> For students, using their own language reinforces their learning, and teachers can only know part of the languages. #10 post

When asked whether students should be encouraged to use their L1s to better understand lesson content, many of the participants reported that using L1s equates to meaningful learning:

> A good command of your own language supports the learning of foreign languages, so it is certainly useful to deal with subjects in your L1 in addition to the school language. #14 post

When asked why it would be beneficial to use multilingual learners' L1s in different subject classes, the participants reported that L1 use is beneficial from multiple perspectives:

> Using your own language supports the development of your thinking. Sometimes, I would require Finnish, but I would encourage them to use their own and their friends' language skills. #8 pre

> Students' identities and connections with their cultures are strengthened – no one is excluded on the basis of language, language skills and cultural understanding of all students increase, the cultural atmosphere in the classroom is enriched, learning of own language and Finnish increases, subject content can be easier to learn, academic language/subject content is also learned in [one's] own language … #10 pre

> Reinforces learning, strengthens student's identity, encourages students to be themselves. #5 post

3.3. Teaching strategies associated with linguistic support

More than half of the participants (14/20 pre-test, 11/13 post-test) presented several teaching strategies for supporting students' language comprehension in the classroom. No differences were found in the responses between the pre- and post- chi-square and *z*-tests (Table 5).

The most often mentioned strategy was visual support (pre-test 41%, post-test 44%). The following strategies were mentioned more often in the post-test: explaining structures (pre-test 12%, post-test 16%), using plain language (pre-test 6%, post-test 12%), and simplifying the task (pre-test 6%, post-test 8%).

> Phrases, difficult words, and tenses should be elaborated on so that everyone understands them. Illustrative pictures or writing on the board could also help. #7 pre

> I would draw a picture of the situation, […] simplify the sentence structure [or] put the sentences on different lines and shorten them. #5 post

Only one student (4%) answered in the post-test that using students' L1s would be a relevant strategy:

> A piece of paper, some kind of illustration tool, using your own language as a tool. #6 post

The following strategies were mentioned less in the post-test: explaining the vocabulary (pre-test 18%, post-test 8%), dividing the task into smaller pieces (pre-test 12%, post-test 8%), underlining or highlighting important parts (pre-test 3%, post-test 0%), and modelling the calculation (pre-test 3%, post-test 0%).

Table 5. Linguistic support: response frequency and comparison of pre- and post-tests.

	Pre-test ($n = 20$)	Post-test ($n = 13$[a])	Comparison pre-test vs. post-test
2. Linguistic support			
A) What kind of linguistic support (0–2 points)	0: 5.3% 1: 21.1% 2: 73.7%	0: 0% 1: 15.4% 2: 84.6%	$X^2 = 0.9$, $df = 2$, $p = 0.63$, Cramér's V = 0.17 ns.
B) Linguistic support (types)[b]			$X^2 = 6.6$, $df = 5$, $p = 0.26$, Cramér's V = 0.46 $X^2 = 11$, $df = 7$, $p = 0.14$, Cramér's V = 0.7 $X^2 = 2$, $df = 2$, $p = 0.37$, Cramér's V = 0.7
Visual support	41.2%	44%	ns.
Explaining vocabulary	17.6%	8%	ns.
Explaining structures	11.8%	16%	ns.
Offering a model calculation	2.9%	0%	ns.
Breaking the task into smaller pieces	11.8%	8%	ns.
Plain language	5.9%	12%	ns.
Underlining or highlighting	2.9%	0%	ns.
Simplifying the task	5.9%	8%	ns.
Using students' L1s	0%	4%	ns.

[a]1 missing answer.
[b]Separate tests were done on the three different responses given by the participants.

> The task could be drawn out to make it easier to understand. You could also use the numbers written out to help. The text could also be converted into plain language. #8 pre

> Drawing a picture, splitting the text into shorter sentences. #17 pre

3.4. Ready-made digital material and multilingual pedagogies

When asked about the use of *Binogi,* 57% of the participants reported never using the platform, 21% used it once, and 21% used it a few times. When asked how beneficial *Binogi* was for their teaching practice and how much they were able to use it, those who had used it perceived it as a beneficial teaching tool, and they found it to be motivating and engaging for students.

> The videos are clear and visually simple. (#5 post)

> [It] supports opening up concepts to the student, ensuring understanding if you use a quiz. – It is good that the audio of the video is also readable in text format. Students followed the videos with interest. (#9 post)

> With ready-made material, you don't have to produce so much yourself. (#13)

Some of the participants mentioned the benefits of *Binogi* regarding supporting students' L1 use or implementing multilingual pedagogies. Only a few participants reported using the videos in multiple languages while teaching, but they encouraged their students to watch the videos in their L1s at home.

> At home, especially with the family, you could watch the video and discuss the content of the teaching. – For example, you can use ready-made videos in different languages, which is an easy way to create multilingual pedagogy. (#8 post)

> [The platform helps you] to motivate, clarify, and support the use of the student's own language. (#9 post)

The teaching practice was tightly scheduled; many of the participants reported being unable to familiarise themselves with the platform due to time constraints.

> There was a lot of material available, but not much time. A lot of time was spent planning teaching based on the materials in the books. (#10 post)

When asked how the teaching practice influenced their perceptions of multilingual pedagogy, some participants reported that it reinforced the significance of multilingual pedagogies.

> Yes, discussions with the instructor opened up the mind. (#2 post)

> It gave me new ideas about what multilingual pedagogy is, and a bit about how to use it. (#9 post)

In the post-test, most of the participants (8/14) reported no change in their perceptions or were unable to define any change. They justified their responses by saying that they already appreciated multilingual pedagogies or that they were not used at the teacher training school. Two participants reported that the concept of multilingual pedagogies was still unclear.

> Hasn't changed because I can't say what it is exactly. (#5 post)

> No, because multilingual teaching was not used. (#8 post)

4. Discussion

This study investigated pre-service teachers' understanding of the role of language(s) in learning mathematics and how this understanding developed during a period of teaching practice at a teacher-training school. We examined how the participants experienced the usefulness of a ready-made multilingual digital platform, *Binogi*, and their perceptions of how the teaching practice period influenced their thoughts on multilingual pedagogies. Our results indicate that the teacher training period increased awareness of the linguistic challenges of and differences between subject-specific and contextual vocabulary (see, e.g. Beacco, 2017; Cummins, 2021). In the post-test (i.e. after the training period), the participants were better able to identify the linguistic challenges of mathematical tasks. However, some participants presented relatively superficial responses concerning the links between language and content learning, even after the training period. In interpreting this result, it should be considered that, with complex issues, participants' answers may not be as comprehensive as their thoughts, and the practice period was relatively short (seven weeks). Nevertheless, future teachers could benefit from stronger support in developing their skills to provide linguistic support and scaffold instruction (e.g. Gibbons, 2015; Tharp et al., 2000; Vygotsky, 1986). For multilingual learners, developing language skills and content knowledge simultaneously requires teachers' support in all subjects (Carlson et al., 2018; Harju-Autti et al., 2021).

In examining pre-service teachers' knowledge about learners' linguistic repertoires as resources for learning mathematics, the practice period seemed to help most of the participants gain a greater awareness of the importance of students' L1s in learning. However, as in previous studies conducted among in-service teachers (Alisaari et al.,

2019a), monolingual ideologies were also reflected. Surprisingly, in the post-test, some responses were more conditional or even strictly against using students' L1s to support the development of the school language. This aligns with previous studies: pre-service teachers, especially in the natural sciences, developed more negative approaches to the role of languages in learning during teacher training (Heikkola et al., 2022).

It is crucial that multilingual learners develop their skills in the school language to succeed educationally and integrate into society. However, seeing L1s as an asset supports socioemotional development (Chung et al., 2019) and performance in education and the labour market (Agirdag, 2014; Feliciano, 2001; Glick & White, 2003; Lutz & Crist, 2009). It is important to provide pre-service teachers with research-based information about multilingual pedagogies and how strong L1 skills benefit learning the language of instruction and other subjects (e.g. Eunjung Relyea & Amendum, 2019; Ganuza & Hedman, 2019). Furthermore, it is important to critically reflect on the language policies and practices of Finnish teacher education and support the dialogue between research and practice regarding a shared understanding of valuing linguistic diversity. The need to critically analyze how Finnish teacher education responds to cultural and linguistic diversity is reflected in the results of this study. Due to a deeper awareness of the importance of multilingual pedagogies, the participants expressed interest in learning more about concrete multilingual pedagogical practices.

With regard to teaching strategies associated with linguistic support, the participants reported using visual supports and explaining vocabulary and structures the most. This is important, as the language of mathematics entails special vocabulary and specific structures (see also Ahlholm & Portaankorva-Koivisto, 2018). However, using students' L1s as a resource received only one mention in the post-test. These findings are similar to those of studies conducted among in- (Alisaari et al., 2019a) and pre-service teachers (Heikkola et al., in press) in Finland, indicating that Finnish pedagogical practices centre around using visual aids, while more linguistically oriented supports are lacking (Heikkola et al., 2022). Combining various support methods for learning language and content is crucial in implementing linguistically responsive pedagogy.

Although many participants perceived *Binogi* as beneficial and motivating, less than half reported having used it, and these only rarely. The infrequent use of the material was justified by the lack of time and the abundance of materials available. Nevertheless, *Binogi* was considered beneficial in supporting students' L1 use (see also Cummins, 2021), and some participants emphasised that the practice period reinforced their understanding of the importance of multilingual pedagogies. Some of the participants reported that they were unfamiliar with multilingual pedagogies, even in the post-test. This may reflect the fact that, according to the participants, students' linguistic resources are not considered significant assets for learning in teacher studies. Thus, multilingual pedagogies have not been adequately mainstreamed into pedagogical practices in Finnish teacher education (see also Bergroth et al., 2022); therefore, even a ready-made tool cannot easily take root in classrooms. However, based on the findings of this study, pre-service teachers are eager to learn more about implementing multilingual pedagogies.

The limitations of this study include a relatively short teacher training period, a survey as a method, and a small number of participants. Longitudinal studies covering the entirety of teacher studies should be conducted; it would be essential to critically analyze the content provided to future teachers and observe their pedagogical practices.

Due to the voluntary nature of the study, only a small number of pre-service teachers were reached. Therefore, broader participation in subsequent studies must be encouraged.

5. Conclusions

Traditionally, classroom interactions have been guided by the norm of monolingualism (Jørgensen, 2008; Lehtonen, 2021). However, students' linguistic resources are assets for learning if teachers have adequate knowledge about multilingual pedagogies. It is vital to support the development of the language of instruction (Cummins, 2021). Therefore, teacher education must include instruction concerning the language of mathematics, so all learners' mathematical competence can be developed to meet the curriculum's objectives (EDUFI, 2014).

Providing pre-service teachers with research-based, practice-oriented instruction for deepening their knowledge of multilingual pedagogies in all subjects is needed for all teacher education units. To promote inclusive education for all learners regardless of linguistic background, developing meaningful approaches and methods for teaching both the language of instruction and subject content is essential. Thus, language-related pedagogical matters should be considered in teacher education. Although this study concerns the Finnish context, the knowledge gained can be applied to other contexts.

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