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Multilingual pedagogies and digital technologies to support learning STEM in schools in France and Canada

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ABSTRACT

For many years, French and Canadian schools have welcomed students from around the world. This article presents the Binogi/ESCAPE project, which supports the integration of a multilingual digital resource in the classroom that presents STEM content through a multilingual lens with associated animated videos and quizzes. The study aims to encourage the inclusion of multiple languages in STEM content in both language-based (FSL/ESL) and content-based (STEM) classrooms. Researchers collected data during the 2020–2022 school years through focus groups, interviews, logs, observations, and questionnaires. Study participants included 17 teachers in France and 18 teachers in Canada. The results show that opening up to languages through a multilingual resource works as a springboard, allowing teachers and their students to find innovative ways to include other languages. Teachers who have used the resource have also appreciated the use of Binogi for instructional differentiation. Binogi's multilingual features supported translanguaging activities in the classroom, linking STEM content to literacy activities. However, more research is needed to understand how to train teachers to use multilingual resources to better support newcomer students.

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Digital education; newcomer students; plurilingualism; translanguaging; multilingual pedagogies; STEM education

1. Introduction

In this introduction, we endeavour to examine the facilitative role of multilingual pedagogies and digital technologies in promoting STEM education within the educational frameworks of France and Canada. To achieve this, we start by providing an overview of the distinct educational contexts prevailing in France and Canada, which constitute the backdrop for the research conducted in these regions.

In France, since 2012, many migrant students in France have been welcomed into a special programme for incoming allophone students, called the Pedagogical Unit for Newly Arrived students (the French acronym is UPE2A), what the Ministry of Education in France labels Newly Arrived Allophone Students (the French acronym is EANAs). In schools where available, this cohort meets for half of the week for up to 18 months to

learn French as a second language. The rest of the time, these students are part of a regular class with peers of the same age and must follow the official curriculum like any other student of their grade level. The objective of this approach is to offer a specific programme during which newcomer students receive support in learning French as the new language of schooling while being connected to a mainstream class in their middle and high school. Within this framework, students are expected to reach a level of competence in French as a second language (FSL) sufficient to follow the various subjects taught, particularly the STEM subjects (Mathematics, Life and Earth Sciences, Physical and Chemical Sciences, and Technology). Many schools in France do not offer this programme, and as a result, students are directly included in the regular classes for all subjects.

In this paper, we discuss the Binogi/ESCAPE (BE) Project in the context of France and Canada, during the 2020–2022 school years. The language of participating schools is English in Canada and French in France.

The project aimed to foster students' acquaintance with the language used in Science and Mathematics. It specifically focused on incorporating Binogi, a versatile tool, into both UPE2A and in the regular sciences classes to facilitate this process.

The BE Project aimed to respond to the needs of teachers and multilingual students who have challenges teaching/learning STEM subjects, particularly those students aged 11–14 (Cycle 4; see [Table 1](#)). The BE Project can also be helpful to children who have been in France for several years and have complex language needs. Cummins (2011) indicates that it can take 5–7 years for allophone students (allophone is the term used in the curriculum in France to refer to students who still need to learn the school language) to reach the competencies of their age group. In addition, the BE resources can also be of value to students who live in France and who speak languages other than French. In 2019, the European Commission proposed to the different ministries of education in Europe to add the knowledge of two languages in addition to the school language(s). Considering this objective, the Binogi resource is seen as a means to encourage students not only to appreciate various languages but also to develop specific competencies in scientific subjects across multiple languages, promoting transversality.

In Canada, education is regulated by each province or territory. In the province of Ontario, two school systems coexist: an English speaking and a French speaking system. In the English-speaking system at the elementary school level, most newcomer students are integrated into the regular school upon their arrival and are provided with occasional support according to their needs in the language of the school. Some

Table 1. A comparison of grades and school divisions/cycles in France and Ontario.

Age	Grade in Canada	Divisions in Ontario	Grade in France	Cycle in France	Binogi Content
6–7	1	Primary	CP	Cycle 2	Not included
7–8	2		CE1		
8–9	3	Junior	CE2	Cycle 3	
9–10	4		CM1		
10–11	5		CM2		
11–12	6	Intermediate	6ème	Cycle 4	Included
12–13	7		5ème		
13–14	8		4ème		
14–15	9		3ème		

schools offer ESL (English as a Second Language) withdrawal support for small groups of students to provide focused support, when needed. Binogi is a tool that can support a smooth transition for students, giving them the opportunity to access the academic content in their own language until they are able to do so in the language of the school. In high school, students may be enrolled in ESL (English as a Second Language) and ELD (English Literacy Development) courses, based on their needs. These classes are based on language skills, not age or grade. Some students may only take a few ESL courses before transitioning into mainstream classes, while others will take advantage of the full spectrum of ESL courses. In the Toronto District School Board (TDSB), for example, the ELD curriculum is offered through a separate programme called the Literacy Enrichment Academic Programme (LEAP), which offers more support in literacy and numeracy skills, and academic skills and knowledge. If a significant gap in prior schooling is initially identified, students may be placed in the LEAP programme to provide students more individualised support. Teachers supporting these students, in mainstream or in ESL/ELD classrooms alike, have shown interest in Binogi as they often lack resources to support their students, particularly at the early stages of learning the school language. Teachers of ESL/ELD classrooms see Binogi as an opportunity to meet the academic needs of their students using a differentiated and individualised approach. In addition to the support of multiple languages, Binogi allows them to assign different topics to students and help them progress at their own pace. Another attractive aspect of Binogi is the availability of both official languages. The officially English-speaking province of Ontario has developed a system of immersion classes for English-speaking students to give them a chance to develop bilingualism in both official languages. Students are taught part of the day in French for subjects such as science and geography. Binogi provides these students the opportunity to review the content learned in class in English or in another language and potentially include the parents of the students who might not be proficient enough in the school language to support their children.

In the Francophone system in Ontario, there are public and faith-based schools that share the same curriculum framework. From an inclusive perspective, newcomer students are not placed in separate classes. Once the initial assessment is done by the school board, they are assigned support, depending on the level of their needs identified: ranging from moderate, high need, and very high need. However, as we have experienced in this research, a multilingual resource like Binogi may be more difficult to implement in French speaking schools in Canada because of the prevailing language context; French is a minority language in Canada (outside of Quebec), and the challenge to maintain the rights of French speakers can lead to exclusive practices such as the disregard of speakers' home languages (Fleuret, Bangou, Ibrahim, 2013).

In summary, many students and teachers are interested in the implementation of the Binogi resource in France and in English-Speaking school systems in Canada. For recently arrived allophone students, students speaking other languages and French-speaking students who wish to learn other languages, the resource aims to meet a variety of needs to provide equity in the classroom. The resource might also help to create classroom dynamic that benefits everyone allowing for better development of STEM and languages skills.

2. Digital tools in the classroom

We first describe the functionalities of Binogi before explaining how teachers appropriate this digital tool drawing on various individual interviews, focus groups, logbooks, and direct classroom observations. We considered the teachers' use of the short videos, a format which has existed for a long time in science education (Rocher, 2014). Binogi offers a choice of oral and subtitled languages, along with an individualised management of the speed of the video (Le Pichon et al., 2021; Le Pichon & Cummins, 2020). Moreover, it is important to emphasise that these videos are designed for the resource, which allows the application's specifications to be met, particularly in terms of the stability of the interface. Used thoughtfully, screentime can be both a source of motivation as a mediation tool (Guiraud & Sauvage, 2020) and also a vector of transmission and personal acquisition of knowledge.

In 2021, Le Pichon, Cummins and Vorstman published the results of a pilot research conducted in a suburban Toronto school using Binogi. They identified the positive role of multilingual access to content knowledge on students' learning autonomy and attitudes toward mathematics (Le Pichon et al., 2021). They found that flexible language use, supported by linguistic aids such as subtitles, video texts or quizzes, contributed to improving students' access to educational content. The programme allowed for the mobilisation of students' entire language repertoire supporting an asset-based pedagogical approach. The research took place in Grade 6 classes (11 & 12 year olds) in the English school system prior to the pandemic that struck the world the year after the research was completed. With a move to more online and distance learning during the pandemic, we were hopeful that the implementation of an online multilingual STEM resource such as Binogi that would allow parents to support their children from home, would be well received by educators across diverse school systems.

2.1. Learning in the classroom through Languages

In the project, schools in France used a research specific Binogi pilot website, with a library of more than 200 videos, including 198 in sciences and 33 in math, at the time of writing. In Canada, teachers used a Binogi Canada website with an English interface that had a more extensive selection of lessons: more than 500 in sciences, and more than 200 in math. The videos are entertaining and last no more than seven minutes. They correspond to the French school curriculum from the sixth to the third grade and in Canada from grade six through nine (corresponding to ages 11–14, see Table 1).

In Europe and Canada, researchers, institutions (such as the Council of Europe) and teachers more often use the term plurilingualism (Auger, 2023; 2020; Auger & Le Pichon-Vorstman, 2021; Fleuret, 2020; Gogolin, 2021; Herzog-Punzenberger et al., 2017; Van Avermaet et al., 2018) or multilingualism (for instance, Kendrick et al., 2022) to recognise the diverse language skills of the students in the classroom and use them as a resource. It is important to highlight that the platform currently provides content in various languages (approximately 10 as of the current date). This includes both video materials and accompanying quizzes in the available languages. Multilingualism is thus well represented. The transfers between languages are operationalised in the platform by the fact that at any time, a user can switch from one language to another (without hybridisation), to

change the language of the audio or subtitles in the video, and the written text of the quizzes. Moreover, in the same video, two languages can co-exist: one for the spoken word and another for the subtitles.

During the course of the research, the video transcripts were accessible in two languages: French and English. Additionally, from the back-end teacher section of the resource, teachers could assign tasks, such as watching videos and completing quizzes, to various learning groups. This included the option to assign tasks to individual students, groups of students, or the entire class, allowing educators to tailor assignments based on each student's specific needs and abilities (Figure 1).

2.2. Working on the linguistic continuum

The teacher can monitor the students individually and collectively through access to analytical data. This data includes information on the time each student has spent watching the videos, the answers provided in quizzes (with translations into the school language for the teacher, even if the student responded in another language), and statistics on quiz responses for specific students or groups. By utilising these analytical insights, the teacher gains valuable feedback on the progress and performance of each student, enabling them to assess comprehension levels, identify areas for improvement, and provide targeted support and guidance as necessary. The ESCAPE team created several resources to assist teachers in effectively utilising Binogi, such as Concept Lists (Figure 2) and a Concept Detective (Figure 3). These resources prompt students to actively engage with the lesson content by providing their own explanations of new terms,

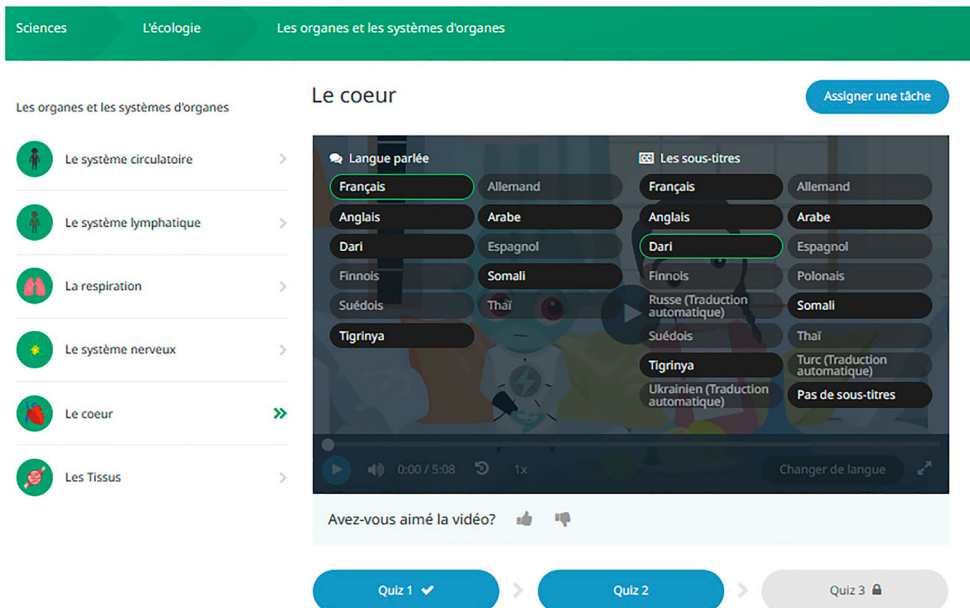


Figure 1. The Binogi interface: This figure represents a screenshot of the Binogi platform in French, showcasing a lesson on 'the heart'. The screenshot displays the available language options for audio (langue parlée) and subtitles (les sous-titres).

Binogi Video: The Animal Cell
English-Add a Language Bilingual Concept List
The Escape Projects


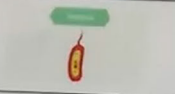
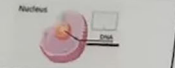
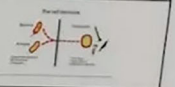
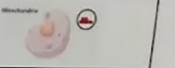
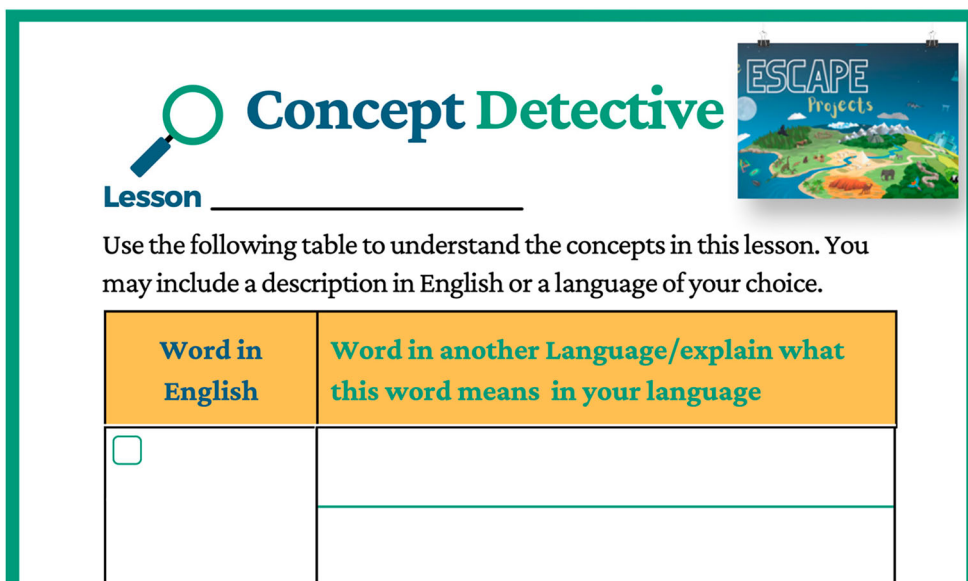
Concept in English	Add the Concept in another Language	Picture
Molecule A group of atoms attached to each other by a chemical bond.	صركع صجيوعة من الذرات مصللة الي بعضها البعض بواسطة اساطط الكيمائية. د كيميائيم	
Bacterium A group of organisms consisting of only one cell. They can be found everywhere in our surroundings. Some of them can cause diseases while others are essential to life.	صجيوعة من الكائنات الحية متكونة من خلية واحدة فقط. بعضها يتواجد في كل مكان في محيطنا مثل: بعضهم يسببون امراض، وبنهاه هناك الاخرين اساسيون للحياة.	
Genetic Something related to genes and how they are passed down from generation to generation.	وراثة شئ متعلق بالجينات، وكيف تنتقل من ميلد الي جيل	
Cell The smallest unit of life that exists in all living creatures. The human body consists of several millions of cells and the simplest organisms consist of only one cell.	خلية اصغر وحدة الحياة التي موجودة في كل الكائنات الحية. الجسم البشري يتكون من عدة ملايين من الخلايا واربسط كائن حي متكون من خلية واحدة فقط.	
Mitochondrion A part of the cell that converts nutrients into energy.	ميتوكوندريون جزء من الخلية تحول العناصر الغذائية الي طاقة	

Figure 2. Concept List: As depicted in the screenshot, the student is encouraged to provide an explanation of the concepts in a language of their choice. In this particular instance, a student from a Canadian school opted to use Arabic for their explanation. On the left side of the screen, the concept is described, while the right side features an image representing the concept from the Binogi website.

fostering a deeper understanding and connection to the educational material. Students can choose to write their understanding of the terms (either from the concept list that Binogi has provided, or through their own exploration of the assignment) in the language of their choice. Alternatively, they may choose to complement their understanding by creating visual representations through their drawings (see Figure 3). We proposed a colour system to facilitate student learning: for example, terms that are well understood are written in green, terms for which students have doubts or questions are written in yellow, and terms that students do not understand are written in red. Throughout the sessions, students completed their glossary by continuing to add words they encounter in the lessons.

3. Method

Data for our research was collected via focus groups, interviews, and questionnaires for students, teachers, and families. We aimed both to understand how students use the platform and develop competencies in language and disciplinary content. Participating students received a pre-study questionnaire and a questionnaire during the course of the study, before participating in a focus group near the end of the project. Teachers also completed a pre-study questionnaire, participated in teacher and teacher/student focus



The poster features a magnifying glass icon over the title "Concept Detective". Below the title is a line for the lesson name. To the right is a small illustration of a landscape with the text "ESCAPE Projects". Below the title and illustration is a table with two columns: "Word in English" and "Word in another Language/explain what this word means in your language". The table has two rows, with the first row containing a small square box in the first column.

Concept Detective

Lesson _____

Use the following table to understand the concepts in this lesson. You may include a description in English or a language of your choice.

Word in English	Word in another Language/explain what this word means in your language
<input type="checkbox"/>	

Figure 3. Concept Detective: All posters can be accessed and downloaded from www.escapeprojects.ca, facilitating convenient printing for teachers. This accessibility ensures that teachers can readily utilise the posters in their classrooms without any difficulty. This activity was developed by the Canadian research team and shared with all project members.

groups, and took part in a semi-structured interviews in July 2021 and 2022. They completed a logbook throughout this portion of the study. Tablets were offered to teachers and students to ensure access to hardware as necessary.

In France, 17 teachers and over 120 students participated in the study. The results presented in this article focus on the observations that took place during the 2020–2022 school years. The COVID-19 pandemic, which began in Winter 2020, created some opportunities as well as challenges to carrying out our research. However, we were able to conduct interviews, sometimes remotely, as most teachers recognised the value of using the digital resource. In this first cohort of students, we identified the following spoken languages: French, Turkish, Pashto, Arabic, Romanian, Georgian, Russian, English, German, Spanish, Bengali, Dutch, Italian, and Portuguese.

In Ontario, Canada, French language schools were entirely closed to research for the duration of the pandemic. However, following the pandemic, we contacted school boards to recruit teachers. One of the boards was not interested, having defined their priorities for the year in terms of reading and writing delays and excluding the issue of multilingualism. Two other boards agreed, but due to pandemic issues and school closures, it took us over a year to begin training. The teachers became familiar with the resource during spring break. They seemed motivated and interested at the time of onboarding, however, most of them soon abandoned the use of the resource. When asked why, they gave two main reasons: Firstly, they emphasised the value of using software they were already familiar with, minimising the multilingual and inclusive value of Binogi. Instead of taking time to learn the resource with their students, especially in the already exhausting teaching/learning conditions that the pandemic created, they

preferred to continue with familiar resources. Secondly, teachers shared that the variety and depth of the content and activities offered on the platform discouraged their continued effort. Several videos were not yet available in French and this caused the teachers to reject the resource as a whole. Considering the reasons mentioned, as well as the hints of language-assimilation still present in the minds of Franco-Ontarians, the idea of using English as an alternative was not an option these teachers considered. Only one teacher decided to continue with the project because he saw the potential. However, his involvement was moderate. In his class, there was also a wide variety of languages, including Creole, various African languages and Spanish.

Within the English-Speaking school system however, in 2020–2021, 18 teachers from three different provinces (Ontario, New Brunswick and Newfoundland) participated in the research with their classrooms.

4. Results and analysis

In the framework of our article, we consulted only the qualitative data generated from interviews, focus groups, logbooks, long-answer questionnaires, and direct observations of teachers to understand the translanguaging activities proposed by the teachers. Between France and Canada, the responses from teachers varied greatly. Teachers in France did not have any particular challenges in using the tool and were quickly at ease with the platform. They used Binogi in class either with the tablets lent to them in the project or with the tablets already available at the school.

In Canada, schools were closed for most of the 2020–2021 school year in Ontario, and in the other two provinces, the situation varied from a complete closure to an unpredictable schedule during which the schools opened and closed several times. Of the 18 teachers who participated, only three rated the transition from classroom to online instruction as easy or very easy. For the remaining 15, six rated it as neutral and nine said the transition was challenging or very challenging. The implementation of the Binogi platform was done entirely online, as members of the project were not authorised to enter schools. The challenges related to the implementation of Binogi and mentioned by the teachers range from access to technology for each student, lack of connectivity, or general digital literacy skills of learning how to use a tablet. Others mentioned their students' limited attention spans. However, many mentioned that Binogi saved them time in preparing for class.

In the next sections, we detail the strategies and challenges identified by the teachers regarding the use of the resource.

4.1. Translation issues and teachers' views

The first redundant comments observed, consistent with findings from interviews and logbooks, pertain to the availability (or lack thereof) of some students' languages within Binogi. It was noticed that certain students' languages were not currently included in the platform's offerings. In interviews, teachers were concerned about providing unequal opportunities by using a platform that does not offer all the languages in their students' repertoires. The sense of equality (present in the French token 'liberty, equality,

fraternity') is most important for teachers. It is part of the professional identities of teachers

Teacher G (France). The fact that there weren't enough languages represented was a big hindrance (...) that's what I was afraid of at the start (...) that's the most annoying thing because it creates segregation between those who can do it and those who don't have their language on Binogi

Nevertheless, some teachers tried other ways to restore the equality principle between students devised a workaround to overcome the absence of certain languages on the platform by pasting the lessons scripts of each video using free online translator tools. The teachers then used the transcripts to work on reading comprehension with the learners, allowing them to make links with their languages before engaging with the video content presented in French.

That is why instead of showing the video, some teachers would study the translated text from the online translator before making the students watch the videos.

Other teachers took the opportunity to use languages from the students' repertoire other than the home language. For example, a sciences teacher who hosts Albanian students realised that they had sufficient English proficiency to understand de videos in that language and therefore offered sessions in English as in the example:

Teacher T (France): then there are students who are not here but who also use English (...) so she uses English Veronica/English/because she speaks English well

The same is true of other teachers who received Algerian or Moroccan students, some of whom had been in school for some time in Spain. These students were Berber-speaking and had never been schooled in Arabic. For some, rather than viewing the videos in Arabic, being able to access them in Spanish was a great help.

Other students used a language close to their own to watch the videos:

Teacher T (France): I have students who are Portuguese, but there's no Portuguese on the video, so they use Spanish/the proximity of the language helps them.

In Canada, out of the 13 teachers who answered the course of study questionnaire, only one teacher said that he did not use the language function of Binogi because of the absence of certain languages used by his students. The others proposed compensatory strategies that allowed them to open their classes to the different languages present.

Some of them encouraged their students to use translation servers.

Teacher S (Canada): 'Most of my second language students are Korean first language speakers. So, there wasn't a lot of opportunities there. They did benefit though because when they wanted to use a translator and they had two tabs open, because the text for the video is down below, and uses that quite often. And then of course replaying the videos they did indicate that they appreciate that'.

A French immersion teacher, inspired by the word detective resource on our project website, decided to develop a glossary of concepts identified in science lessons with his two classes. He opened an Excel file including a different page for each of his classes, and the students were given the opportunity to use the languages of their choice in the file. At the end of each week, two to three concepts were included in the file and the students were instructed to add words to the file in their own language,

asking their parents for support as necessary. The teacher noted that, contrary to his fears, he did not fall behind in the curriculum. The students invested themselves in this activity, showing great enthusiasm and thus a better understanding of the concepts. In this case, the teacher in question used Binogi to extend the concept list to all the languages of his students. He encouraged them to enter into the reading and writing of these languages by building on their own and/ or their parents' knowledge and thus recognising these funds of knowledge as valuable for learning (Cook, 2001).

4.2. Towards answering each student's needs

In France, teachers have also used the Binogi resource tool to implement pedagogical differentiation between allophone and francophone students. As previously mentioned, one of the key features of the platform is the ability for teachers to assign videos and quizzes to different target groups, individual students, small groups, an entire class or even several classes.

Teacher T (France): Binogi is used by allophone students in FSL classes, by allophone pupils during their integration into their class's science classes (math, SVT, PC, techno), but also as support for oral and written comprehension exercises in their class's modern language classes (English, Spanish, German). There was also 'homework' slots by foreign-speaking pupils, when they are asked to revisit scientific concepts that may not have been fully understood in the ordinary classroom.

Having the videos and quizzes available in the students' languages helped students explore their curiosity while minimising the disciplinary academic gap much more quickly than with French-only videos, while developing autonomy.

Teacher T (France): Hadj says it helped him learn more science vocabulary. There were some science words he didn't know/ And by watching the Binogi videos on the topics he covers in science/ He understood some words/ I had him watch a video on genes/ He's in 3rd grade/ So they cover genetics in SVT /So it helped him understand some vocabulary words.

Being able or at least trying to answer to each student's needs also took place in specific moments during which the teachers used the available languages as supports to allow the students to acquire abstract or complex concepts:

Teacher F (Canada): The advantage is for pedagogical differentiation already, in relation to their level. That is to say, it allowed each student, as I said, to see the concepts in French, of course. But as soon as it became too complicated, they switched to another language to acquire the concepts.

The teachers have extensively explored and leveraged the platform's language flexibility, a characteristic that is emphasised and valued.

Teacher F (Canada): But then, I say to myself that Binogi for me is something that is flexible, that will allow them to work in French because that's what they say 'But Madame, we want to work in French'. Of course, but afterwards, it will allow them, when there is something or a concept that is too complex, to use their language. I think that's really important because it also allows them to make the link with the French language.

Teacher T (France): What Donato likes is that you can listen in French and associate the French words with the subtitles in his native language. He finds that it helps him learning new words.

Canadian teachers also mentioned the possibility of differentiating between students from a language point of view and from an academic point of view, by offering different videos or having students listen in their own language during class time. They appreciated the language versatility of the tool:

Teacher J (Canada): There is also available headsets and headphones in the classroom that kids could then choose, whether or not they wanted to watch it while we were watching it or to watch it again in their home language. So, there were many options available. And, I think what was really cool was watching them listen to it in English, figure out how much they understood and then watch it in their home language to figure out what was missing.

Some teachers demonstrated the versatility of languages to their students by regularly switching between languages or utilising various modes (such as audio in one language and subtitles in the other) while watching the video together as a class and the slow-motion mode.

R: Did you use the slow-motion mode/ you know/ to slow down the video?

Teacher T (France): So I did it with them in class/ But they themselves listened to it in speed 1

R: Ok ok great

Teacher T (France): But in class I sometimes played them the videos at speed 0.75.

Other teachers gave their students complete autonomy in their language choices and the use of Binogi.

Teacher S (Canada): If I've got a class where everybody speaks Arabic, then I'll just play it in Arabic, and maybe I'll use the English subtitles so, you know. And then I will encourage them to watch it again once or twice in their own language. And then to put on English subtitles or to listen to it first in English, and they have Arabic subtitles. And then the next time they watch it, they have English audio and English subtitles. So like we sort of just do like that transition, right? All from Arabic to Arabic and subtitles, to English spoken and Arabic subtitles, and then English, English they can go to eventually.

Teacher M (Canada): I've seen some of the students have it in Arabic audio, or I'll see it while they're sharing their screen asking me a question that they'll have the subtitles in Arabic.

One teacher mentioned a student's excitement when he realised the video was in Tigrinya.

Teacher J (Canada), quoting a student: 'Oh my goodness, they're speaking my language. I understand what they're saying'.

4.3. Towards holistic practices of working with different language skills

Beyond the work on math and science, teachers in France and in Canada explained that they used the resource to develop listening and reading skills, and oral and written expression in French or English, dependent on the school context, through the languages already known by the students:

Teacher F (Canada): It was great (...) to work on reading comprehension. It was transversal. I thought it was great to use texts from other subjects to work on the CEFR (Common European Framework of Reference for Languages used in Europe) with written comprehension skills, and even written production. Because I also thought about that, saying to myself that it's really nice

to have them listen to videos and to have them give me summaries of the video. And then, we'll also be working on written production, on the restitution of what they've learned.

Teacher T (France): I've created editable PDFs which I've combined with the quizzes and videos already available on Binogi. I prepare DELF-type exercises (oral and written comprehension, oral and written expression) based on the Binogi videos and their transcriptions.

Teacher S (Canada): I always encourage them even if it's in English audio, like, to see the words. And then of course that helps reinforce the word so that they remember the terms, you know all that new vocabulary. So, like, to me it's excellent.

In Canada, the strong focus on building school language literacy may also be due to the fact that many ESL teachers participated in the study. Their role is specifically to help students learn the school language through the subjects taught. Often, math and science are difficult subjects for them to teach because they are not (or not always) teachers of these subjects (Le Pichon et al., 2022). Binogi gave them the opportunity to address these subjects with their students in a language-focused class and thus form a bridge between these classes and their STEM classes.

Additionally, some teachers have expressed their satisfaction of being able to involve their students in the early stages of language learning:

Teacher S (Canada): You know, like, even for the recent arrivals who have limited English skills, they can be very much a part of the lesson and involved with the lesson. So, instead of being in class kind of dazed and confused and, you know, feeling really inadequate, like they can be much more engaged now as learners.

It is interesting that teachers appreciated the social justice aspect of being able to offer academic content in the languages of their students according to their needs, while still working on their target language skills.

4.4. Adapting to learners and reaching targeted objectives

The teachers were able to explain at length the value of Binogi for individual and collective monitoring of students by having access to data such as the length of time each student watched the videos and the answers given to the quizzes. On the Binogi platform, teachers have access to the details of each student's answers in order to see what knowledge has been acquired, what is still unclear and needs to be reviewed, or what is problematic and has not been understood. The notions of content knowledge and the school language can thus be dissociated since the students can continue their learning even if their knowledge of the language of schooling is in the early stages of development. During the interviews, teachers often mentioned the possibility of accessing the statistics in the quizzes for a given student or group to obtain interesting information for personalised follow-up concerning both language skills (to see when students change languages, for example) and in science subjects.

Teacher S (Canada): So I give them their quiz first, and then, they go back and see the right answers and get feedback from that. And then I take the same assessment, I make a copy of it. And I switch some things around or I look at the questions the students had difficulty with. And then I realized, oh, oh, so I meant this but they understood that. So, you know, I'll just go and tweak everything, [...] they get their feedback and, you know, it's awesome so like that's another way I've been using technology.

This teacher explains that when students take the quizzes, they are allowed to take them as many times as they want until they pass. Therefore, she lets them work as they wish and then, based on the answers they give, which she can check through the platform, she understands what she needs to reteach or modify. Then, she assesses her students based on the formative assessments that they have worked on during the term.

4.5. The advantages of a versatile platform

Binogi is a versatile platform, allowing teachers to decide where a video fits best for their class and lesson planning. For example, the video can be used at the beginning of a session, as a minds-on activity. A minds-on activity aims to check on what students already know, both in content and in language (depending on the students' choice of language). To reach this objective, a video can also be used during a session to reinforce a point or illustrate a concept, or near the end of the theme to check students' knowledge.

In France, during different semi-structured interview with the teachers, all agreed on the potential of the platform to use it in different circumstances: at home or in class, as a brain-storm activity to introduce a notion and to review one.

Teacher D (France): so I showed them a video with a quiz to do at home to reinforce or review points that had been seen over the year, and then I showed them two videos in class that I showed to the whole class to go into a concept in greater depth.

It is possible to show a video to a whole class, but it is also possible to suggest that a small group of students watch it independently. Teachers have used this flexibility as needed.

Some teachers adopted a flipped classroom approach, utilising Binogi as a resource for students to learn content through video lessons at home (Le Pichon & Cummins, 2020). This allowed teachers to utilise classroom time for more interactive and higher-order thinking activities. During the project, this model has also garnered the interest of parents, with teachers in France reporting that some families spontaneously talked about the videos during parent-teacher meetings. Students shared that they could share STEM content with their parents, thanks to the flexibility of choosing their language for the videos (see also Le Pichon et al., 2023). Some parents who could not read or write in their home language greatly appreciated the oral explanations provided by the characters.

5. Discussion

Undoubtedly, the introduction of the resources facilitated the adoption of translanguaging practices in STEM subjects. Teachers employed targeted pedagogical differentiation based on their students' language requirements within diverse school and programme settings across France and Canada. Considering distinct skill needs (oral, written, monologic, dialogical), teachers differentiated their instructional approaches at various junctures during sessions (e.g. in the flipped classroom, before, during, or after lessons, activities, or exercises). Notably, teachers across all classes made noteworthy observations regarding the richness of their students' language repertoires and their remarkable familiarity with multiple languages available on the Binogi platform.

In France, the teachers were generally enthusiastic about the Binogi resource, in which they saw great potential for language and content integration. The reasons that pushed them to join the project were diverse. Some teachers decided to participate out of curiosity, to help newcomer students in classes for newcomers or in regular classes. Others decided to support students who speak other languages or wish to be exposed to other languages they want to learn by themselves. The teachers in our study stressed the need for a resource like Binogi to make links between languages and content, and to set up real pedagogical differentiation and transversality between the lessons.

It is important to note that while schools in France were closed for a maximum of two weeks during the year 2020–2021, Canadian schools were closed for most of the year, with variations by province. This situation has been extremely disruptive to teaching, with teachers in a survival mode rather than an innovation mode. That said, in the English school system, when teachers decided to work with the resource, they did so in a flexible and plurilingual manner, embracing the platform enthusiastically. Most developed strategies for differentiation and openness that went beyond the languages and opportunities contained in the resource. Teachers found the resource comprehensive, addressing STEM subjects and languages at the same time. Teachers expressed desire to have access to more resources like Binogi to support their students. During the interviews and the focus-groups, teachers reported to lack such tools, especially in the disciplines concerning French as a language of schooling or for Canada, ESL support in STEM subjects. The teachers valued the effectiveness of using translanguaging pedagogy in order to promote the acquisition of knowledge and the development of skills by all students. Nonetheless, teachers identified certain limitations, notably the discrepancy in available languages which could potentially impede access for some students and their families, and concerns surrounding the use of the flipped classroom approach.

An intriguing and yet underutilised feature is the correlation between the audio and text components of the videos. The establishment of intra and interlanguage connections offers valuable opportunities for engaging in metalanguage reflection. This process proves beneficial for comprehending and memorising not only scientific vocabulary but also syntactic elements (Auger & Chesnais, 2022). By exploring the relationships and patterns between languages, students can enhance their language awareness and grasp linguistic structures, ultimately contributing to a deeper understanding of the scientific content. In practice, engaging students in activities that target meta-competences, encouraging them to reflect on language systems and practices' disparities and similarities, prove highly beneficial for comprehension and memorisation. By integrating meta-activities that prompt reflection on language(s) as subject and as a means of communication, the educational process acknowledges language's dual role as both an object of study and a tool for learning. By exploring interferences, translations, and interpretations, students are given the chance to critically examine language practices within STEM fields and gain a deeper understanding of disciplinary objectives. These meta-activities provide valuable opportunities for students to develop language awareness, analytical skills, and a broader perspective on the ways language influences their comprehension and engagement with scientific subjects.

Interestingly, upon committing to invest time in implementing the resource, teachers discovered that their efforts resulted in time saved rather than wasted. Furthermore, they

observed that their students exhibited improved understanding and higher engagement with the educational content. This highlights the importance of raising awareness among teachers about the value of making students' languages visible and encouraging their utilisation as learning resources. Urgent action is required to sensitise teachers to foster an inclusive environment that embraces linguistic diversity, enabling students to draw on their language skills to enhance their learning experiences. A resource like Binogi seems to address some of the language needs of all students in the STEM classroom and these benefits are not limited to newcomer students (Cavalli, 2005; Coste, 2003). Finally, the global reach of the Binogi platform presents a valuable resource for teachers in many countries. However, one limitation is that not all videos were systematically aligned with the STEM curriculum in each country at the time of the research. This lack of alignment may pose challenges for teachers in effectively integrating the platform into their educational settings. As a result, ongoing efforts to align the platform's content with various STEM curricula in different countries will be crucial for its successful implementation in the future.

6. Conclusion

The Binogi resource was very useful during the COVID-19 health crisis, as it helped teachers to implement distance learning for students and the students' parents at home. It is no longer the pedagogical uses of the teachers but those of the students that remain to be observed in future research. In France, we noticed that the videos were watched even more at home, both by students and their parents because of the pandemic. The fact that they were 'locked down' at home allowed the students to share the videos with their parents, some of whom were not French speaking, (Sauvage et al., 2023). In the Canadian context, the utilisation of Binogi in both classroom and home settings has exhibited considerable variability among teachers (Le Pichon et al., 2023). Some teachers expressed concerns regarding their students' unequal access to computer resources at home, fearing potential hindrances to effective learning. In contrast, other teachers embraced this opportunity to foster student autonomy. These divergent experiences underscore the significance of tailoring Binogi's implementation to suit individual educational settings and student needs, while also highlighting the platform's potential to empower learners and accommodate their unique preferences and circumstances.

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