Title

Exploring the Approaches to Learning of Bilingual Students in Online Upper Elementary Mathematics Classes: A Mixed-Methods Investigation

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Exploring the Approaches to Learning of Bilingual Students in Online Upper Elementary Mathematics Classes: A Mixed-Methods Investigation

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in Education.

by

Le Xiu

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ABSTRACT OF THE THESIS

Exploring the Approaches to Learning of Bilingual Students
in Online Upper Elementary Mathematics Classes: A Mixed-Methods Investigation

by

Le Xiu
Master of Arts in Education
University of California, Los Angeles, 2024
Professor Alison Bailey, Chair

This study examines bilingual students' learning experiences, online teaching strategies and family support structures within the context of online mathematics education in upper elementary grades. It addresses the gap in research regarding how these strategies shape students' approaches to learning (ATL), considering the dual challenge bilingual students face in mastering both mathematical concepts and dual languages through online learning environments. Employing a mixed-methods approach, the initial phase involved administering a questionnaire to assess students' language skills, educational background and their engagement with online learning. This was followed by gathering qualitative insights through interviews with teachers and with families—to explore the challenges associated with educational practices in online learning for multilingual students. The study highlights the critical roles of effective teaching strategies and parental support in enhancing the ATL of upper-elementary bilingual students. It

calls for a collaborative effort between educators and parents to meet students' diverse needs and to create a supportive online learning environment.

Keywords: Approaches to Learning, Bilingual Students, Mathematics Education, Online Classroom

The thesis of Le Xiu is approved.

Teresa L. McCarty

Anna J. Markowitz

Alison Bailey, Committee Chair

University of California, Los Angeles

2024

Dedication

Dedicated to the students who navigated the challenges of online classes during COVID-19, and to my thesis committee, whose invaluable guidance and expertise have been a beacon throughout this journey. Special thanks to my graduate advisor, Alison Bailey, for her meticulous guidance and encouragement, which have been instrumental in my growth. My heartfelt appreciation goes to my UCLA language research RAC group, and I am deeply grateful to have had the opportunity to peer with this exceptional group. I extend my deepest gratitude to my parents for their unwavering support in my academic endeavors and to my friends, whose steadfast belief in me has always fueled my passion.

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Curriculum Vitae

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May 19th, 2024

EDUCATION

Bachelor of Arts	English (Creative Writing) & Education (Early Childhood and Family Studies) *University of Washington*	2018 - 2022

RESEARCH

2022 - 2024	UCLA Language and Literacy Research Lab
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TEACHING

2022 - 2023	Online Mathematics Teacher *Think Academy, San Jose, California UNITED STATES*
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Section 1. Introduction

The educational landscape is dynamic and ever-evolving, particularly in its response to over half of the global population that is bilingual (Grosjean, 2010). Bilingualism is so widespread throughout the world that it can arguably be considered more typical than monolingualism (Krause et al., 2022). As we progress into a globalized society, the importance of understanding these students' engagement with learning processes becomes paramount. Approaches to learning (ATL) refers to how students engage with, interpret, and respond to learning tasks, which covers a spectrum of cognitive and emotional aspects, including attention, flexibility, organization, and emotional regulation—all crucial to a student's academic and developmental progress (Li-Grining et al., 2010). These ATL skills that students adopt can greatly influence their academic performance, level of engagement, and overall educational satisfaction.

In the post-COVID-19 era, many schools worldwide have adopted virtual and hybrid classes to continue educational processes. The trend towards online classrooms has become particularly pronounced in subjects like mathematics (Videla et al., 2022). This shift necessitates an in-depth exploration of online mathematics education, with a specific focus on its impact on bilingual students in the upper elementary grades. During these formative years, students not only build essential academic skills but also establish ATLs that shape their future learning (Chu et al., 2017).

For bilingual students, the challenge is twofold: mastering mathematical concepts while also acquiring proficiency in multiple languages. The introduction of online learning environments introduces a complex variable into their education, emphasizing the need for effective teaching strategies and inhome family support that nurture their unique ATL in

mathematics. However, there are relatively few studies that have examined the relationship between online teaching strategies and the formation of students' learning approaches.

Learning and teaching represent two facets of the same educational continuum. Effective mathematics teaching encompasses the selection and sequencing of appropriate content, the use of instructional resources and materials, the creation of a supportive learning environment, and the application of teaching strategies to engage and guide students in their mathematical learning. Moreover, in this landscape, family support in reinforcing and supplementing the teaching strategies employed by educators is also vital in facilitating the formation of effective ATL skills, particularly in an online learning context where traditional classroom structures are absent. The role of the family, particularly in providing an environment conducive to learning and offering lexical support for bilingual children, as well as emotional and logistical support, is crucial in online settings where students may lack face-to-face interaction and direct teacher support. To understand the formation of students' ATL behaviors in an online setting, this study examined not only the experiences of bilingual students and teachers' online teaching strategies, but also the significant role of family support. By analyzing these factors, the research aimed to uncover teaching strategies and family supports on bilingual students' ATL behaviors with the digital learning context.

In this mixed-methods study, I investigated a group of children enrolled in Think Academy's online mathematics classrooms (an educational platform), as the primary research site to provide a comprehensive overview of a digital learning environment. Think Academy is a mathematics teaching platform offering both offline and online classes to a diverse group of students, primarily from California and various parts of Asia, with many being bilingual learners from Asian linguistic backgrounds, creating a dynamic and interactive learning environment.

Section 2: Review of the Literature

The literature review presents a Venn-diagram structured, multi-faceted comparative analysis of the key scholarly works, centralizing on the concept of ATL as it intersects with the three domains of bilingualism, mathematics education, and online learning environments as presented in a Venn diagram (See Appendix A). This approach is particularly suitable when the research question comprises multiple interrelated layers, all of which require analysis in the context of a central theme. In this study, the central theme is "Approaches to Learning," and the goal is to understand how this core concept interacts with various elements. This method enables the systematic review of the relationship between ATL and the other concepts under consideration in this study: 'Bilingual Students,' 'Teaching Strategies,' and 'Online Mathematics Learning' in the 'Upper Elementary' context.

Online Mathematics Education and Students' ATL. Student-centered approaches that foster active engagement, collaboration, and critical thinking are particularly important for supporting the learning of bilingual students in online mathematics classrooms (Cadiero-Kaplan & Rodríguez, 2008). Persistence involves the ability to stay engaged in tasks, exert effort, and persevere in the face of challenges. Bilingual students who exhibit persistence continue to work on challenging mathematics problems, try different strategies, and seek help until they find a solution. This dimension of ATL contributes to enhanced learning and problem-solving skills. Eagerness to learn reflects the motivation and curiosity of bilingual students. They actively seek out learning opportunities, participate enthusiastically in classroom activities, and display a positive attitude toward learning. Attention skills, which is one ATL, refer to the ability of bilingual students to sustain and direct their attention during learning activities. They minimize distractions, concentrate on the learning material, and actively engage in classroom activities.

Strong attention skills facilitate information processing, retention, and successful task completion.

Online Mathematics Education and Teaching Strategies. In examining online teaching strategies within mathematics education, I synthesizes the methods that effectively support student learning in an online setting, particularly during the COVID-19 pandemic period. Videla and colleagues (2022) provide a comprehensive breakdown of instructional techniques, pedagogical resources, and educational contexts pertinent to online mathematics. A pivotal strategy identified is the provision of clear instructions and explanations, which involves the articulation of explicit guidance and the utilization of visual aids to clarify complex mathematical ideas. Additionally, the literature suggests that interactive and participatory activities are essential in engaging students and promoting an active learning environment. Digital tools such as virtual simulations, online mathematics games, and collaborative problem-solving tasks have been recognized for their capacity to enliven mathematical concepts through interactions (Videla et al., 2022).

Online mathematics education can be delivered through synchronous or asynchronous models. Synchronous learning occurs in real-time, allowing immediate interaction between instructors and students similar to traditional classrooms. In contrast, asynchronous learning involves activities and lectures that students can access at their own pace, without real-time interaction. This study focuses on the synchronous approach, which mirrors the immediacy of traditional classroom settings by fostering real-time interactions between instructors and students, according to Finkelstein (2006) and further discussed by Lowenthal and colleagues (2020). In such environments, educators are encouraged to utilize synchronous sessions for

group work, discussions, and collaborative problem-solving, which enhances student engagement and mimics face-to-face instructional strategies (Morge, 2020).

Next, research underscores the importance of instructional strategies that support active engagement, collaboration, and language development for English Language Learners in this study. Peer tutoring learning and interaction and communication play significant roles too (Chu et al., 2017). Peer tutoring approaches, both formative and conventional, have been found to significantly improve students' learning achievement compared to online collaborative learning (Chu et al., 2017). Interaction and communication are crucial in online learning, facilitating effective communication between students and educators and promoting engagement and interaction in online classrooms. Hands-on activities, as noted by Bustamante and colleagues (2018) and Fantuzzo and colleagues (2011), allow students to engage directly with content, thereby fostering both practical skills and language proficiency. Scaffolding mathematical discourse has also been highlighted as a successful approach in facilitating inclusive and linguistically rich classroom discussions (Banse et al., 2017). Collaborative learning and teamwork are particularly emphasized in bilingual settings too. Habók and Magyar (2020) illustrate how group work and the sharing of varied perspectives can enhance comprehension and foster critical thinking skills, an example of ATL. These strategies not only align with ATL principles but also support the metacognitive development of students.

To summarize, strategies that empirical research has shown to be effective for online mathematics teaching involve clear instructions, interactive activities, and synchronous engagement, set up collaboration activities all of which cater to diverse learning needs and preferences. These methods, grounded in interactive and student-centered approaches, not only

facilitate mathematical understanding but also contribute to the broader educational development of students in an online learning context.

Online Learning and Parental Autonomy Support. During COVID-19 pandemic, from 2020 to 2022, a significant challenge identified in online learning was the diminished support from parents, compared to the pre-pandemic period when physical schooling allowed more direct and continuous parent-teacher interactions (An et al., 2021). The reduction in parental involvement has been a critical issue, as various studies have underscored the significant impact of parental support on students' success in online education during the COVID (Fox, 2020; McCarthy & Wolfe, 2020; Novianti & Garzia, 2020). The comparative lack of parental engagement in the home learning environment can hinder student motivation and achievement, emphasizing the need for strategies to enhance parental support in times of remote schooling. The concept of parental autonomy support refers to the extent to which parents value and employ strategies that promote independent problem-solving, choice, and participation in decision-making (Bai & Gu, 2022). This type of support includes nurturing children's initiatives, adopting their viewpoints, providing options for choice, respecting their opinions and fostering engagement in problem-solving activities thereby enhancing their competence (Feng et al., 2019). Studies have shown a positive correlation between parental autonomy support and students' academic engagement (Boonk et al., 2018; Xu et al., 2018). The pandemic period, characterized by increased cohabitation durations between parents and students, presented unique opportunities for providing autonomy support (Bai & Gu, 2022). For example, in the absence of structured schedules, students might be prone to procrastination. Parents, recognizing this, can encourage and facilitate purposeful and effective time management strategies for their

children (Bai & Gu, 2022). However, to my knowledge, there are limited explorations into how parental autonomy support specifically affects bilingual students' online learning experience.

Despite the progress made in understanding teaching strategies and learning outcomes in online mathematics classrooms, there are limitations and gaps in the literature. Limited attention has been given to the bilingual students in online mathematics instruction, regarding their ATL. To fill this gap in the literature, the current study explores the specific ATL of bilingual students, what online teaching strategies have been used in supporting bilingual student, and the integration of parental support in home environment while bilingual students do online synchronous learning.

Section 3. Conceptual Framework

The conceptual framework for this study integrates Vygotsky's sociocultural theory, the Bilingual Advantage Hypothesis and an ATL framework to guide the investigation into the effective teaching strategies, ATL, and parental supports in online mathematics classrooms for upper-elementary bilingual students.

Vygotsky's Sociocultural Theory

Vygotsky's Sociocultural Theory posits that learning is a social process and knowledge is constructed through social interaction (Hoff, 2013, p.215). It highlights the necessity of creating interactive online environments where teachers employ scaffolding and modeling to facilitate learning, reflecting Vygotsky's assertion that knowledge construction occurs through social interaction. This approach underscores the significance of teacher and parental roles in supporting bilingual students, enabling them to navigate the challenges of learning mathematics online. By leveraging Vygotsky's theory, this investigation seeks to explore how tailored teaching strategies—such as interactive problem-solving, real-time feedback—alongside parental support manifested as active involvement in learning activities and act as elements in enhancing bilingual students' ATL. These strategies must be adapted to suit the digital learning environment, emphasizing the interaction between teaching methods and parental engagement to foster a conducive learning environment for ATL development.

The Bilingual Advantage Hypothesis

Bilingualism may confer cognitive advantages in areas of executive function, such as attention, inhibition, and task-switching abilities (Moore & Lorenzo, 2015). This hypothesis provides a theoretical lens for examining how bilingualism may influence the development and

employment of ATL in mathematical learning within online environments. It also informs the quantitative dimension of the study, wherein data from questionnaires are used to assess language proficiency and the learning habits associated with the use of English or the second language in online learning.

Approaches to Learning Framework

The five domains and ten clusters of ATL skills outlined by McKenzie (2016) offer a structured way to categorize and quantify the ATL strategies might employ by students. Figure 1 categorizes key learning skills into five main categories—Communication, Social, Self-Management, Thinking, and Research—each encompassing various clusters that contribute to student learning. For example, Communication focuses on Effective Communication through interaction, essential for expressing and interpreting information in dialogue. Social skills, such as Collaboration, highlight the ability to work cooperatively with others, while Self-Management covers Organization Skills for managing tasks and time, Affective Skills for dealing with emotions, and Reflective Skills for learning from experiences. Thinking is subdivided into Creative Thinking, encouraging innovation; Transfer Skills, applying knowledge in various contexts; and Critical Thinking, for critical analysis of information. Lastly, Research involves Information Literacy and Media Literacy, both crucial for effectively locating, evaluating, and utilizing information. The use of this ATL framework in the inductive analysis provides a theoretical scaffold that guides the discussion, allowing for a detailed examination of how specific ATL correlate with student success.

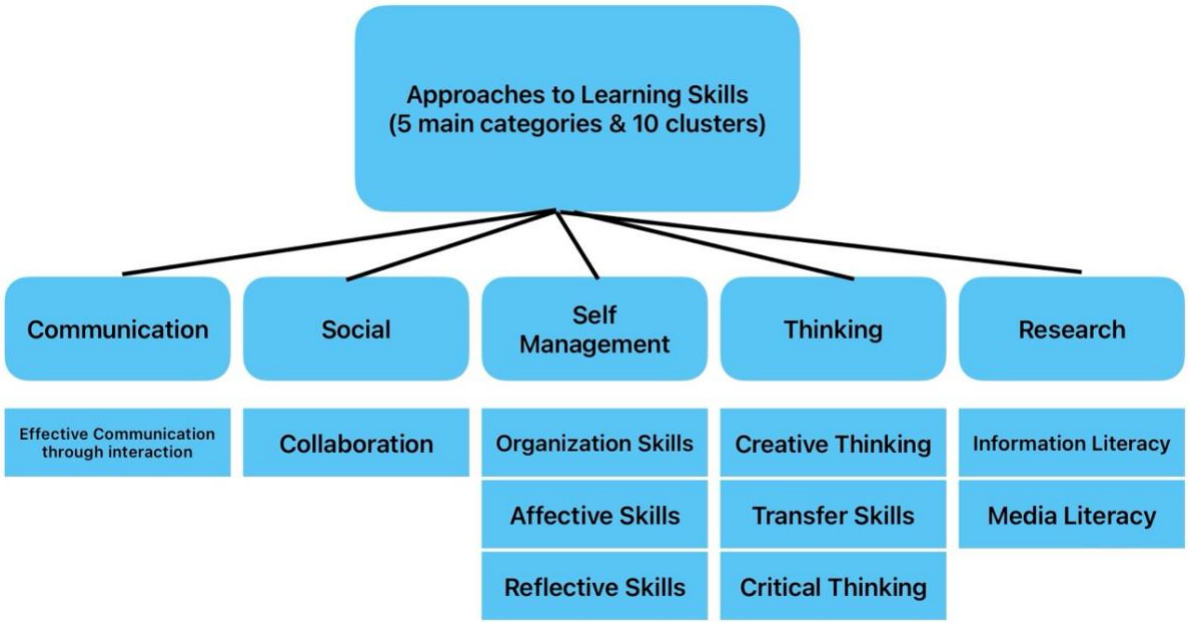


Figure 1. Framework of Approaches to Learning Skills (modified and adapted from McKenzie, 2016). (*Definitions of each cluster are included in Appendix B)

Given the problem statement and conceptual framework outlined above, the following are the research questions addressed in this study:

Research Questions

RQ1. What are the language skills and educational experiences of upper-elementary bilingual students in online math classrooms?

RQ2. What types of ATL do upper-elementary bilingual students develop and manifest in online mathematics learning enrionment?

RQ3. What teaching strategies are effective in cultivating upper-elementary bilingual students' ATL in online mathematics classrooms?

RQ4. How do parents support the development of their children's ATL during online mathematics instruction?

Section 4. Methodology

Research Site

The focus of this study was online mathematics classes conducted by the research site called Think Academy in the United States. Think Academy is an educational institution that provides after-school education and tutoring for students in primary and secondary school. One of their dedication is enhancing students' mathematical skills. The platform serves a broad student body, primarily from California, rest hailing from various locations including Asia, reflecting its affiliation with its well-known parent company, TAL Education, a leading private tutoring company from China. The stakeholders of Think Academy include students, parents, educators, and administrative staff, all committed to delivering high-quality education. The leadership team, comprised of experienced educators and administrators, drives the mission to create an engaging and effective learning environment. Parents and students typically learn about Think Academy through word-of-mouth recommendations, online marketing, educational fairs, and community events. They come to attend and participate in its programs through a straightforward enrollment process, often drawn by the academy's reputation for excellence and its ability to cater to the needs of bilingual and multicultural students.

A significant portion of the elementary-level students in this research site were primarily from Asian linguistic backgrounds including Mandarin, Vietnamese, and Japanese, who are classified as bilingual learners. For students in this research site, their bilingual language acquisition likely came from their family heritage, community exposure, and educational settings. These students, along with those from Mandarin-speaking households, created a dynamic and interactive learning environment. The interactions among students with various home language backgrounds were a vital aspect of the study, providing insights into how

bilingualism shapes their learning experiences and interactions in the online mathematics classes, taught in English.

An online classroom in this study referred to an online synchronous learning environment where students and teachers engaged in educational activities and interact remotely through the Think Academy invented digital platform (a downloadable app). In the online classroom, students‘ course materials, participation in chatbox discussions, collaborations with peers, and video conferencing received instruction from teachers, all conducted through internet-based technologies such as virtual class activity games. The online classroom setting provided flexibility in terms of time and location, allowing students to engage in learning activities from their homes or other remote locations. The academy offered a range of class sizes, with some virtual classes accommodating up to 20 students. In larger class settings, where there might be as many as 46 students, the teaching approach was divided among one content teacher and two supporting teachers. This structure allowed for more focused and tailored instruction, even in larger groups, which facilitated a more effective learning environment for bilingual students. Supporting teachers were able to give students online private talks during class time. Such varying class sizes and teaching formats presented a diverse range of interactions and educational experiences. The presence of additional teachers in larger classes also provided an opportunity to observe how different teaching roles and styles impacted student learning and engagement.

Participants

The study's participant sample comprised 153 students, with demographic information categorized by age and grade levels in Table 1. The majority of participants were ten to eleven years old (58.1%) and in the fifth grade (32.7%). Student assent to the study was collected before they completed the stuent questionnaire (See Appendix C).

Table 1. Demographic Information of Participants by Age and Grade (N=153).

Age	N	Percentage (%)	Grade	N	Percentage (%)
Eight - Nine	52	34.0%	Third	34	22.2%
Ten - Eleven	89	58.1%	Fourth	42	27.5%
Twelve	12	7.8%	Fifth	50	32.7%
			Sixth	27	17.6%

A selected subset consisting of five students and their respective parents is depicted in Table 2, all of whom engaged in further family interviews. Additionally, the five students' corresponding teachers are profiled in Table 3, all of whom engaged in further teacher interviews..

Table 2. Participating student-parent interviewees.

Students	Role	Country of Origin	Heritage Languages	Geographic Location	Study Level
S1	Daughter	United States	English & Mandarin	Seattle	Grade 5
P1	Mother	China	Mandarin	Seattle	/
S2	Daughter	United States	Mandarin	San Jose	Grade 4
P2	Mother	China	Mandarin	San Jose	/
S3	Son	United States	Cantonese	New York City	Grade 5
P3	Mother	United States	Cantonese	New York City	/
S4	Daughter	China	Mandarin	Shanghai	Grade 5
P4	Father	China	Mandarin	Shanghai	/
S5	Son	China	Mandarin	Shenzhen	Grade 4
P5	Father	China	Mandarin	Shenzhen	/

Coding conventions such as “S1” for Student 1 and “P1” for Parent 1, where P1 is the parent of S1, were maintained throughout the family interview context. Consistency was upheld with subsequent pairings; for instance, S2 with P2, and so on. These participants were integral to Think Academy's mathematics acceleration program, which prepares fourth and fifth-grade students, ages 10 to 12, for the American Mathematics Competitions 8 (AMC 8)—a distinguished annual examination designed to enhance and evaluate students’ problem-solving skills in mathematics. The selection of this subset of students was strategically based on the diversity of their online classroom attendance from various geographic locations, including three participants from different cities in the United States and two from China. The range of their heritage languages spanned Cantonese-English, or Mandarin-English bi-language. The data collection process complied with ethical standards set by the UCLA institutional review board.

The teachers from Think Academy, who were predominantly bilingual and mostly native Mandarin speakers adept at delivering an English curriculum, are profiled in Table 3.

Table 3. Participating teachers interviewees.

Teachers	Gender	Received their BA/BS from	Heritage Languages	Geographic Location	Teaching Level
T1	Female	United States	English & Mandarin	Seattle	Grade 4
T2	Female	United States	English & Mandarin	Boston	Grade 4
T3	Male	United States	English & Mandarin	San Jose	Grade 4&5
T4	Male	China	Mandarin	Beijing	Grade 4&5
T5	Female	United States	Mandarin	San Jose	Grade 4&5

These teachers were recruited through direct messages.The semi-structured teacher interviews were conducted in accordance with the protocol in Appendix D, and with assent noted in Appendix E. This professional cadre, designated sequentially from “T1” to “T5,” was proficient in surmounting potential linguistic barriers encountered during online instruction. These teachers’ educational backgrounds were varied, with four having completed their bachelor’s degrees in the United States and one, T4, in China. Although Think Academy's policy necessitated instruction in English, these five educators were equipped to provide bilingual support in supplementary after-class sessions. They were geographically dispersed, with locations spanning Seattle, Boston, San Jose, and Beijing. T1 and T2 were dedicated to teaching students in grade four, while T3, T4, and T5 imparted lessons to both fourth and fifth graders. This assembly of participants, selected for their linguistic and geographic diversity, provided a rich aspect for looking into the interplay between teaching strategies, bilingual student engagement and parental support in an online learning envrionment.

Positionality

While working part-time as an online mathematics instructor at Think Academy, I was captivated by the intricacies of students' language development and the unique at-home virtual learning experiences that students brought to their online learning environments. This motivated me to delve deeper into understanding how upper-elementary bilingual students navigate abstract math reasoning when faced with the challenges of online learning and language barriers. This interest led me to chart my master's thesis trajectory: focusing on how pedagogical techniques and familial support influence the 4th and 5th-grade bilingual students' development of their ATL.

As a native Mandarin and English speaker, my own linguistic abilities and heritage significantly shaped my approach to this research. During my fieldwork, I utilized both languages to take comprehensive notes, ensuring accurate capture of interviewees' interactions and language use. My bilingualism also facilitated effective translation and transcription processes, allowing for precise and culturally nuanced interpretations of the data. Having been both a teacher and a student, I feel a profound connection to the exploration of how educators can facilitate student growth in ATL. My bilingualism not only enhanced my ability to communicate with students and understand their perspectives but also enriched my interpretations of how language and pedagogy intersect to shape their learning experiences.

Procedures

This study adopts a mixed-methods design, incorporating quantitative data from an e-questionnaire alongside qualitative data from interviews with five teachers and five groups of families. The questionnaire was utilized to estimate students' language proficiency and learning

habits, offering a quantitative perspective on the student body's characteristics, answering RQ1. This information also serves as a foundation for the subsequent qualitative phase, informing the development of tailored interview questions that probe deeper into bilingual students' ATL development with a subset of the students, with their teachers and families.

RQ2 explored about types of ATL which they might employ based on the ATL framework in Figure 1 by collecting interview datas. Teacher interviews qualitatively address RQ3 by exploring the specific teaching strategies that educators employ to foster ATL in online mathematics classrooms. Teachers' experiences, methodologies, and reflections provide a rich narrative on the effectiveness of various teaching strategies from the pedagogical frontline. The e-questionnaire and family interviews offer insights into RQ2 and RQ4 by explaining the types of ATL bilingual students develop and how familial support structures contribute to this process. Parents' perspectives answered about the home learning environment, parental involvement, and the strategies families use to support their children's education during online learning. To accommodate linguistic preferences, all participants had the choice to respond in either Mandarin or English. Table 4 outlines the research questions and the corresponding data sets used to address each RQs.

Table 4. Research questions and methods mapping.

Research Question	Participant	Data sources			Data Analysis Plan		
		Questionnaire	Teacher Interview	Family Interview	Phase I	Phase II	Phase III
RQ1. What are the language skills and educational experiences of upper-elementary bilingual students in online math classrooms?	153 Students	X			DataVisualization	Exploratory data analysis: Descriptive Statistics (frequencies and proportions)	/
RQ2. What types of ATL do upper-elementary bilingual students develop in online mathematics learning?	S1		X	X	Initial Coding	Inductive Coding	Color coding with cross-case analysis
	S2		X	X			
	S3		X	X			
	S4		X	X			
	S5		X	X			
RQ3. What teaching strategies are effective in cultivating upper-elementary bilingual students' ATL in online mathematics classrooms?	T1		X	X	Initial Coding	Deductive Coding	Color coding with cross-case analysis
	T2		X	X			
	T3		X	X			
	T4		X	X			
	T5		X	X			
RQ4. How do parents support the development of their children's ATL during online mathematics instruction?	P1			X	Initial Coding	Deductive Coding	Color coding with cross-case analysis
	P2			X			
	P3			X			
	P4			X			
	P5			X			

Questionnaire Procedures

The student questionnaire, formulated and disseminated via Google Forms, was methodically designed to capture constructs related to online learning experiences, exploring the bilingual students backgrounds (RQ1). These constructs were derived from educational research literature, ensuring that the questionnaire items were rooted in established pedagogical frameworks and theories. Prior to distribution, the questionnaire underwent a piloting phase with a small group of children to confirm its age-appropriateness and comprehensibility, which was five of them. This preliminary testing phase was crucial in refining the questions for clarity and relevance. The finalized questionnaire, shared through WeChat to reach Mandarin-speaking students and parent groups, included sections on engagement, motivation, and language use in an online setting—key indicators as identified in recent studies on bilingual online education. Think Academy granted permission for this purposeful sampling approach, aimed at selectively recruiting participants who could provide relevant data aligned with the research questions(Ravitch & Carl, pp. 122). Responses were collected in the Fall of 2023, yielding insights into the students' perceptions of their online learning environment.

Interview Procedures

The development of the teacher's interview protocol was informed by the objectives of RQ3, focusing on eliciting detailed information regarding effective teaching strategies that foster ATL in online mathematics education for upper-elementary bilingual students. This structured protocol ensured that each interview systematically addressed the key aspects of RQ3 while allowing for the flexibility to explore emergent themes related to teaching practices. These teachers' interviews were video recorded to capture not only the verbal responses but also non-verbal cues like facial expressions and gestures, which can provide deeper insights into the

teachers' perspectives and experiences. The interviews were 30 minutes long on average and ranged from 25 minutes to 45 minutes.

To recruit these teachers, I initially identified a pool of 10 current teachers at Think Academy who taught 4th and 5th-grade students, ensuring they were directly relevant to the research focus. Selection criteria included their experience with online teaching, familiarity with the students involved in the family interviews, and willingness to participate in a video-recorded interview. I reached out to these teachers by messaging them individually, explaining the research's purpose, objectives, and the reason for video recording. Six teachers responded to my invitation. From these, I selected five teachers who specifically taught the students involved in the selected family interviews to ensure consistency and relevance in the data. Informed assent was obtained from each participant to ensure they were fully aware of the study's nature, the recording process, their rights, and the option to withdraw at any time.

Moreover, this study included a qualitative component consisting of five family interviews conducted via Zoom to explore students' and parents' perspectives on the online mathematics classroom. The interview protocol for these family sessions (See Appendix F) was derived from insights gained from the initial questionnaire data. Recruitment of family participants was conducted through two methods: (1) students indicating their interest for follow-up interviews by reaching out via WeChat or email after completing the questionnaire, which led to one family's recruitment, and (2) direct communication with parents of students I had previously taught, where four out of twelve approached families agreed to participate, five groups in total. For families not initially part of the questionnaire group, a request to complete the questionnaire was made before their interview to ensure uniformity in data collection. Informed consent was secured from all participants (referenced in Appendix G). The interviews,

which included three mothers and two fathers alongside their children, lasted an average of 53 minutes, ranging from 35 to 65 minutes.

Data Analysis Plan

Data were uploaded in text form in Google spreadsheet, which facilitated qualitative thematic analysis. The questionnaire responses served as a foundational tool for identifying potential participants and informing the development of the family interview protocol. On the right side of Table 4, I list the data analysis plan for the different data sources. Phase I, for the questionnaire analysis, Microsoft Word and R Studio were utilized to create data visualization result tables, including pie charts to display distributions of responses, including participant demographics, language proficiency levels, and experiences with online learning. These tables and visualizations were designed to succinctly organize and illustrate the percentage of responses to each questionnaire question, enhancing the interpretation of the data collected via Google Forms. In Phase II, descriptive statistics (frequencies and proportions) were used to interpret the visual representations of data, providing insights into student backgrounds.

Additionally, the qualitative analysis of the interview transcripts utilized a three-cycle thematic coding process, integrating inductive coding, deductive coding and color coding with cross-case analysis, as guided by Saldaña's *Coding Manual for Qualitative Researchers* (2021). This approach began with the transcription of 10 interviews, five teachers' and five families'. Phase I, the open coding was organized in a Google Spreadsheet. The effective organization and preliminary analysis of the transcripts also structured on the google spreadsheet. Phase II, the inductive coding, ATL categorizing codes were placed adjacently after the transcriptions, enabling an efficient comparison and synthesis of emerging themes. This format was pivotal in

bridging the exploratory insights from the open coding with the structured analysis provided by the ATL framework (see Figure 1). This was complemented by a more focused inductive approach, utilizing the ATL categorizing coding, derived from the Approaches to Learning Framework detailed in the Qualitative Codebook found in Appendix H.

As the analysis progressed from the initial coding to the inductive ATL categorizing coding, phrase 1 to phrase 2, it allowed for the aggregation of initial codes into broader categories that reflected the overarching narratives and patterns within the data. This categorizing phase was instrumental in aligning individual perspectives from students, teachers and parents under unified ATL skills. Teachers and Family pespctives were able to be deductively coded to different results. In Phase III, I utilized color coding to differentiate participants and link their responses to specific ATL skills within the spreadsheet. This method allowed the coding person to easily identify which interviewee's response illustrated the development of a particular ATL skill. Following this, a cross-case analysis was able to be conducted to examine patterns across the data sets.

The outcome of this analytical process was a coherent synthesis of the data around four research questions, articulated around the shared ATL categorizing codes, which provided a structured yet insightful understanding of the participants' experiences. This methodical approach ensured that the analysis was both grounded in the data and aligned with the theoretical frameworks underpinning the study, resulting in a detailed and insightful examination of the qualitative data collected.

Interrater Reliability

To enhance the rigor of the analysis, a second coder was trained on the codebook (See Appendix H). The coding team consisted of myself and a colleague with experience in qualitative data analysis, who joined the project to provide additional perspective and ensure robustness in the findings. The second coder's involvement began with a detailed training session where we discussed the codebook, coding scheme, and the objectives of the research. To calculate interrater reliability, two randomly selected subsets of the data, which included one teacher interview transcript (20%) and one family interview transcript (20%), were independently coded by the second coder. The percentage agreement (83%) was expressed as the number of agreements divided by the total number of agreements and disagreements combined. Discrepancies in coding were discussed and reconciled through collaborative meetings, where we reviewed the context and reasoning behind each code. The collaborative nature of the coding process helped ensure that the coding scheme was applied consistently and that the findings were trustworthy. By involving a second coder, we were able to cross-validate the interpretations and enhance the credibility of the data analysis. This teamwork and thorough discussion of discrepancies significantly influenced the analysis and interpretation, providing a more comprehensive and reliable understanding of the data.

Section 5. Findings

This study started with an in-depth exploration to investigate the relationships between the development of ATL among upper-elementary bilingual students and the influence of students, teachers, and families within online mathematics learning environments. The objective was to find targeted student group background, the types of ATL that students develop, distinguish effective pedagogical strategies, and evaluated the role of parental support in this online synchronous learning process. This empirical research drew upon a diverse range of data sources, including questionnaires completed by students, interviews with teachers, and family interviews.

RQ1. Students' Language Skills and Educational Experiences

The quantitative questionnaire data provided initial insights into the characteristics and experiences of the student group involved in this study. The questionnaire data revealed the characteristics and experiences of the student group involved. The Likert scale used in the questionnaire is defined as follows: 1 - Lowest rating (e.g., Beginner/Not Enjoyable at all/Never/Not Comfortable at all), 5 - Highest rating (e.g., Native/Extremely Enjoyable/Always/Very Comfortable). In Table 5, the majority of student participants self-assessed their English proficiency with high ratings, with 69% (N=153) of them positioning themselves at a near-native or native speaker level, as indicated by scores of 4 (0.37) and 5 (0.32). This suggested a strong foundation in English among the bilingual students, facilitating their engagement in online learning environments.

Table 5. Proportions of Student Responses on English Proficiency, Online Mathematics Enjoyment, Parental Assistance, and Language Switching Comfort (N = 153).

	Likert Scale (with proportion of students selecting each level)				
	1	2	3	4	5
Proficiency in English	(Beginner)				(Native)
	0.05	0.10	0.16	0.37	0.32
Enjoyment of learning mathematics online	(Not Enjoyable at all)				(Extremely Enjoyable)
	0.06	0.10	0.19	0.31	0.34
Frequency of seeking parents' help in home language for mathematics concepts	(Never)				(Always)
	0.07	0.16	0.20	0.26	0.32
Comfort with language switching during mathematics learning	(Not Comfortable at all)				(Very Comfortable)
	0.09	0.09	0.26	0.29	0.28

Additionally, the data reflected a positive disposition towards online mathematics learning, with the largest segment of participants expressing enjoyment at levels 4 (0.31) and 5 (0.34). This enthusiasm for online mathematics learning pointed to the effectiveness of the synchronous class in maintaining student interest and engagement. Furthermore, the questionnaire highlighted the significant role of parental support in the students' learning process, particularly in their home language. A considerable number of students often or always turned to their parents for help with mathematics concepts, with the most frequent responses being ratings of 4 (0.26) and 5 (0.32). This underscored the value of parental involvement in the

educational experiences of bilingual students. Equally important was the students' comfort with language switching during mathematics learning, with a majority (57%: ratings 4 and 5 combined) rating themselves as comfortable or very comfortable with this practice. Taken together, these findings painted a picture of a student group that was not only proficient in English and enjoyed the online learning format but also benefited from parental support and demonstrated adaptability in navigating linguistic challenges.

In Figure 2, language preference in learning mathematics also presented an important picture. While a quarter of the students defaulted to the language of the mathematics problems, a significant proportion prefered using their home language, suggesting a comfort level that may facilitate comprehension and learning. Only 17% of the participants primarily used English, indicating that while bilingual students might be navigating their courses in English, there was a notable reliance on their native language for processing complex academic content like mathematics. This reliance underscored the importance of supporting bilingual learners to also gain proficiency in mathematical English.

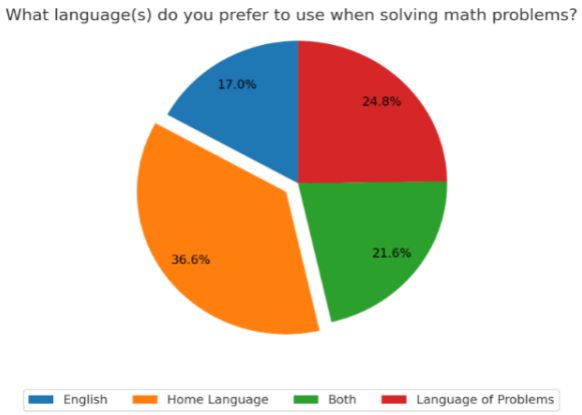


Figure 2. Language Preferences of Students when Solving Mathematics Problems (N = 153)

Figure 3 indicated that challenges in learning mathematics online were a common experience, with 1.3% of students facing all listed obstacles, including difficulty understanding

the teacher, online learning technical issues, and a lack of sufficient practice problems. This suggested that online mathematics education must evolve to address these barriers more effectively, perhaps through clearer communication, better at-home technical support, and more abundant practice opportunities.

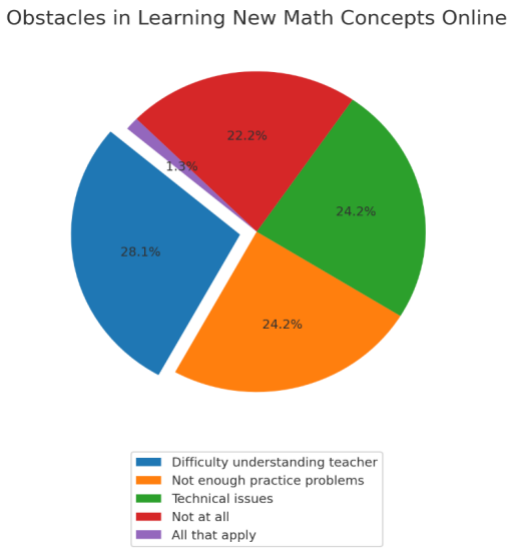


Figure 3. Challenges Faced by Students in Online Mathematics Learning (N=153)

In summarizing the quantitative findings, this aspect of the study provided essential insights into the demographics of the student cohort, students‘ language skills and obstacles they faces in online environment, laying the groundwork for deeper inquiry in subsequent research phases.

RQ2. ATL

This foundational knowledge from RQ1 had highlighted potential areas for further investigation through teacher and family interviews, particularly focusing on the intersection of home language use in learning mathematics and strategies to navigate the challenges of online learning environments. Questions explored the role of the home language in mathematics learning, and strategies to overcome obstacles in online mathematics education. Examples of interview questions added into the family interview protocols included: (1) In what ways do you support your child's understanding of mathematics concepts in both English and your home language? (2) Can you share how you've addressed any technical challenges that have arisen during your child's online mathematics learning? (3) What strategies do you find effective in helping your child practice and understand mathematics problems in an online setting?(See Appendix F)

The initial analysis suggested the development of a spectrum of ATL skills (See Figure 1) vital for online mathematics education through inductive coding, spanning Communication, Social Collaboration, Self-Management (Reflective, Affective, Organization Skills), Thinking (transfer skills, critical thinking), and Research (Information literacy, Media Literacy) (Mckenzie, 2016). These competencies highlighted the diverse strategies bilingual students employ in online learning contexts. According to the evidence of students' development in ATL during the online class, Student S1 discussed her ability to raise her hand to answer questions, discuss problems, use the chatbox for communication, and attend office hours. These activities contributed to the development of her communication skills. Student S3 identified his social collaboration development by stating,

"There would be about ten students. There weren't always a lot. There would usually betwo teachers, and then they would explain, and sometimes they would separate us into groups. We learned different stuff."

The evidence from Student S3 demonstrated the development of students' self-management and affective skills, particularly in dealing with frustration and maintaining confidence in challenging learning environments. His parent, Parent P3, explained,

"He complains because even though I registered him for the class, he was like, 'Mommy, I don't want to do this anymore because I don't get enough practice. I feel like I need more practice to understand deeper before they throw me into questions that I don't understand, and all of a sudden, it's another concept."

This highlights the student's struggle to manage emotions and the need for additional practice to build confidence. Specifically, it shows the student's need to regulate emotions, build resilience, and seek additional support to prevent discouragement and maintain confidence in their learning process.

There was also evidence illustrated the development of students' thinking skills, particularly in adapting to and utilizing new learning methods and technologies. The Parent P4 described a balanced approach to education at home, emphasizing both guided support and the development of students' independent learning. As the Parent P4 states,

"So I think the grid(schedule?) in our house is quite good, and sometimes you can see that he also recognizes it, and sometimes he also needs some independent time."

This balance allowed the student to develop critical thinking and transfer skills by navigating both online and offline resources independently. There are some trends that make us feel that there are a lot of learning resources. There are also some learning methods that have gradually become using Pad(electronic devices) facilitating learning, both offline and online, highlights the shift towards integrating technology in learning. This shift requires students to adapt their thinking skills to effectively use digital tools and access those diverse educational resources, enhancing their ability in thinking critically and learning autonomously.

Student S5 showed evidence about the development of research and information literacy skills by highlighting Student S5's proactive approach to problem-solving and resourcefulness in seeking information. Student S5 described his experience with trigonometric functions, noting that although they initially felt sleepy, engaging with the problems helped them stay alert and actively think. Student S5 stated,

> *"If the teacher doesn't explain a concept further during class, I would search for the question myself, possibly by taking a screenshot of it."*

This indicated that Student S5 took initiative in finding answers independently. Furthermore, when asked where they would seek help, Student S5 mentioned using search software to find answers, showcasing their ability to effectively utilize digital tools and online resources for learning. This behavior exemplified strong research skills, including the ability to identify information needs, locate relevant information, and critically evaluate sources to enhance their understanding of complex concepts.

Furthermore, the research provided revelations on teaching strategies that might enhance ATL development, addressing the RQ3. The analysis of student questionnaires and combined

responses from students and parents in family interviews had enriched the understanding of these strategies. By employing inductive coding within the ATL framework (referenced in Figure 1), the results illustrated on the RQ4, offering a deeper understanding of how parental supports were implemented and perceived in the online educational context fot bilingual students. Moreover, the significance of parental support emerged distinctly from the responses during family interviews, explaining its crucial role in enhancing students' ATL during online mathematics instruction at home, thereby further addressing the RQ4.

RQ3. Teaching Strategies

The third research question of the study centered on identifying effective teaching strategies that facilitated the cultivation of ATL skills. A suite of effective teaching strategies emerged through interviews with five experienced educators. These strategies are characterized by their dynamic adaptability and their focus on fostering active and engaging learning experiences, including Differentiated Instruction, Facilitate small group discussions, Pair-Up instructions, Assigning Memorization Tasks, Interactive Teaching, Regular checks for understanding, Encouraging peer assistance, Providing virtual whiteboard, Using online instructional media and On-pad educational games. Each teaching strategy was considered to help students in this study develop their ATL.

Differentiated Instruction allowed teachers to customize their methods to accommodate the diverse learning needs of students, especially Bilingual Instruction in this study. Teachers T2 and T5 highlighted the use of students' primary languages alongside English in teaching, which aided in understanding complex concepts. Switching between languages during instruction,

especially for key terminologies, had been instrumental in bridging the lexical gap for bilingual students (Tulloch & Hoff, 2022). Teacher T2 noted,

> *"Using both languages can be beneficial in aiding their understanding, especially when dealing with complex concepts. However, when teaching specific terminology or key concepts, I often switch to the language where they are more proficient."*

Addtionally, Teacher T5 noted,

> *"The main challenge is ensuring that all students, regardless of their language proficiency, can access the content synchronously in my flat online teaching board. To overcome this, I use a lot of visual aids and provide instructions in English but using mandarin as a learning "trigger." For example, I did bring some easy-remembering terms during lecture in mandarin though I gave the full lecture in English. Regular checking students' feedback and personalized support are also key in addressing individual challenges."*

Integrating language learning with math instruction and incorporating digital tools to enhance students' engagement and understanding is a dual-focus approach that helps in reinforcing both language and mathematical skill. Furthermore, Teacher T5 introduced teaching strategies based on storytelling and culturally relevant real-life scenarios, which significantly aided students' learning. Teacher T5 mentioned,

> *"When I connect math problems to stories from their own culture, students become more engaged and understand the concepts better. For example, using traditional festivals to explain fractions really made a difference."*

Another Instructional strategy cited by Teacher T2 in fostering student communication skills included the use of breakout rooms to facilitate small group discussions on class-related topics. *Facilitating Small Group Discussions* enabled students to collaborate and engage deeply with the material. For the interviewee student who corroborated this approach (Student S1), she stated that, *"teachers would divide them into subgroups to deliberate on guided questions."*

The online platform provided opportunities for students to engage in collaborative exchanges and demonstrate communication skills by sharing their thoughts through the virtual classroom's chat feature. This integration of technology-enhanced collaborative spaces reflects an online-only feature to nurture social interaction and collective problem-solving among students in a digital learning environment. Instructional strategies cited by teachers in fostering this skill included the use of breakout rooms to facilitate small group discussions on class-related topics. Student S3 also corroborated this approach, noting that even in classes of ten, teachers would divide them into subgroups to deliberate on guided questions.

In the cultivation of students' ATL skill in the domain of Thinking – Transfer Skills, evidence emerged of students applying previously learned skills to novel and diverse contexts, a critical component of mathematical reasoning. Teacher T1 discussed employing strategies such as assigning memorization tasks beyond the classroom, for example, reciting multiplication tables in Chinese syllables. *Assigning Memorization Tasks* helped students retain important information and concepts. This method leverages the unique features of the language to aid in memorization and enables students to apply these memorized facts to tackle new problems presented in English, thereby practicing and enhancing their Thinking – Transfer Skills. Student

S1 echoed this approach, having experienced a blend of English and Mandarin in learning sessions facilitated by her father:

"Here, if you look carefully, this is my dad's work. He uses mostly English threaded with Chinese. So he usually just says "a" and "b" in English. It's interesting. We were working on this 24th AMC (American Mathematics Competitions) problem, and in the end, we actually figured out how to solve it. The mix of languages helped me understand the problem better and memorized the solution. When I didn't get something in English, my dad would explain it in Chinese, and that made it click."

This bilingual instructional strategy cultivated Student S1 to develop and engage their Thinking – Transfer Skills and her father would able to go further with her after-class. Such feedback highlighted how students navigating and assimilating mathematical concepts under parental support through teacher's assigning homework effectively enhanced their cognitive processing and problem-solving abilities.

The subsequent component within the Thinking series of ATL skills focuses on Critical Thinking. Student S2's development in this area was notably facilitated by the teacher's strategy of permitting her to annotate on the virtual whiteboard. This *interactive teaching approach* allowed the student to engage actively by writing, drawing, or making notes directly on the screen, thereby enhancing her ability to critically analyze and synthesize information.

Data from this study also highlighted the development of Self-Management ATL skills, including Reflective, Affective, and Organizational skills. Teaching strategies aimed at fostering Reflective skills involved two teachers prompting students to articulate solutions presented in the online classroom and *regularly encouraging them to check for understanding* by affirming their comprehension of new concepts through gestural feedback, such as thumbs-up or thumbs-down

signs. Teacher T2 demonstrated these gestures during our interview, illustrating their practical application. Further reflective engagement was evidenced by students being encouraged to inquire discreetly by raising a virtual hand or typing questions into the chatbox, a method suitable for fourth and fifth graders and endorsed by Teacher T2 for its effectiveness in the online setting. Student S1 also collaborated on this approach, explaining:

"You can actually raise your hands. You can raise your hands when you want to by pressing the button. In an online class, you have more freedom because you have this chat box. So, I can talk to the teacher even when I'm not raising my hand. Sometimes it helps if you have an original question. Like if you have to leave the classroom early, you can catch up in the chat box or raise your hand again.

Besides, Teacher T4 highlighted the nurturing of Affective skills, guiding students to embrace the learning opportunities presented by mistakes and to view bilingualism as an asset. T4 elaborated:

"I always encourage my students to see their mistakes as part of the learning process. We discuss how being bilingual can give them unique advantages in problem-solving and adapting to new challenges. It's about building confidence and showing them that their language skills are a strength, not a barrier."

This approach aligns with the Bilingual Advantage Hypothesis posited in this study, which suggests that bilingualism may enhance executive functions like attention, inhibition, and task-switching (Moore & Lorenzo, 2015).

The development of students' *Organizational skills* is particularly highlighted. Both Teacher T1 and Teacher T2 noted that the completion of class assignments on the *virtual whiteboard* hinges on the students' ability to effectively manage and organize their resources. Student S4 corroborated this, reflecting on instances where she had to strategically coordinate the use of her textbook and draft paper to address new problems displayed on the screen. Moreover, the process of *capturing and submitting photographic evidence of her completed work* via a virtual application further underscores the reliance on and the cultivation of robust Organizational skills. This sequence of tasks—spanning the preparation, execution, and submission of assignments—illustrates the practical application and significance of organizational aptitudes in the context of an online learning environment. Parent P4 added an evidence into this learning process. Parent P4 emphasized the importance of structured routines and time management strategies to help students stay organized at home. Parent P4 stated,

"I implemented daily schedules and checklists to help S4 manage her tasks and deadlines for her online learning programs. This not only improved her organizational skills but also her overall academic performance. Encouraging S4 to keep her learning materials and workspace organized has made a significant difference in their ability to focus and complete assignments efficiently."

This structured approach to enhancing Organizational skills has proven effective in fostering a more disciplined and productive learning environment. These narratives collectively underscore the multifaceted nature of Self-Management skills development in the context of online learning with teacher and their parents, revealing the essential role of teacher-facilitated strategies and parental support in fostering these ATL skills.

Within the Research domain of ATL skills, encompassing Information and Media Literacy, cognitive flexibility was highlighted as a significant asset by Teacher T5. Teacher T5 touched upon the development of Digital Literacy, emphasizing the integration of **interactive media tools** within the virtual teaching platform. Teacher T5 stated,

"For bilingual students, especially at the upper-elementary level, the key skills are quite multifaceted. Firstly, language comprehension is crucial; they need to understand mathematical terminology in both their native language and in English. Secondly, cognitive flexibility is important—being able to think about concepts in two languages enhances their problem-solving skills. Lastly, digital literacy is essential in the online environment."

These three skills—language comprehension, cognitive flexibility, and digital literacy—together form a comprehensive foundation for bilingual students' success in online mathematics learning. Understanding mathematical terms in both languages allows students to grasp concepts more fully, while cognitive flexibility enables them to approach problems from multiple perspectives. Digital literacy ensures they can effectively navigate and utilize online learning tools, making the overall learning experience more accessible and productive. Student S5 resonated with this perspective, noting the variation in understanding when seeking solutions through instructional media. Student S5 stated,

"When I watch Mandarin-speaking tutorial videos with English subtitles, like the one describing how pi was discovered and how Chinese ancestors used it, I understand the concepts better. If I don't get it in one language, I can rely on the subtitles to help me figure it out. My teacher can always find a video that illustrates the topic and concept clearly."

Another example provided was the use of *on-pad educational games* that reinforce mathematical skills; successful completion of one level would unlock the subsequent one, thus engaging students in a progressive learning experience. On-Pad Educational Games were integrated to make learning more engaging and enjoyable in online teaching, leveraging technology to create a fun and interactive educational experience.

In summary, Teachers employed various strategies to engage students and foster ATL development: utilizing engaging pedagogical materials and activities; addressing the distinctive lexical needs of bilingual learners; facilitating small group dialogues through breakout rooms; assigning memorization work; applying storytelling and culturally relevant situations; encouraging active confirmation of concept comprehension; endorsing the value of bilingualism; allowing for digital annotation; providing access to illustrative educational videos and motivating students' learning interests through on-pad educational games. These methods were instrumental in enhancing the students' ATL proficiency.

RQ4. Parental Support.

Parental contributions were varied and significant. Interviews revealed that all five parents played a crucial role in helping students adjust to online education and overcomed technological challenges. Parents often acted as both tech support and bilingual facilitators, helping their children navigate devices, connected with online teachers, and accessed content. This parental support system createed a dynamic learning environment that enhanced the ATL skills essential for the academic and personal growth of bilingual students in their online learning. Key forms of parental support include Language Support, Hands-on Guidance,

challenging children with advanced problems, and a Hands-off approach to students' self-learning.

Parental support, particularly in the form of **language support,** played a crucial role in helping a bilingual child navigate the abrupt transition to online learning during the COVID-19 pandemic. Parent P2 reflected on the initial challenges her child faced with English content in online mathematics classes. The sudden shift to remote learning disrupted routines and created difficulties such as internet instability, a lack of social connections, and a lack of instant English instruction. With Mandarin as the family's home language, the language barrier added another layer of complexity. Parent P2 shared,

"So the language barriers or challenges that bilingual children have faced while learning math in online classrooms, for S2, she started online learning in first grade when her English was better than Chinese at the time, actually already very good. Because it was the beginning of the covid at that time, their school turned to online learning at that time. Then the math at that time was also online learning, and my child thought it was okay at that time, and then she would start to feel a little challenge. I had to follow her all the time. Online is a bit harder because sometimes the teacher speaks very fast and doesn't stop. She needs me to explain it to her. I communicated with her in a language she could grasp, aiming to facilitate comprehension, with the hope that this was a transient issue and she would swiftly acclimate."

This statement highlights the transitional nature of language barriers and the critical role of parental support in fostering the development of ATL skills within a bilingual educational setting. Also, through parental **hands-on guidance** in familiarizing the student with the instructional steps provided by the online teacher, the student quickly adapted, acquiring the Thinking – Transfer Skill necessary for assimilating new knowledge. In this process, students

experienced concurrent development in language skills alongside their mathematical understanding, highlighting the interdependence of linguistic proficiency and cognitive growth in academic disciplines (Wilkinson, etal., 2020).

In addition, parental support also facilitated students' improvement in thinking skills by **challenging them with advanced programs**. Parent P3 said that when her child first started learning math lessons at Think Academy, he needed to "go through a bridge" to connect his past understanding from a local school to more advanced material. At the same time, Student S3 expressed a need for additional practice to deepen understanding before progressing to complex questions, highlighting a tension between the desire for mastery and the pace of curriculum delivery. This sentiment was mirrored by Parent P3, who recognized the quality of the program and its content but expressed concern over the potential impact on the child's confidence in mathematics. This approach underscores the importance of balancing advanced challenges with adequate support to ensure students' growth and confidence. Parent P3 shared,

"Yes, but I want him to... He complains because even though I registered him for the class, he was like, Mommy, I don't want to do this anymore because I don't get enough practice. I feel like I need more practice to understand deeper before they throw me into questions that I don't understand, and all of a sudden, it's another concept."

Another key finding was the role of parents in fostering academic resilience by challenging their children with complex tasks while supporting their mathematical confidence. This approach supports the development of critical ATL skills by encouraging students to tackle difficult problems and persevere through challenges. Parents also valued the online platform for providing access to high-quality educational resources that were not available locally, which

further supports the development of ATL by exposing students to superior learning materials and instructional methods. Parent P4 highlighted this benefit, saying,

"The quality of learning materials we can access online is much higher than what we get locally. This environment provides my child with access to exemplary teaching resources, enhancing their educational opportunities."

This shows how parents appreciate the superior quality of online educational resources and their positive impact on their children's learning, thereby supporting the development of their ATL skills during online mathematics instruction.

Besides, Parent P1 stated that the ability of managing technology had been a beginning lesson for any student who accessed online learning. Students needed to have the skills to manage their own schedule, go to class on time, and be able to submit their after-class homework by using web services. Parent P1 remarked,

"At first, it was challenging for my child to navigate the online platform independently, but over time, she learned to manage her own schedule and complete assignments on her own."

This **Hands-off Approach to Self-Learning** allows children to learn independently, fostering autonomy and self-directed learning skills.

In conclusion, RQ3 explored the diverse roles parents played during the transition to online learning, particularly for bilingual students. This support was crucial, especially during the COVID-19 pandemic when many parents struggled to maintain the same level of engagement as during in-person schooling (Fox, 2020). Initially, parents provided essential bilingual support, helping their children understand educational content in English despite the

lack of face-to-face teacher interaction. As students adjusted to the online learning environment, parents employed hands-on guidance strategies to familiarize their children with necessary technology, such as laptops, computers, and iPads. This not only facilitated technological proficiency but also encouraged students to become independent learners. Additionally, parents appreciated the online platform for providing access to high-quality educational resources that might not be available locally, thus offering challenging learning materials. This access is particularly beneficial for bilingual students, enhancing their learning opportunities and exposure to comprehensive educational content. Moreover, parents fostered academic resilience by challenging their children with complex tasks while nurturing their mathematical confidence. This careful balance helped maintain student engagement and motivation through difficult concepts and assignments. Furthermore, some parents adopted a hands-off approach to self-learning, allowing their children to develop autonomy and self-directed learning skills.

Section 6. Discussion

The quantitative data from the study reveals several critical insights into the demographics and learning experiences of the bilingual student participants (RQ1). A significant majority of the students rated their English proficiency as near-native or native, indicating a strong linguistic foundation that supports their engagement in online learning environments. This proficiency likely contributes to their enjoyment and effectiveness in online mathematics classes, as evidenced by the high levels of enjoyment reported. Additionally, the frequent reliance on parental assistance for understanding mathematics concepts underscores the importance of family involvement in the educational process, particularly in using the home language to enhance comprehension. The students' comfort with language switching during mathematics learning reflects their adaptability and cognitive flexibility, essential skills in bilingual education. However, the preference for using the home language in learning mathematics, as opposed to English, highlights a potential area for educational support, ensuring that students can navigate complex academic content in both languages. Despite the generally positive experiences, the presence of challenges such as technical issues and insufficient practice opportunities indicates areas where online mathematics education could be improved. Therefore, this initial exploration sets the stage for a deeper qualitative inquiry, which provided rich, detailed insights into the specific ways in which ATL skills were reported to be used by a subset of students and supported by their teachers and parents.

The guiding questions in the interviews were designed to explore how students' home language impacts their mathematics learning and to identify strategies families use to navigate the challenges of online education, particularly in developing ATL skills. The subsequent qualitative analysis of interview transcripts was categorized according to the ATL skills

framework. Regarding RQ2, both the literature review and the study's results highlight the importance of active engagement, collaboration, and critical thinking, fostered by persistence, intrinsic motivation, and attention management. Peer tutoring and effective communication, as noted by Cadiero-Kaplan and Rodríguez (2008) and Chu et al. (2017), also play significant roles. These factors align with the ten ATL skills identified in this study (see Figure 1). These skills include Communication, Social Collaboration, Self-Management (Reflective, Affective, and Organizational skills), Thinking (transfer skills and critical thinking), and Research (Information and Media Literacy). These skills provide a comprehensive framework for bilingual students' ATLs in the digital learning environment.

The qualitative components of the study advanced the research by systematically coding the interview transcripts into categories corresponding to the ATL skills. Furthermore, the data revealed teaching strategies that may foster the development of ATL (RQ3), as discussed in the teacher interviews. It also underscored the improtant role of family support in cultivating these competencies among students (RQ4). By integrating both quantitative and qualitative data, the study was able to provide multifaceted perspectives on the online learning experiences of upper-elementary bilingual students.

Table 6 outlines the influences on ATL by highlighting specific teaching strategies and the role of parental support. It listed various ATL skills from the framework presentend in Figure 1 (McKenzie, 2016) and aligned teaching methods and parental involvement from the results of this study. For instance, effective communication is fostered through differentiated instruction also facilitate small group discussions from teachers and language support from parents, while critical thinking is developed via interactive teaching and challenging children with advanced problems by parents.

Table 6. Influences on ATL: Teaching Strategies and Parental Support.

ATL types (Figure 1)	Teaching Strategies (RQ3)	Parental Support (RQ4)
Communication - Effective Communication through interaction	Differentiated Instruction	Language Support
	Facilitate small group discussions	
Social - Collaboration	Pair-up instructions	
Thinking - transfer skills	Assigning memorization tasks	Hands-on Guidance
Thinking - critical thinking	Interactive teaching	Challenging children with advanced problems
Self Management - Reflective Skills	Regularly checks for understanding	
Self Management - Affective Skills	Encouraging peer assistance	
Self management - organization skills	Providing virtual whiteboard	Hands-off Approach to self-learning
Research - information literacy	Using online instructional media	
Research - Media Literacy	On-pad educational games	

With regard to RQ3, teachers employed a variety of strategies to engage students and foster ATL development. They utilized dynamic and interactive pedagogical materials to capture students' interest and addressed the specific vocabulary needs of bilingual learners through tailored lexical support. Interactive dialogue facilitation, such as using breakout rooms for small group discussions, helped students engage more deeply with the content (See Column 2, Table 6). Memorization work was assigned to reinforce key concepts, and storytelling with cultural relevance was incorporated to make learning more relatable and engaging. Additionally, teachers encouraged active confirmation of concept comprehension through gestures and feedback, emphasizing the value of bilingualism in learning. Digital annotation tools were used to enhance understanding, and illustrative videos were provided to explain complex concepts visually. On-pad educational games were employed to motivate students and make learning fun. These

strategies were instrumental in enhancing the students' ATL proficiency by providing a comprehensive and supportive learning environment. By integrating these methods, educators were able to address the unique needs of bilingual students, making learning more engaging and effective.

RQ4 explored the multifaceted involvement of parents during the shift to online education. By bridging the language gap, parents enabled their children to better grasp complex concepts, thereby enhancing their overall learning experience. They also facilitated technological adaptation, ensuring students could effectively engage with online learning tools, which promoted both digital literacy and independence (See Column 3, Table 6). Access to high-quality online resources, appreciated by parents, highlighted the potential for online platforms to bridge educational gaps, offering students opportunities that might be unavailable locally. Moreover, parents fostered academic resilience by balancing challenging tasks with support, thereby nurturing their children's confidence and perseverance. Also, the adoption of a hands-off approach by some parents to encourage self-directed learning was crucial for developing autonomy and critical life skills. These insights illustrate the adaptive nature of parental support.

Implications for Future Research and Educational Practice

The results of the four research questions highlight several important implications for both research and educational practice. A significant area of future research is conducting comparative studies between bilingual students and monolingual students in online study environments. These studies would identify key differences and similarities in ATL skill development and their effects on learning outcomes, offering a deeper understanding of linguistic influences on learning. Another critical area is investigating the impact of generative AI tools on students' digital learning environments. Understanding how these advanced

technologies influence ATL skill development, student engagement, and academic performance could provide essential guidance for effectively integrating AI tools in educational practices.

Additionally, examining the longitudinal effects of the identified ATL skills on students' mathematics achievement in online settings is recommended. By understanding how these skills evolve over time and their impact on long-term academic success, targeted interventions can be developed to enhance student outcomes. Investigating the specific pathways through which ATL skills are cultivated and applied could also offer valuable insights into the mechanisms driving these skills. Together, these research directions can inform both policy and practice, ultimately contributing to more effective and inclusive online learning environments for bilingual students in particular.

In terms of educational practice, educators and curriculum designers could incorporate the key teaching strategies along with cultivating ATL skills into the design and implementation of online math courses. Professional development for teachers could focus on creating strategies to effectively develop those ATL in a digital classroom. This could include training on the use of digital tools to create interactive and engaging learning experiences tailored to the needs of different groups of students. Think Academy’s position within the broader educational space underscores the need for online teaching institutions to provide comprehensive support systems that address both academic and technological challenges faced by students.

Parental involvement also emerges as a critical area for practical action. Schools and online educational platforms should create resources, flyers, or workshops to empower parents to support their children's learning effectively. This might involve providing guidance on how to use educational technology and strategies to support bilinguals’ learning at home. Recognizing

the unique challenges faced by bilingual families, these initiatives should be accessible in multiple languages and sensitive to different cultural contexts.

Lastly, the appreciation parents expressed for access to high-quality educational resources indicates a demand for equitable educational technology. The importance of access to high-quality educational resources, particularly for bilingual students, cannot be overstated. By integrating these implications into ongoing educational practices and research agendas, the field can advance towards an educational model that not only accommodates but also leverages the strengths of different kinds of students in an increasingly digital world.

Limitations of this study

There were several limitations to this study in data collection methodologies, and the scope of the investigation. First, the initial plan to incorporate class observations as a primary method for gathering real-time data on teaching and learning interactions in online mathematics classrooms had to be abandoned due to restrictions on accessing the digital teaching and learning platform. The absence of observational data limits the depth of insight into the immediate responses and interactions between teachers and students during the online learning process, which could have provided a richer, more insightful understanding of the effectiveness of teaching strategies and student engagement.

Second, the design of the questionnaire may have introduced biases or inaccuracies in capturing the linguistic background and proficiency of the participants. The assumption that respondents possessed basic English proficiency for daily communication might not accurately reflect the diversity of language skills among the participants. The questionnaire's design, with a proficiency scale from 1 (basic) to 5 (native), and the lack of stringent criteria for defining home

language versus second language and English, may have affected the accuracy and reliability of the data regarding participants' self-assessed response on English proficiency.

Third, the study's focus is on upper-elementary bilingual students within a specific educational context. This group primarily consists of students who are bilingual in Mandarin and English, learning in an online mathematics program. While this allows for a detailed exploration of their unique experiences and needs, it may not fully represent the challenges and strategies applicable to bilingual students of different age groups, linguistic backgrounds, or educational contexts. Additionally, the sample size, although sufficient for an initial investigation, may not capture the full range of experiences and effective teaching strategies in varied educational settings. For instance, younger bilingual students or those speaking different heritage languages might face distinct challenges and benefit from different pedagogical approaches. This limitation suggests caution in applying the study's conclusions beyond the specific context and demographic examined.

Moreover, in the qualitative procedures, the manner in which the interviewer is introduced influences the results in various ways. When I interviewed former students, there was a risk of bias due to pre-existing relationships, which needed to be carefully managed and acknowledged in my analysis. For new students, the lack of a prior relationship meant that building rapport took longer, potentially impacting the depth of information shared in initial interviews. However, this also offered a fresh perspective and could yield unbiased, genuine responses that are crucial for the authenticity of the research. Being mindful of these dynamics was essential for conducting the study and interpreting the data collected.

The findings from this study contribute to the ongoing discussion on optimizing online learning environments for bilingual students. The effective teaching strategies identified

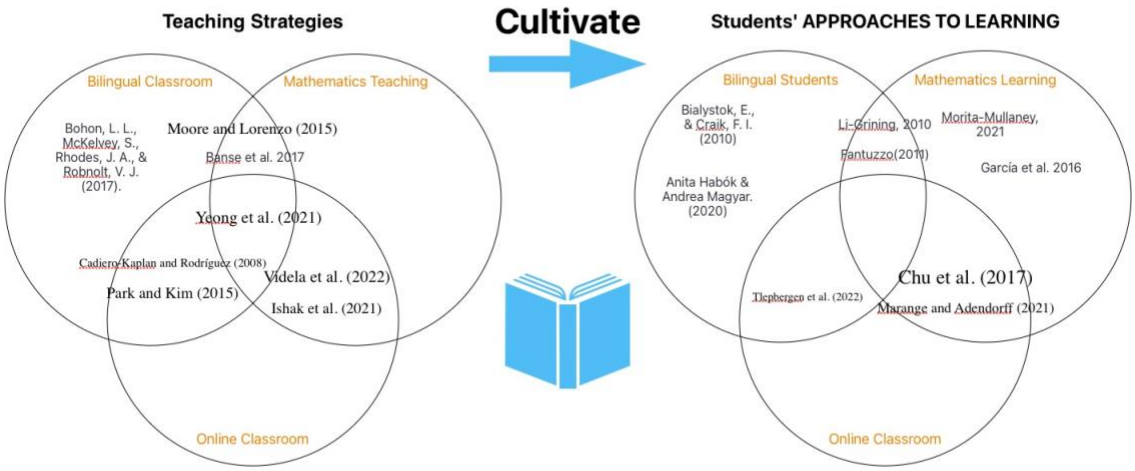
underscore the necessity for adaptive approaches that cater to the needs of bilingual learners. These strategies align with broader educational goals of inclusivity and accessibility, emphasizing the importance of real-world relevance, personalized learning experiences, and the development of ATL skills. Moreover, the study highlights the role of parental involvement in supporting online learning. The collaborative effort between educators and parents is essential for creating a supportive learning ecosystem that encourages the development of students' learning. This partnership can be especially crucial in online settings, where direct teacher-student interactions are limited, and learning is more self-directed and removed from teacher direct monitoring. Future research should aim to address limitations by incorporating larger, more diverse samples and continue to employ mixed methods approaches to combine the depth of qualitative insights.

Section 7. Conclusion

This study explored the development and application of ATL skills among upper-elementary bilingual students in an online mathematics learning environment, focusing on the diverse roles played by teachers and parents. Through a mixed-methods approach that combined quantitative questionnaires and qualitative interviews with teachers and family groups, the study provided a comprehensive understanding of how ATL skills such as communication, social collaboration, self-management, thinking, and research abilities are cultivated and applied. The findings highlighted the importance of bilingual support, dynamic pedagogical materials, and a balance between hands-on and hands-off guidance in fostering students' academic resilience. By incorporating these insights into educational practices and research, educators may develop models that accommodate and leverage the strengths of diverse student populations, thereby enhancing the overall quality and inclusivity of digital education.

Appendixes

Appendix A : Literature Review Map



Appendix B : Definitions of the Ten Clusters Within Approaches to Learning Skills

Communication: Effective Communication through interaction	• Use a variety of media to communicate with a range of audiences. • Use a variety of speaking techniques to communicate with a variety of audiences. • Share ideas with multiple audiences using a variety of digital environments and media. • Organize and depict information logically.
Social Collaboration	• Collaboration in learning encompasses working together constructively to achieve shared goals, leveraging individual strengths for collective success.
Self Management Organization Skills	• Plan short- and long-term assignments; meet deadlines. • Create plans to prepare for summative assessments (examinations and performances). • Use appropriate strategies for organizing complex information. • Select and use technology effectively and productively.
Affective Skills	• encompass the emotional components of education, focusing on the management of feelings, motivation, and attitudes. • recognizing, understanding, and effectively managing one's emotions, fostering empathy and respect for others, and nurturing a positive mindset toward learning and personal growth.
Reflective Skills	• Reflective skills in learning involve the thoughtful analysis of one's own knowledge, experiences, and actions

	to continuously improve understanding and performance. • requires a conscious effort to think about, question, and assess one's learning processes, decisions, and outcomes, leading to deeper insights and personal growth.
Thinking Creative Thinking	• The ability to think outside the box, generate original ideas, and approach problems in novel ways. • Cognitive processes, including ideation, innovation, and the ability to view situations from multiple perspectives.
Transfer Skills	• The ability to apply knowledge, skills, and understanding learned in one context to new contexts. • This skill set is crucial for adaptive learning, enabling individuals to recognize the relevance of their acquired abilities in various situations and adapt them to solve different problems or tackle unfamiliar challenges.
Critical Thinking	• the ability to engage in clear, reasoned thinking, and apply logical and analytical reasoning to various situations. • questioning assumptions, evaluating evidence, discerning hidden values, identifying inconsistencies, and assessing conclusions. • Critical thinkers are not only skilled in analyzing the validity of arguments but also in synthesizing information and making informed decisions based on their analysis.
Research Information Literacy (more advanced)	• the ability to recognize when information is needed and to locate, evaluate, effectively use, and communicate information in its various formats.

	• Information literacy goes beyond traditional literacy and encompasses the analytical and critical thinking skills needed to navigate the vast landscape of information sources available in the digital age.
Media Literacy	• the ability to access, analyze, evaluate, create, and communicate using all forms of communication. • understanding how media messages are constructed and for what purposes, recognizing the roles of media in society, and using media thoughtfully and effectively. • Media literacy empowers individuals to be critical thinkers and makers, effective communicators, and active citizens in a digital age where media is pervasive.

Appendix C: Students' Questionnaire Protocol

Student Assent Script in a Research Study
My name is Le Rosie Xiu, and I am a researcher at UCLA. I'm conducting a study to explore **the learning approaches and strategies of bilingual students like you in online mathematics classrooms**. Your insights would help us understand what teaching methods are most effective and how we can enhance the learning experience for all students. By participating in this short, **8-minute questionnaire**, you'll be contributing valuable information to our research. Please know that your participation is entirely voluntary, and you can choose to **stop** at any time without consequences. Rest assured, your responses would remain confidential, with all identifying information removed during data analysis.

If you understand the purpose of this study and agree to participate, **please click "Next" to begin.** If you have any questions or choose not to participate, you can simply close this form. Thank you for considering this opportunity to contribute to our understanding of online mathematics classrooms for bilingual kids.
If you have any questions or concerns about this study, please feel free to contact me at my Phone Number: (206) 569-8865 or Email: xiul@ucla.edu.

Title: After-Class Questionnaire for Bilingual Students in an Online Mathematics Classroom

Objective: To gather information on students' learning approaches and experiences in an online dual-language mathematics classroom, in order to investigate students' learning approaches.

Age Group: 9-12 ages old students

Instructions: Please take a few minutes to answer the following questions about your experiences in the online dual-language mathematics classroom. Your answers would help us understand how you learn and how we can improve the learning experience.

1. How do you feel about learning mathematics in an online classroom? Please rate your experience on a scale of 1 to 5, with 1 being "not enjoyable at all" and 5 being "extremely enjoyable."
   ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

2. What kind of obstacles do you face while learning new mathematics concepts in the online classroom?
   a) Language barriers
   b) Difficulty in understanding the teacher's explanations
   c) Not enough practice problems
   d) Technical issues with the online platform
   e) Other
   f) All that apply

3. Which of the following teaching strategies helps you learn mathematics the best in the online classroom?
   a) Teacher's step-by-step explanations
   b) Interactive activities and games
   c) Group discussions with classmates

d) Watching videos or animations

4. What language(s) do you prefer to use when solving mathematics problems?
   a) Language 1: English
   b) Language 2: home language
   c) Both languages
   d) It depends on the problem

5. How do you usually learn new mathematics concepts in the online classroom?
   a) I listen to the teacher's explanations.
   b) I take notes and review them later.
   c) I watch videos or read books about the topic.
   d) I ask my parents for help.
   e) Explaining to a classmate

6. When you find a mathematics problem difficult, what do you do?
   a) I try to solve it on my own.
   b) I ask the teacher for help.
   c) I ask my parents for help.
   d) I discuss it with my classmates.

7. How often do you ask your parents for help in your home language when you have difficulty understanding the mathematics concepts?
   a) Never
   b) Rarely
   c) Sometimes
   d) Often
   e) Always

8. How do you feel when you have to switch between languages while learning math? Please rate your level of comfort on a scale of 1 to 5, with 1 being "not comfortable at all" and 5 being "extremely comfortable."
   ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

9. When you learn new mathematics concepts, how do you relate them to previous topics you have learned?
   a) I try to find connections between the new and old concepts.
   b) I memorize the new concepts without relating them to old ones.
   c) I use examples from real life to understand the new concepts.
   d) I don't relate the new concepts to old ones.

10. Do you have any additional comments or concerns about your experience in the online mathematics classroom? Please share any thoughts or feedback you would like us to consider.

Thank you for taking the time to complete this questionnaire. Your input is greatly appreciated and would help us better understand the learning approaches and experiences of bilingual students in online mathematics classrooms.

Appendix D: Teachers Interview Protocol

1. What teaching strategies do you find most effective in engaging and supporting bilingual students in the online mathematics classroom?
2. Would you try to incorporate both languages into your lessons, (what is the level of the willingness) and what challenges have you faced in doing so?
3. Can you share an example of how you helped a student overcome language barriers during a mathematics lesson?
4. How do you foster the development of these academic skills or approaches to learning in your teaching strategies?
5. How do you ensure that your assessments and feedback are accessible and understandable to students with varying proficiency levels in both languages?

Appendix E: Teacher Interview Assent

University of California, Los Angeles

RESEARCH INFORMATION SHEET

[Bilingual Students' Learning Approaches in Online Mathematics Classrooms in Upper Elementary]

INTRODUCTION

Le Xiu, from the Education Department at the University of California, Los Angeles is conducting a research study. You were selected as a possible participant in this study because as an experienced teacher in this domain, your expertise and insights would be invaluable to this research. Your participation in this research study is voluntary.

WHAT SHOULD I KNOW ABOUT A RESEARCH STUDY?

- Someone would explain this research study to you.
- Whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision would not be held against you.
- You can ask all the questions you want before you decide.

WHY IS THIS RESEARCH BEING DONE?

The purpose of this study is to learn more about how bilingual students approach learning in online mathematics classrooms. We want to understand what teaching strategies work best for students like you and how we can improve the learning experience for everyone.

HOW LONG WOULD THE RESEARCH LAST AND WHAT WOULD I NEED TO DO?

We are seeking teachers who have experience teaching mathematics to bilingual students in online settings to participate in a 30-minute interview via Zoom. Your participation in this study would involve discussing your teaching methodologies and strategies, as well as sharing your experiences working with bilingual students in an online mathematics classroom.
Additionally, we would like to include classroom observations as part of our research procedures. With your consent, we would like to observe your online mathematics classroom sessions for a specific duration. These observations would allow us to gain valuable insights into the teaching practices and dynamics within a bilingual online learning environment. The observations would be conducted unobtrusively, and we would not interfere with the ongoing classroom activities.

ARE THERE ANY RISKS IF I PARTICIPATE?

Voluntary Participation: Your participation in this study is completely voluntary. You can choose not to participate or stop answering the questions at any time without any consequences.

ARE THERE ANY BENEFITS IF I PARTICIPATE?

Your insights and experiences would contribute to a better understanding of bilingual students' learning approaches and strategies, ultimately helping to improve their educational experiences and outcomes. Your alternative to participating in this research study is to not participate.

HOW WOULD INFORMATION ABOUT ME AND MY PARTICIPATION BE KEPT CONFIDENTIAL?

The researchers would do their best to make sure that your private information is kept confidential. Information about you would be handled as confidentially as possible, but participating in research may involve a loss of privacy and the potential for a breach in

confidentiality. Study data would be physically and electronically secured. As with any use of electronic means to store data, there is a risk of breach of data security.

Use of personal information that can identify you:

The use of personal information that can identify participants would be minimized by implementing an ID coding system. Each participant would be assigned a unique identifier code that would be used to link their data, records, or specimens to their identity.

How information about you would be stored:

The research data would be securely stored in accordance with data protection regulations and institutional guidelines. This includes appropriate physical or digital storage methods that ensure the confidentiality, integrity, and availability of the data. Access to the data would be limited to authorized personnel involved in the research project.

People and agencies that would have access to your information:

The research team, authorized UCLA personnel, may have access to study data and records to monitor the study. Research records provided to authorized, non-UCLA personnel would not contain identifiable information about you. Publications and/or presentations that result from this study would not identify you by name.

Employees of the University may have access to identifiable information as part of routine processing of your information, such as lab work or processing payment. However, University employees are bound by strict rules of confidentiality.

How long information from the study would be kept:

The research data, records, and specimens collected as part of this study would be maintained until the end of December, which is by the end of this study after analysis.

USE OF DATA FOR FUTURE RESEARCH

No data and/or specimens collected during this study, including de-identified data would be shared for future research.

WHO CAN I CONTACT IF I HAVE QUESTIONS ABOUT THIS STUDY?

The research team:

If you have any questions, comments or concerns about the research, you can talk to the one of the researchers. Please contact: **Le Xiu, xiul@g.ucla.edu**

UCLA Office of the Human Research Protection Program (OHRPP):

If you have questions about your rights as a research subject, or you have concerns or suggestions and you want to talk to someone other than the researchers, you may contact the UCLA OHRPP by phone: (310) 206-2040; by email: participants@research.ucla.edu or by mail: Box 951406, Los Angeles, CA 90095-1406.

WHAT ARE MY RIGHTS IF I TAKE PART IN THIS STUDY?

- You can choose whether or not you want to be in this study, and you may withdraw your consent and discontinue participation at any time.
- Whatever decision you make, there would be no penalty to you, and no loss of benefits to which you were otherwise entitled.
- You may refuse to answer any questions that you do not want to answer and still remain in the study.

You would be given a copy of this information to keep for your records.

Appendix F: Family interview Protocol

Title: Family Interview Protocol for Online Mathematics Classroom with Bilingual Students

Objective: To explore the perspectives of families with bilingual students in an online mathematics classroom, focusing on their children's learning approaches, their role in supporting their children's learning, any challenges they may have faced, and the collaboration between parents and their children during learning.

Interviewer: _____

Interviewee (Family Member and Child): _____

Date: _____ Time: _____ Duration: 30 - 60 minutes

Platform: Zoom

Introduction: (2 minutes)

1. Greet the family member and child, and thank them for their time.
2. Introduce the purpose of the interview and explain how their insights would contribute to the study.

Part 1: Parent-Child Collaboration

1. Can both of you describe a typical mathematics learning session in the online bilingual classroom, focusing on how you work together and communicate during the process?
2. How do you, as a parent, provide support and guidance to your child while they are learning mathematics in a bilingual context?
3. And as a child, how do you seek help from your parent during the learning process?
4. In what ways do you support your child's understanding of mathematics concepts in both English and your home language?

Part 2: Challenges and Language Barriers

1. Have you noticed any language barriers or challenges your child has faced while learning mathematics in the online bilingual classroom? If so, please describe these challenges.
2. Can you share how you've addressed any technical challenges that have arisen during your child's online mathematics learning?

Part 3: Learning Approaches and Outcomes

1. How do you think the online mathematics classroom has influenced your child's learning approaches or outcomes?

2. What strategies do you find effective in helping your child practice and understand mathematics problems in an online setting?
3. Have you observed any benefits or advantages in your child's learning as a result of being in a bilingual online mathematics classroom and collaborating with you, as a parent?

Conclusion: (3 minutes)

1. (optional) Based on your experience, what suggestions or improvements would you recommend for online mathematics classrooms that cater to bilingual students and foster parent-child collaboration during learning?

Appendix G: CONSENT FOR PARENT AND PARENTAL PERMISSION FOR MINOR TO PARTICIPATE IN RESEARCH

University of California, Los Angeles

[*Bilingual Students' Learning Approaches in Online Mathematics Classes in Upper Elementary*] Le Xiu, Rosie, from the Education Department (UCLA SE&IS) at the University of California, Los Angeles (UCLA) are conducting a research study.

You and your child were selected as possible participants in this study because your eligibility may be based on factors such as being a bilingual student in the upper elementary level and having experience with online mathematics classrooms. Your participation in this research study is voluntary.

Why is this study being done?

The purpose of this study is to learn more about how bilingual students approach to learning in online mathematics learning. We want to understand what teaching strategies work best for students like you and how we can improve the online learning experience for everyone.

What would happen if we take part in this research study?

If you and your child volunteer to participate in this study, we would ask you to do the following:

Child's Participation:

- Complete a questionnaire: Your child would be asked to answer questions about their experiences and approaches to learning mathematics in online classrooms. The questionnaire would ask about their preferences, challenges, and strategies used in their mathematics studies.
- Potentially participate in interviews: There may be an opportunity for your child to take part in an interview, where they can share their perspectives, experiences, and suggestions related to learning mathematics in online classrooms. The interview questions would be open-ended, allowing your child to express their thoughts and opinions freely. Interviews would be video recorded.

Parent's Participation:

- Provide consent: As a parent, you would be asked to provide informed consent for your child's participation in the study. This consent would outline the purpose of the research, the procedures involved, and the safeguards in place to protect your child's privacy and confidentiality.
- Participate in interviews: There may be an opportunity for you to participate in an interview, where you can share your insights and perspectives on your child's mathematics education, particularly in an online setting. The interview questions would be designed to explore your experiences, concerns, and suggestions as a parent. Interviews would be video recorded.

Parent and Child Participation Together:

- Engage in the family interview: There may be instances where you and your child would be invited to engage in joint discussions or conversations related to their mathematics learning experiences in online classrooms. These discussions would provide an opportunity to explore shared perspectives, strategies, and challenges. Interviews would be video recorded.

How long would we be in the research study?
We are seeking families with bilingual students enrolled in online mathematics courses to participate in a 30 - 60 minutes interview via Zoom.
Are there any potential risks or discomforts that we can expect from this study?
There are no anticipated risks or discomforts associated with participating in this study. However, it is possible that some participants may experience minor inconveniences or time commitments associated with completing the questionnaires, participating in interviews, or engaging in classroom observations. We would make efforts to minimize any potential inconvenience and ensure that the study procedures are conducted in a respectful and non-intrusive manner.
Are there any potential benefits if we participate?
Your child may benefit from participating in this research study by reflecting on their own mathematics learning approaches and contributing to the broader understanding of how bilingual students navigate online mathematics classrooms. While there may not be direct individual benefits for participating, the insights gained from this study have the potential to inform educational practices and support the development of effective strategies for bilingual mathematics learning in online environments.

The results of this research may contribute to the advancement of knowledge in the field of mathematics education and enhance our understanding of effective instructional practices for bilingual students in online settings. This knowledge may benefit educators, policymakers, and researchers in promoting inclusive and effective mathematics instruction for bilingual learners.
Would information about our participation be kept confidential?
Any information that is obtained in connection with this study and that can identify you and your child would remain confidential. It would be disclosed only with your permission or as required by law. Confidentiality would be maintained by means of the researchers would do their best to make sure that your private information is kept confidential. Information about you would be handled as confidentially as possible, but participating in research may involve a loss of privacy and the potential for a breach of confidentiality. Study data would be physically and electronically secured. As with any use of electronic means to store data, there is a risk of breach of data security. Your data, including de-identified data, may be kept for use in future research.
What are my rights if I take part in this study?
- You can choose whether or not you want to be in this study, and you may withdraw your consent and discontinue participation at any time.
- Whatever decision you make, there would be no penalty to you or your child, and no loss of benefits to which you or your child were otherwise entitled.
- You and your child may refuse to answer any questions that you do not want to answer and still remain in the study.

What are my and my child's rights if he or she takes part in this study?
- You can choose whether or not you want your child to be in this study, and you may withdraw your permission and discontinue your child's participation at any time.
- Whatever decision you make, there would be no penalty to you or your child, and no loss of benefits to which you or your child were otherwise entitled.
- Your child may refuse to answer any questions that he/she does not want to answer and still remain in the study.

Who can I contact if I have questions about this study?
- **The research team:**

If you have any questions, comments or concerns about the research, you can talk to the one of the researchers. Please contact: Le Xiu.

- **UCLA Office of the Human Research Protection Program (OHRPP):**
  If you have questions about your rights as a research subject, or you have concerns or suggestions and you want to talk to someone other than the researchers, you may contact the UCLA OHRPP by phone: (310) 206-2040; by email: participants@research.ucla.edu or by mail: Box 951406, Los Angeles, CA 90095-1406.

You would be given a copy of this information to keep for your records

Appendix H: Qualitative Analysis CodeBook

Codebook for [Exploring the Approaches to Learning of Bilingual Students in Online Upper Elementary Mathematics Classrooms]

1.Code Name: [Initial Coding]

Definition: ["Open Coding"; breaks down qualitative data into discrete parts, closely examines them]

Example: [Provide an example of data that would be coded as this]

Notes: [Inductive codes; suitable for interview transcripts]

2. Code Name: [ATL Categorizing]

Definition: [Dedudctive Coding, starting with a predefined set of codes, then assigning those codes to the new qualitative data]

Example: See the ATL definitions in Appendix B.

Qualitative analysis coding example

CONVERSATION	**Initial Coding**	**ATL Categorizing**
First, similar to how we address students who speak only one language, we provide engaging materials and class activities.	engage students through classroom activities	Communication - Effective Communication through interaction

References

An, Y., Rakowski, K. R., Yang, J., Conan, J., Kinard, W., & Daughrity, L. A.(2021). Examining K-12 teachers' feelings, experiences, and perspec-tives regarding online teaching during the early stage of the COVID-19 pandemic.Educational Technology Research and Development,69,1–25.https://doi.org/10.1007/s11423-021-10008-5

Bai, X., & Gu, X. (2022). Effect of teacher autonomy support on the online self-regulated learning of students during COVID-19 in China: The chain mediating effect of parental autonomy support and students' self-efficacy. *Journal of Computer Assisted Learning*, *38*(4), 1173-1184. https://doi.org/https://doi.org/10.1111/jcal.12676

Banse, H. W., Palacios, N., Merritt, E. G., & Rimm-Kaufman, S. E. (2017). Scaffolding English language learners' mathematical talk in the context of Calendar Math. *Journal of Educational Research*, *110*(2), 199–208. https://doi.org/10.1080/00220671.2015.1075187

Blommaert, J., & Jie, D. (2020). *Ethnographic fieldwork: A Beginner's Guide*. Multilingual Matters.

Bohon, L., Mckelvey, S. D., Rhodes, J. A., & Robnolt, V. J. (2017). Training for content teachers of English Language Learners: using experiential learning to improve instruction. *Teacher Development*. https://doi.org/10.1080/13664530.2016.1277256

Boonk, L., Gijselaers, H. J. M., Ritzen, H., & Brand-Gruwel, S. (2018). Areview of the relationship between parental involvement indicatorsand academic achievement.Educational Research Review,24,10–30.https://doi.org/10.1016/j.edurev.2018.02.001

Bormanaki, H. B., & Khoshhal, Y. (2017). The role of equilibration in Piaget's Theory of Cognitive Development and its implication for receptive Skills: a Theoretical study.

Journal of Language Teaching and Research, *8*(5), 996. https://doi.org/10.17507/jltr.0805.22

Bustamante, A. S., Greenfield, D. B., & Nayfeld, I. (2018). Early Childhood Science and Engineering: Engaging Platforms for Fostering Domain-General Learning Skills. *Education Sciences*, *8*(3), 144. https://doi.org/10.3390/educsci8030144

Cadiero-Kaplan, K., & Rodríguez, J. L. (2008). The Preparation of Highly Qualified Teachers for English Language Learners: Educational Responsiveness for Unmet Needs. *Equity & Excellence in Education*, *41*(3), 372–387. https://doi.org/10.1080/10665680802179444

Chu, H., Chen, J., & Tsai, C. (2017). Effects of an online formative peer-tutoring approach on students' learning behaviors, performance and cognitive load in mathematics. *Interactive Learning Environments*, *25*(2), 203–219. https://doi.org/10.1080/10494820.2016.1276085

Chwialkowska, A. (2020). Maximizing Cross-Cultural Learning From Exchange Study Abroad Programs: Transformative Learning Theory. *Journal of Studies in International Education*, *24*(5), 535–554. https://doi.org/10.1177/1028315320906163

Dickinson, D. K., & Neuman, S. B. (2013). *Handbook of Early Literacy Research, Volume 2*. Guilford Publications.

Dörnyei, Z. (2001). New themes and approaches in second language motivation research. *Annual Review of Applied Linguistics*, *21*, 43–59. https://doi.org/10.1017/s0267190501000034

Fantuzzo, J. W., Gadsden, V. L., & McDermott, P. A. (2011). An Integrated Curriculum to Improve Mathematics, Language, and Literacy for Head Start Children. *American Educational Research Journal*, *48*(3), 763–793. https://doi.org/10.3102/0002831210385446

Feng, X., Xie, K., Gong, S., Gao, L., & Cao, Y. (2019). Effects of parentalautonomy support and teacher support on middle school Students'homework effort: Homework autonomous motivation as mediator.Fron-tiers in Psychology,10,612.https://doi.org/10.3389/fpsyg.2019.00612

Fox, K. R. (2020). Bidirectional benefits from school to home literacy prac-tices in the early childhood virtual classroom. In R. E. Ferdig, E.Baumgartner, R. Hartshorne, R. Kaplan-Rakowski, & C. Mouza (Eds.),Teaching, technology, and teacher education during the COVID-19 pan-demic: Stories from the field(pp. 133–140). Association for theAdvancement of Computing in Education (AACE).

García, T., Rodríguez, C., Betts, L. R., Areces, D., & González-Castro, P. (2016). How affective-motivational variables and approaches to learning predict mathematics achievement in upper elementary levels. *Learning and Individual Differences*, *49*, 25–31. https://doi.org/10.1016/j.lindif.2016.05.021

Habók, A., & Magyar, A. (2020). The role of students' approaches in foreign language learning. *Cogent Education*, *7*(1). https://doi.org/10.1080/2331186x.2020.1770921

Ishak, H., Sukestiyarno, Y. L., Waluya, S. B., Rochmad, & Mariani, S. (2021). Description of student's difficulty in understanding online mathematics learning materials. *Journal of Physics*, *1918*(4), 042095. https://doi.org/10.1088/1742-6596/1918/4/042095

Krause, G., Adams-Corral, M., & Maldonado Rodríguez, L. A. (2022). Developing Awareness Around Language Practices in the Elementary Bilingual Mathematics Classroom. *Journal of Urban Mathematics Education*, *15*(2). https://doi.org/10.21423/jume-v15i2a462

Li-Grining, C. P., Votruba-Drzal, E., Maldonado-Carreño, C., & Haas, K. (2010). Children's early approaches to learning and academic trajectories through fifth grade. *Developmental Psychology*, *46*(5), 1062–1077. https://doi.org/10.1037/a0020066

Marange, T., & Adendorff, S. A. (2021). The contribution of online mathematics games to algebra understanding in Grade 8. *Pythagoras*, *42*(1). https://doi.org/10.4102/pythagoras.v42i1.586

McCarthy, J., & Wolfe, Z. (2020). Engaging parents through school-widestrategies for online instruction. In R. E. Ferdig (Ed.),Teaching, technol-ogy, and teacher education during the COVID-19 pandemic: Stories fromthe field(pp. 7–12). Association for the Advancement of Computing inEducation (AACE).

McKenzie, D. (2016). *Approaches to Learning skills*. (n.d.). https://librarygrits.blogspot.com/2016/07/approaches-to-learning-skills.html

Moore, P., & Lorenzo, F. (2015). Task-based learning and content and language integrated learning materials design: process and product. *Language Learning Journal*, *43*(3), 334–357. https://doi.org/10.1080/09571736.2015.1053282

Moos, D., & Ringdal, A. (2012). Self-Regulated Learning in the Classroom: A Literature Review on the Teacher's Role. *Education Research International*, *2012*, 1–15. https://doi.org/10.1155/2012/423284

Morita-Mullaney, T., Renn, J., & Chiu, M. M. (2021). Contesting mathematics as the universal language: a longitudinal study of dual language bilingual education language allocation. *International Multilingual Research Journal*, *15*(1), 43–60. https://doi.org/10.1080/19313152.2020.1753930

Moschkovich, J. (2007). Bilingual mathematics learners: How views of language, bilingual

learners, and mathematical communication impact instruction. In N. S. Nasir & P. Cobb (Eds.), Improving access to mathematics: Diversity and equity in the classroom (pp. 89– 104). New York: Teachers College Press.

Nasir, N. S., Hand, V., & Taylor, E. V. (2008). Culture and Mathematics in School: Boundaries between "Cultural" and "Domain" knowledge in the mathematics classroom and beyond. *Review of Research in Education*, *32*(1), 187–240. https://doi.org/10.3102/0091732x07308962

Novianti, R., & Garzia, M. (2020). Parental engagement in children's onlinelearning during COVID-19 pandemic.Journal of Teaching and Learningin Elementary Education,3(2), 117–131.https://doi.org/10.33578/jtlee.v3i2.7845

Park, H., & Kim, D. (2015). English Language Learners' Strategies for Reading Computer-Based Texts at Home and in School. *The CALICO Journal*, *33*(3). https://doi.org/10.1558/cj.v33i3.26552

Peña, E. D., Bedore, L. M., Torres, J., & Prado, Y. (2022). Growing Up in Multilingual Communities. In *Cambridge University Press eBooks* (pp. 144–165). https://doi.org/10.1017/9781108643719.009

Quintero Perez, M. (2022). *A Mixed-Methods Longitudinal Study : Exploring the Home Language Maintenance and Bilingual Development of Espa ol-English Bilingual Elementary-Aged Students Using a Family Language Policy Framework / by Marlen Quintero Perez.* University of California, Los Angeles.

Ravitch, S. M., & Carl, N. M. (2019). *Qualitative research: Bridging the Conceptual, Theoretical, and Methodological*. SAGE Publications.

Ryan, È., Bailey, A. L., & Grace, Y. H. (2019). Rethinking the role of transitions between activities in early childhood settings: An examination of their linguistic characteristics in two preschool classrooms. *Journal of Early Childhood Literacy*, *21*(4), 538–567. https://doi.org/10.1177/1468798419870596

Saldana, J. (2021). *The Coding Manual for Qualitative Researchers*. SAGE.

Shadiev, R., Wang, X., Wu, T., & Huang, Y. (2021). Review of Research on Technology-Supported Cross-Cultural Learning. *Sustainability*, *13*(3), 1402. https://doi.org/10.3390/su13031402

Smagorinsky, P. (2008). The method section as conceptual epicenter in constructing social science research reports. Written Communication, 25 (3), 389–411 .

Tlepbergen, D., Akzhigitova, A., & Zabrodskaja, A. (2022). Language-in-Education Policy of Kazakhstan: Post-Pandemic Technology Enhances Language Learning. *Education Sciences*, *12*(5), 311. https://doi.org/10.3390/educsci12050311

Tulloch, M. K., & Hoff, E. (2022). Filling lexical gaps and more: code-switching for the power of expression by young bilinguals. *Journal of Child Language*, *50*(4), 981–1004. https://doi.org/10.1017/s0305000922000307

Videla, R., Rossel, S., Muñoz, C., & Aguayo, C. (2022). Online Mathematics Education during the COVID-19 Pandemic: Didactic Strategies, Educational Resources, and Educational Contexts. *Education Sciences*, *12*(7), 492. https://doi.org/10.3390/educsci12070492

Wilkinson, L., Bailey, A., & Maher, C. (2020). Students' learning language and learning to reason mathematically. In M. Daszkiewicz & A. Dąbrowska (eds.) In search of the language educational paradigm; Strand 2.4 (pp. 211–226.) Kraków, Poland: Oficyna Wydawnicza Impuls Press. ISBN 978-83-7850-779-6.

Xu, J., Du, J., Wu, S., Rippley, H., & Cosgriff, A. (2018). Reciprocal effectamong parental homework support, effort, and achievement? Anempirical investigation.Frontier in Psychology,9,1–11.https://doi.org/10.3389/fpsyg.2018.02334

Yeong, J., I., Martinez, R., & Jackson, C. (2021). Culturally Sustaining Pedagogy for Emergent Bilinguals in a Teacher Education Online Course. In *Research in mathematics education* (pp. 131–145). Springer International Publishing. https://doi.org/10.1007/978-3-030-80230-1_7