Exploring Teachers' Perceptions of Translanguaging and Technology in English-Medium STEM Classrooms in Kazakhstani Secondary Schools

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Ethical Approval

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Date: 11 of November, 2024

Dear:

Zhibek Baigulova

This letter now confirms that your research project titled:

Exploring Teachers' Perceptions of Translanguaging and Technology in English-medium STEM classrooms in Kazakhstani Secondary Schools

has been approved by the Graduate School of Education Ethics Committee of Nazarbayev University.

You may proceed with contacting your preferred research site and commencing your participant recruitment strategy.

Yours sincerely,

D. Philip Montgomery

On behalf of:
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Abstract

Exploring Teachers' Perceptions of Translanguaging and Technology in English-Medium STEM classrooms in Kazakhstani Secondary Schools

This study examines the role of translanguaging and technology in English-medium STEM (EMI-STEM) classrooms in Kazakhstan, where multilingual education is expanding rapidly. As EMI becomes a national priority in secondary schools, teachers face challenges related to students' diverse language backgrounds, unequal access to digital tools, and lack of institutional guidance on multilingual pedagogy. This study argues that while translanguaging and technology are both commonly used by teachers in EMI-STEM classrooms in Kazakhstan, they are rarely integrated in a cohesive pedagogical approach. Their separation, both in practice and in policy, limits their full potential to enhance student engagement, deepen content understanding, and support equitable multilingual education. To analyze this disconnect, the study applies the Technological Pedagogical Content Knowledge (TPACK) framework, adapted to include translanguaging, as a lens to examine how teachers balance language, technology, and content in multilingual STEM settings. The study is guided by the following questions: (1) How do teachers experience EMI-STEM teaching in multilingual contexts? (2) What challenges and opportunities do they encounter? (3) How do they use translanguaging and technology to promote student engagement to improve academic outcomes? Using a qualitative phenomenological design, the study involved 6 private secondary school STEM teachers across four schools in Astana: a STEM-focused school, a tech-focused school, an IB school, and an international school. Data were collected through semi-structured interviews and classroom observations, then analyzed using thematic coding. The findings reveal that while teachers often rely on translanguaging to scaffold STEM content and support student understanding, this practice remains informal and is not reflected in policy or assessment practices, which remain largely monolingual. Technology is widely

used to support content delivery and student engagement, but it is rarely aligned with multilingual teaching practices. The study offers practical implications for EMI-STEM policy, teacher training, and curriculum design. Additionally, it contributes theoretically by suggesting that explicitly embedding translanguaging within the TPACK model would strengthen its relevance and applicability in multilingual education systems such as Kazakhstan's.

Keywords: EMI, STEM, translanguaging, teachers' perceptions of translanguaging, translanguaging use, multilingual education, TPACK framework, technology in education

Аңдатпа

Қазақстандық орта мектептерде ағылшын тілінде оқытатын STEM-сыныптарда мұғалімдердің транслингвизм мен технологияларды пайдалануын қабылдауын зерттеу

Бұл зерттеу көптілді білім беру қарқынды дамып келе жатқан Қазақстан мектептерінде ағылшын тілінде жаратылыстану-ғылыми цикл пәндерін (EMI-STEM) оқытудағы транслингвизм мен технологиялардың рөлін қарастырады. Ағылшын тілінде оқыту (EMI) орта білім беру жүйесінде ұлттық басымдыққа айналғандықтан, мұғалімдер оқушылардың әртүрлі тілдік тәжірибелерімен, цифрлық құралдарға тең емес қол жетімділікпен және көп тілді педагогика бойынша институционалдық нұсқаулықтың болмауымен байланысты қиындықтарға тап болуда. Зерттеудің мақсаты-орта мектеп мұғалімдерінің EMI-STEM оқытуына транслингвизм мен технологияны қалай қабылдайтынын және енгізетінін және бұл стратегиялардың оқушылардың қатысуы мен оқу процесіне қалай әсер ететінін зерттеу. Бұл зерттеу TPACK (Технологиялық-педагогикалық-мазмұндық білімдер) моделін пайдалана отырып, транслингвизм мен технологиялардың көбіне параллель түрде іске асырылатынын көрсетеді, бұл жан-жақты кәсіби даму қажеттілігін көрсетеді. Зерттеу келесі сұрақтарға негізделді: (1) Мұғалімдер көптілді ортада EMI негізіндегі оқытуды қалай қабылдайды? (2) Олар қандай қиындықтар мен мүмкіндіктерге тап болады? (3) Олар оқушылардың белсенділігін арттырып, академиялық жетістіктерін жақсарту үшін трансланғвизм мен технологияны қалай қолданады? Сапалы феноменологиялық зерттеу әдісі аясында бұл жұмысқа Астанада орналасқан төрт мектептен – STEM бағытындағы мектеп, IB мектебі және халықаралық мектептен алты STEM пәнінің мұғалімі қатысты. Деректер жартылай құрылымдалған сұхбаттар мен сабақ бақылаулары арқылы жиналып, содан кейін тақырыптық кодтауды қолдану арқылы

талданды. Нәтижелер көрсеткендей, мұғалімдер STEM мазмұнын бекіту және оқушылардың түсінігін қолдау үшін басқа тілге аударуға жиі жүгінгенімен, бұл тәжірибе әлі де бейресми болып қалуда және білім беру саясаты мен бағалау жүйесінде көрініс таппайды, олар әлі де бір тілді болып қала береді. Технологиялар мазмұнды жеткізу мен оқушылардың қызығушылығын арттыру үшін кеңінен қолданылғанымен, олар көптілді оқыту тәжірибесімен сирек ұштасады. Алынған нәтижелер EMI-STEM саясаты, мұғалімдерді даярлау және оқу бағдарламаларын әзірлеу үшін практикалық маңызды. Сонымен қатар, ол транслингвизмді TPACK моделіне тікелей интеграциялау оның қазақстандық сияқты көп тілді білім беру жүйелерінде өзектілігі мен қолданылуын арттырады деп болжай отырып, теориялық үлес қосады.

Түйінді сөздер: EMI, STEM, транслингвизм, мұғалімдердің транслингвизмді қабылдауы, транслингвизмді пайдалану, көптілді білім, TPACK моделі, Білім берудегі технологиялар.

Аннотация

Изучение восприятия учителями использования транслингвизма и технологий в STEM-классах с преподаванием на английском языке в средних школах Казахстана

Данное исследование рассматривает роль транслингвизма и технологий в преподавании предметов естественно-научного цикла на английском языке (EMI-STEM) в школах Казахстана, где многоязычное образование стремительно развивается. Поскольку, преподавание на английском (EMI) становится национальным приоритетом в средних школах, учителя сталкиваются с проблемами, связанными с разным языковым опытом учащихся, неравным доступом к цифровым инструментам и отсутствием институционального руководства по многоязычной педагогике. Цель исследования - изучить, как учителя средних школ воспринимают и внедряют транслингвизм и технологии в обучение EMI-STEM, и как эти стратегии влияют на вовлеченность учащихся и процесс обучения. В исследовании используется модель TPACK (Модель технологическо-педагогическо-содержательных знаний), чтобы показать, что перевод на другой язык и технологии часто внедряются параллельно, что подчеркивает необходимость комплексного профессионального развития. В ходе исследования были заданы следующие вопросы: (1) Как преподаватели воспринимают преподавание на основе EMI в многоязычном контексте? (2) С какими трудностями и возможностями они сталкиваются? (3) Как они используют транслингвизм и технологии для повышения вовлеченности учащихся и улучшения академических результатов? В рамках качественного феноменологического подхода в исследовании приняли участие 6 преподавателей STEM-дисциплин средней школы из четырех школ: школы, специализирующейся на STEM, школы IB и международной школы, расположенных в Астане. Данные были собраны с помощью полуструктурированных

интервью и наблюдений в классе, а затем проанализированы с использованием тематического кодирования. Полученные результаты показывают, что, хотя учителя часто полагаются на перевод на другой язык для закрепления содержания STEM и поддержки понимания учащимися, эта практика остается неформальной и не отражается в образовательной политике и оценивании, которые по-прежнему остаются в основном одноязычными. Технологии широко используются для поддержки предоставления контента и вовлечения студентов, но они редко сочетаются с практикой многоязычного обучения. Исследование имеет практическое значение для политики EMI-STEM, подготовки учителей и разработки учебных программ. Кроме того, оно вносит теоретический вклад, предполагая, что прямое интегрирование транслигвизма в модель TPACK повысит ее актуальность и применимость в многоязычных системах образования, таких как Казахстанская.

Түйінді сөздер: EMI, STEM, транслингвизм, восприятие транслингвизма учителями, использование транслингвизма, многоязычное образование, модель TPACK, технологии в образовании.

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Chapter 1: Introduction

Background of the Study

The integration of English Medium Instruction (EMI) within STEM education in Kazakhstani schools has significantly grown, aligning with global educational trends and reflecting Kazakhstan's multilingual environment. There could be several reasons for this increased interest in EMI-STEM in Kazakhstan. Firstly, learning in an EMI setting helps students develop their identity as English language users, aligning with academic, professional, and intercultural advantages (Manan et al., 2023). Secondly, through this integrated approach, students develop a competitive edge by gaining access to global scientific data and research. In 2008, EMI-STEM education has been implemented in select schools, such as Nazarbayev Intellectual Schools (NIS) and Bilim Innovation Lyceums (BILs), where students study integrated science subjects in English (Karabassova, 2020; Shamshidinova et al., 2014). Typically, admission to these schools is competitive, requiring high levels of language proficiency and content knowledge. Consequently, the methodologies applied in NIS and BILs are challenging to implement in schools with more diverse student backgrounds.

Another obstacle to the implementation of EMI-STEM more widely across Kazakhstan is that teachers need advanced language proficiency and an effective teaching methodology to ensure students' comprehension and engagement. The absence of a consistent methodological framework for teaching STEM subjects in English often leads to increased stress and impacts teaching quality (Seitzhanova et al., 2015). This phenomenological study will thus explore teachers' experiences and perspectives on EMI-STEM education in Kazakhstani private secondary schools.

Specifically, the study aims to understand whether the use of technology and translanguaging in EMI-STEM classrooms, guided by an adapted TPACK framework,

enhances teaching effectiveness and facilitates student academic performance. The TPACK framework highlights the interplay between teachers' technological, pedagogical, and content knowledge and examines how these domains interact to support effective teaching (Koehler et al., 2013). In this context, translanguaging will be explored as a component of pedagogical and content knowledge, integrated within the TPACK model. This study will consider technology and translanguaging as separate yet complementary strategies, rather than investigating their direct relationship, to better understand how these approaches individually contribute to EMI-STEM instruction from the teachers' perspectives.

Main Concepts in the Study

This study examines the core concepts surrounding EMI-STEM education within Kazakhstan's multilingual educational framework, focusing on translanguaging practices and the challenges of implementing EMI. Introduced as part of Kazakhstan's "Trilingual Policy" in 2007, EMI aims to foster multilingualism by integrating Kazakh, Russian, and English as instructional languages across various subjects, especially in STEM disciplines. Translanguaging, which involves alternating between these languages, is a key strategy used by teachers to support students' comprehension by explaining complex concepts in their native languages, thereby fostering a more inclusive learning environment. Despite its potential benefits, EMI faces challenges, including limited teacher training in English proficiency, insufficient resources, and the complexities of managing a multilingual classroom. While teachers and students highlight these challenges, they also recognize EMI's value in providing access to global knowledge, career opportunities, and valuable language skills.

The study further explores the integration of translanguaging and technology in EMI-STEM classrooms within Kazakhstani schools, aligning with global educational

trends. Although the Ministry of Education and Science of the RK implemented EMI in specialized schools like Nazarbayev Intellectual Schools (NIS) and Bilim-Innovation Lyceums (BIL), existing research predominantly focuses on these specialized institutions, which enroll students through competitive exams assessing both English proficiency and content knowledge. Limited research has been conducted on non-specialized schools that offer EMI-STEM education without such competitive entry requirements. Additionally, teachers in these schools face unique challenges, such as accommodating diverse academic and linguistic abilities, adapting to cultural differences, and dealing with limited pre-service training or methodological resources (Hajar et al., 2023; Karabassova & Isidro, 2023).

Understanding the experiences of these teachers is crucial for comprehending how EMI affects various learning communities. Teacher perceptions directly influence classroom practices, shaping students' learning outcomes. While some teachers note improvements in students' English proficiency and future opportunities, they express concerns about the effectiveness of EMI implementation, particularly regarding motivation and competence among both students and teachers. Research on EMI in STEM at the primary and secondary school levels remains limited, underscoring the need for a phenomenological exploration of these concepts from practitioners' viewpoints.

Therefore, this study aims to explore the benefits and challenges of implementing EMI in STEM education within Kazakhstani lower secondary schools, focusing specifically on teachers' perspectives. Using a phenomenological qualitative approach, it seeks to uncover the obstacles and opportunities teachers encounter in their classrooms, investigating how they perceive EMI's impact on student engagement and academic outcomes, particularly regarding the integration of translanguaging and technology.

EMI in Kazakhstan

English as the major language of instruction in a wide range of disciplines is known as English Medium Instruction (EMI), and it is a type of education that is used in both multilingual and primarily English-speaking areas. EMI involves using English as the language of instruction for subjects such as science, mathematics, geography, and medicine (Dearden, 2014) in regions where English is not the first language of the majority population (Macaro, 2018). In Kazakhstan, EMI was introduced in 2007 as part of the "Trilingual Policy", which promotes the teaching of subjects in Kazakh, Russian, and English (Karabassova, 2020). This policy aimed at integrating Kazakhstan into the global educational landscape by fostering multilingual proficiency among students. As a further step toward internationalization, Kazakhstan joined the Bologna Process in 2010, aligning its educational framework with European standards. This move facilitated academic mobility and the development of new programs, solidifying the role of EMI in higher education (Manan et al., 2023).

STEM Education and Approaches

Furthermore, the introduction of Content and Language Integrated Learning (CLIL) in secondary education followed these developments, driven by the government's desire to improve the quality of education in STEM fields and equip students with English-language proficiency. The State Program for Education Development of the Republic of Kazakhstan for 2011-2020 stipulates that English must be taught as a foreign language in addition to being a medium of instruction for content topics (Maximova, 2020). CLIL was seen as a way to harmonize the teaching of both content and language, allowing students to access global scientific knowledge while mastering a second or third language. It required teachers to have specific language proficiency in the scientific field as well. However, the adoption of CLIL has been met with various challenges, including the need for improved

teacher training and the creation of localized pedagogical frameworks that address the unique linguistic and cultural context of Kazakhstan (Bedeker et al., 2023). Teachers in Kazakhstan have had to reconcile traditional Soviet pedagogical methods with new, constructivist approaches required by CLIL, often navigating complex linguistic environments where translanguaging between Kazakh, Russian, and English plays a critical role in student comprehension (Bedeker et al., 2023; Karabassova, 2020; Karabassova & Isidro, 2023).

CLIL: Challenges and Benefits

This section draws on key concepts such as translanguaging, English Medium Instruction (EMI), and technology integration in STEM education, each of which plays a critical role in understanding how multilingual classrooms function in the Kazakhstani context. Regarding the teachers' perspectives, Maximova (2020) explored the perceptions that graduates from pedagogical institutions with a multilingual track have about pre-service training and the challenges they face in CLIL classrooms in specialized schools, namely NIS, BIL, Daryn, and other pilot and mainstream schools. The broad research identified teachers' perceptions regarding the importance of CLIL-specific training, internship opportunities, higher salary for EMI teachers, and language skills development. However, EMI through CLIL was also challenging due to the lower English competence of staff in pre-service trainings, which also contributed to the participants' lower language acquisition. Additionally, it was challenging for students to acquire the content through the foreign language and to establish a language environment due to a lack of materials and resources in English.

Regarding students' perspectives, comparative research conducted by Hajar et al. (2023) focused on students' perceptions from specific-purpose schools, particularly BIL, revealed contrasting findings. In BIL, EMI was privileged, with students benefiting from

access to global knowledge and literature, as well as opportunities for developing speaking skills. Moreover, BIL's students found EMI beneficial as it provides access to world knowledge and literature, as well as developed their speaking skills. Notably, BIL's students have reliable and accessible resources in English, local and foreign teachers fluent in English, and skilled in translanguaging and code-switching. Overall, almost all targeted studies emphasized that the intentions to choose to study in EMI integrated schools are high due to career opportunities (Manan et al., 2023), access to prestigious institutions (Maximova, 2020), and a rich language environment (Hajar et al., 2023).

Translanguaging in STEM

The concepts of code-switching and translanguaging are highly pertinent in multilingual countries like Kazakhstan, where the official language and languages of communication vary. The English term "translanguaging" originated from the Welsh term "trawsieithu," coined by Cen Williams, and was initially conceived as a deliberate cross-curricular approach for integrating two languages within the same lesson. This term was later translated into English as "translanguaging" (Conteh, 2018, p. 3). On the other hand, code-switching was introduced as a practice of "producing discourses which, in the same conversational turn or in consecutive turns, include morphemes from two or more of the varieties in their linguistic repertoire" (Myers-Scotton, 2017, p. 232).

In a CLIL setting in Kazakhstan, where science and math are taught in English, translanguaging is a useful strategy for filling in gaps in language ability and topic comprehension. Instructors might facilitate deeper engagement with the content by purposefully explaining complex concepts to students in their L1 (Kazakh or Russian) before switching back to English. According to Bedeker et al. (2023), this adaptable language use is an essential part of successful education in multilingual classrooms because it helps students meet the linguistic and cognitive demands of CLIL.

Research Problem

In Kazakhstan, there is a rapid shift to EMI in STEM classes within Content and Language Integrated Learning, which requires advanced proficiency in English. However, students who attend these schools may come from diverse backgrounds, like rural and urban areas, private or public schools, and with varying language proficiency levels and readiness. They may have been exposed to different approaches to learning and assessment and may face different challenges in studying content area in English. However, school administrators often do not consider the students' backgrounds or prior exposure to the language (Manan et al., 2023) that cause challenges in academic performance.

While research in higher education on this topic is extensive, there remains a gap in understanding the dynamics within secondary schools, particularly those lacking a highly selective process for enrollment, unlike Bilim Innovation Schools (BILs) and Nazarbayev Intellectual Schools (NIS) that accepts students with advanced English level proficiency. In other schools the linguistic competence of students is not considered in STEM subjects causing low motivation and a lack of understanding of subject materials. Besides, teachers often do not consider language instruction as part of their role, referring responsibility instead to English subject teachers (Richards & Pun, 2022). This study seeks to fill this research gap by exploring the experiences of EMI-STEM from the viewpoints of teachers in secondary schools across Kazakhstan. By examining both positive and negative experiences, this research aims to provide valuable insights into the challenges and successes of EMI implementation in STEM subjects.

Purpose of the Study

This study aims to explore teachers' experience and approaches in English-medium STEM (EMI-STEM) education in Kazakhstani lower secondary schools. Moreover, the study intends to clarify teachers' perceptions of how translanguaging and technology, as

distinct yet potentially complementary strategies, facilitate comprehension, engagement, and academic performance in EMI-STEM classrooms.

Research Questions

1. What are teachers' perceptions of implementing English-medium STEM education within Kazakhstani lower secondary schools?
2. What challenges and opportunities do teachers observe for students from diverse backgrounds in their classrooms?
3. How do teachers promote student engagement to improve academic outcomes?
    a. How, if at all, do teachers use translanguaging?
    b. How, if at all, do teachers integrate technology?

Significance of the Study

This study is relevant as it focuses on how technology and translanguaging can enhance student performance and comprehension in secondary STEM education. By addressing significant gaps in knowledge about the impact of these two approaches on learning outcomes, the research will explore how they can be integrated effectively. As Kazakhstan continues to expand the use of EMI and CLIL, challenges such as language proficiency, teacher preparedness, and the implementation of effective educational strategies remain. This study will examine teachers' experiences to develop a deeper understanding of how these challenges influence student achievement and engagement. While this study focuses on private schools due to their experience with EMI-STEM in Kazakhstan, future research should explore public and rural contexts to enhance the generalizability of findings, ensuring broader applicability to diverse educational settings.

In addition, the research will provide valuable insights into the practical application of translanguaging and digital tools within CLIL classrooms, offering solutions for improving teaching strategies in multilingual and diverse settings. The analysis will focus

on how these tools can support multilingual communication and interactive learning, contributing to a more inclusive and effective learning environment.

While teachers participating in the study may not experience immediate direct benefits, reflecting on their teaching practices during the research process could positively impact their professional development. Engaging in this reflective process may prompt teachers to critically evaluate and improve their use of technology and translanguaging strategies, potentially leading to more effective instruction and enhanced student outcomes in the future. Furthermore, the insights gained from this research could inform broader pedagogical practices, benefiting other educators and contributing to the overall advancement of education in multilingual contexts.

Outline of the Thesis

This study examines teachers' perceptions of translanguaging and technology in EMI-STEM classrooms in Kazakhstani secondary schools through a Multilingual TPACK framework. The introduction outlines the study's context, purpose, and objectives, focusing on enhancing engagement in multilingual EMI settings. The literature review synthesizes qualitative research on translanguaging and EMI, citing Karabassova (2020) and García and Wei (2015) to support semi-structured interviews and observations for capturing teacher practices, policy constraints, and training needs. The methodology justifies a phenomenological approach, detailing interviews and non-participant observations to explore translanguaging and technology integration, with ethical measures like informed consent ensuring integrity. Findings reveal teachers' intuitive translanguaging (e.g., Kazakh explanations) and technology use (e.g., video and simulations) but highlight their disconnect due to limited training. The discussion proposes extending TPACK with translanguaging to address this gap, advocating for inclusive policies and resources. The conclusion recommends a national framework integrating

translanguaging and technology, promoting equitable STEM education locally and globally.

Chapter 2: Literature Review

This literature review examines key themes related to English-Medium Instruction (EMI) in STEM education within Kazakhstan's private secondary schools. It explores EMI's implementation, the role of translanguaging in multilingual classrooms, technology integration, and the Kazakhstani educational context, providing a foundation for understanding teacher practices and challenges in EMI-STEM settings. The following research questions serve as a guide for the study:

1. How do teachers experience the implementation of English-medium STEM education within Kazakhstani lower secondary schools?
2. What challenges and opportunities do teachers observe for students from diverse backgrounds in their classrooms?
3. How do teachers promote student engagement to improve academic outcomes? How, if at all, a) do teachers use translanguaging or b) integrate technology?

In order to answer these questions, this literature review first looks at the concept of EMI, particularly within STEM education, and its role in Kazakhstani context. This is followed by an analysis of teacher and student perspectives, offering insights into the challenges encountered in these classrooms, especially for students with different levels of language proficiency. Translanguaging is then explored as a teaching method within EMI-STEM, with an emphasis on how it has the potential to students overcome language obstacles while honoring Kazakhstan's linguistic diversity, since it has become a useful strategy for subject comprehension. Additionally, the review considers the hierarchical positioning of languages in these classrooms, with attention to the unequal status of minority languages despite translanguaging efforts. The subsequent section covers the role of technology in education, focusing on its integration within EMI-STEM settings, and discusses the TPACK framework as an analytical tool for understanding the interplay of

technology, pedagogy, and content knowledge. Finally, the review examines the integration of translanguaging over the TPACK framework, highlighting how this dual approach supports inclusive and effective STEM learning. By focusing on the experiences and viewpoints of educators in multilingual STEM classrooms, this literature review establishes the foundation for comprehending how the study's themes related to the research questions.

Translanguaging serves as a critical lens for this study, intersecting with both teachers' perceptions (RQ1) and their integration practices (RQ3). In the context of RQ1, translanguaging reflects teachers' lived experiences as they navigate multilingual EMI-STEM classrooms, adapting to students' linguistic diversity through spontaneous or planned use of Kazakh, Russian, or other L1s to facilitate comprehension (García & Wei, 2015). This experiential dimension captures how teachers perceive and respond to linguistic challenges in real-time classroom interactions. Conversely, for RQ3, translanguaging is a deliberate pedagogical strategy, where teachers integrate it with content delivery and, to a lesser extent, technology to enhance student engagement and academic outcomes. For example, teachers may use L1 explanations to scaffold complex STEM concepts or encourage student-led translations, distinct from the experiential adaptation in RQ1. While RQ1 focuses on the broader context of teachers' perceptions and challenges, RQ3 zooms into specific practices, with translanguaging bridging these dimensions as both a reactive and proactive tool. This study treats translanguaging and technology as separate yet complementary strategies, recognizing their potential synergy (e.g., multilingual digital resources) as a secondary interest, as discussed later in the technology integration section.

English-medium STEM implementation in Kazakhstan

English Medium Instruction (EMI) refers to the use of English as the primary language to teach academic subjects such as science, mathematics, geography, and medicine in regions where English is not the dominant language (Dearden, 2014; Macaro, 2018). However, it also extends to native English-speaking regions like the UK, USA, Australia, and New Zealand (Griffiths, 2023). In these contexts, EMI serves various purposes, including facilitating internationalization, promoting language proficiency, and preparing students for global academic and professional environments. Moreover, Richards and Pun (2022) define EMI as the utilization of English in multilingual post-colonial countries, where it functions as a community lingua franca alongside other official and local languages. Additionally, English serves as an official and academic language in education, reflecting its historical and cultural significance in these contexts.

In Kazakhstan, EMI was first implemented in 2007 within the “Trilingual policy” that stands for teaching in three languages, namely Kazakh, Russian, and English (Karabassova, 2020). In 2010, the government-initiated EMI integration with the European Higher Education network through the Bologna Declaration that Kazakhstan adopted to develop more programs in academic mobility (Manan et al., 2023). The need to keep up with international educational trends and Kazakhstan's ambitions for internationalization are reflected in the country's increasing emphasis on EMI. Given the global dominance of English, its development throughout the Asia-Pacific region, and governments' efforts to promote internationalization in education, it is crucial to investigate how these policies are actually implemented, especially in STEM education.

Examining how EMI is integrated into STEM education is important to comprehend how this method improves students' academic content knowledge while also fostering linguistic proficiency and preparing them for opportunities around the world,

particularly in a context like Kazakhstan where English is not the primary language. Initially, EMI spread around the world for several reasons: (1) the emergence of English as a universal language, (2) the spread of English, particularly throughout the Asia-Pacific region, and (3) the increasing prevalence of internationalization in government education policies (Pun & Curle, 2021). Concerns regarding the traditional teaching of physics, math, and engineering subjects, which are frequently taught separately, have also drawn attention to EMI in the context of STEM education (Green, 2014; NAE & NRC, 2009). This raises the question of whether EMI-integrated subjects could support students' growth in terms of acquiring varied viewpoints, integrative abilities, and cross-disciplinary creative thinking. To address the need for students to acquire new competencies in the era of widespread technology, EMI within STEM has emerged as a global trend in integrated learning (Kelley & Knowles, 2016). Initially, the term "STEM" was used in the 1990s by the National Science Foundation (NSF) to refer to any activity, policy, program, or event that involved one or more STEM disciplines, namely science, technology, engineering, and mathematics.

Regarding the teachers' perspectives, Maximova (2020) explored the perceptions that graduates from pedagogical institutions with a multilingual track have about pre-service training and the challenges they face in Content and Language Integrated Learning (CLIL) classrooms in specialized schools, namely NIS, BIL, Daryn, and other pilot and mainstream schools. The research is considered broad because it included diverse participants, such as teachers from various specialized (e.g., NIS, BIL, Daryn, and pilot schools), using a combination of surveys and interviews to capture a wide range of perspectives. It identified teachers' perceptions regarding the importance of CLIL-specific training, access to internship opportunities, higher salaries for EMI teachers, and the need for continuous language skills development. However, EMI through CLIL was also

challenging due to the lower English competence of staff in pre-service trainings, which also contributed to the participants' lower language proficiency. Additionally, it was challenging for students of these teachers to acquire the content through the foreign language and to establish a language environment due to a lack of materials and resources in English that contributed to further language barriers between the teacher and the students.

A comparative study conducted by Hajar et al. (2023) focused on students' perceptions from specific-purpose schools, particularly BIL, revealed contrasting findings that can be compared to the findings from the teachers' perspectives. In BIL, EMI was privileged, with students benefiting from access to global knowledge and literature, as well as opportunities for developing speaking skills. Moreover, BIL's students found EMI beneficial as it provides access to world knowledge and literature, as well as develops their speaking skills. Notably, BIL's students have reliable and accessible resources in English, local and foreign teachers fluent in English, and skilled in translanguaging and code-switching. These findings indirectly highlight the pivotal role teachers play in facilitating such outcomes. Teachers in BIL schools are instrumental in delivering content through EMI, adapting instructional strategies to support language development while ensuring students engage with complex academic material. As my research focuses on teachers, understanding how they perceive and navigate these dual responsibilities is crucial to exploring the effectiveness of EMI in fostering both content mastery and language proficiency.

Almost all targeted studies emphasized that the intentions to choose to study in EMI-integrated schools are high due to career opportunities (Manan et al., 2023), access to prestigious institutions (Maximova, 2020), and a rich language environment (Hajar et al.,

2023). However, teachers face challenges in implementing EMI-STEM, including aligning curricula with linguistic diversity and managing resource constraints (Mehisto, 2023).

Jiang et al. (2019) emphasized that "when learning unfamiliar and complex subject knowledge in EMI contexts, student cognitive capacity is challenged simultaneously by the content and the language" (p. 114). Therefore, studies related to EMI in China (Jiang, 2019), Korea (Byun et al., 2011; Kyeyune, 2003 as cited in Khasbani, 2019), Hong Kong (Pun & Thomas, 2020), and Indonesia (Khasbani, 2019) show the value of code-switching and translanguaging to enhance students' comprehension of the content. For instance, research from Indonesia reveals the necessity of using the native language (L1) as a strategy to address immediate language-related challenges in the classroom until a threshold in English proficiency is achieved (Pun & Thomas, 2020). Besides, the authors divided the classroom into "the idealized reality" and "the immediate reality," where the former accepts support for both teachers and students while the latter employs the L1 as a tactic to reduce immediate language-related issues that arise in the classroom until a threshold is achieved to be able to teach successfully in EMI contexts and/or support—as described above—is offered (p. 255). These studies suggest a need to explore teacher experiences in Kazakhstan's private EMI-STEM schools, where resource equity and linguistic diversity shape instructional practices. The following subsections explore the main advantages and disadvantages of EMI in Kazakhstan's STEM-focused education, focusing on differences in resource accessibility, the influence of language competence on material understanding, and the function of translanguaging techniques to enhance learning.

Challenges in the mainstream schools

Previous studies (Hajar et al., 2023; Maximova, 2020; Manan et al., 2023;) indicate that schools in Kazakhstan not classified as specialized schools face significant challenges,

particularly in terms of access to academic resources. These schools often lack the robust support systems, high-quality resources, and motivating environments that are characteristic of specialized institutions. Additionally, lower language competence among students in these mainstream schools further exacerbates challenges in understanding content and engaging effectively with available tutoring resources.

Impact of lower language competence on comprehension

Students who have had insufficient language courses or from different backgrounds find themselves in "varied language proficiency classrooms" (Maximova, 2020, p.15). Students with a lower language competence struggle because, "although the English language is taught from primary school, most students find it insufficient to acquire the language during two or three hours a week. The absence of an English- speaking environment outside the classroom complicates the problem" (p. 37). The lack of sufficient language environment can be seen in diverse mainstream schools as none of them are considered to be an English medium school.

It makes the lesson even more complicated for the teacher when the content of STEM subjects is delivered in a language that students are not proficient in, making it difficult for students to apply and understand the content. Similar findings were observed in Indonesia (Khasbani, 2019), Hong Kong (Pun & Thomas, 2020), and China (Jiang et al., 2019), in regions where English is not the first language (L1).

Conceptualization of Translanguaging Practices

The concepts of code-switching and translanguaging are highly applicable in multilingual countries like Kazakhstan, where the official language and languages of communication vary. Historically, bilingual or multilingual competence has been understood as the separate use of linguistic abilities in different languages. This perspective reflects a monoglossic view—the idea that each language operates

independently, even during code-switching, with its own structure, system, and distinct pragmatic and sociocultural functions (Fishman, 1967; MacSwan, 2017; Karabassova & Isidro, 2023). Before the concept of translanguaging emerged, code-switching was predominantly limited to use outside the classroom, emphasizing the isolated use of multiple languages.

In contrast, translanguaging has been framed in various studies as the interconnected and fluid use of languages. It is conceptualized as "a unitary view" of linguistic competence (Otheguy et al., 2019, p.632) and a holistic approach that aligns with heteroglossia (Goodman & Tastanbek, 2021). In addition, translanguaging transcends traditional language boundaries, promoting fluid linguistic practices that integrate multiple languages in dynamic ways (Otheguy et al., 2015; Wei, 2018; Wei & Lin, 2019). By encouraging fluid linguistic activities that dynamically merge many languages, translanguaging goes beyond conventional language borders. It can also be seen as a rebranding of code-switching (Nikula, 2016), which improves understanding and communication in multilingual settings. In order to create a more inclusive and productive learning environment, this viewpoint emphasizes how crucial it is to acknowledge and value the language resources that students contribute to their educational experiences.

Translanguaging, derived from the Welsh term *trawsieithu* introduced by Cen Williams, was initially conceived as a strategy to integrate two languages within a single lesson across various curricular areas (Conteh, 2018). The concept, later translated into English as "translanguaging," embodies the idea of transcending traditional language boundaries, as implied by the prefix "trans-" (Li Wei, 2011). According to Otheguy et al. (2019), this understanding reinforces the dynamic nature of language use in multilingual contexts (p. 627). On the other hand, code-switching was introduced as a practice of "producing discourses which, in the same conversational turn or in consecutive turns,

include morphemes from two or more of the varieties in their linguistic repertoire" (Myers-Scotton, 2017). The definitions and impact of these concepts have been highlighted in a further study by Goodman and Tastanbek (2020), which has broadened understanding of them:

> Both codeswitching and translanguaging scholarship illustrate the alternation or mixing of language varieties in and out of classrooms, the planned and spontaneous use in classrooms, the importance of teacher and student beliefs for the extent of use and acceptance of translanguaging practices in classrooms, and the role of beliefs and practices in reifying, resisting, or transforming the power of languages and their speakers (p.45).

The dynamics of multilingual classrooms are greatly influenced by code-switching and translanguaging. Understanding their distinctions and parallels enables teachers to apply these approaches more effectively, creating inclusive classrooms that value the many linguistic backgrounds of their students. Finally, this knowledge facilitates the development of instructional strategies that improve language learning and encourage significant participation in a variety of educational settings.

Translanguaging as a classroom practice

Translanguaging is becoming more widely acknowledged as an educational pedagogical approach that facilitates learning by enabling students to apply their entire language repertoire without viewing multilingualism as separate languages systems (Otheguy et al., 2019; Wei, 2018; Wei & Lin, 2019). In practice, teachers use translanguaging to scaffold content (Cenoz & Gorter, 2017; García & Wei, 2015; Gort & Sembiante, 2014), enhance comprehension through meaning-making (García, 2011), and increase student involvement in the classroom (Mendoza et al., 2023). For instance, a

science teacher might introduce a key term in English, explain its meaning in a student's home language, and then reinforce it in English through examples or visuals.

In EMI settings where subjects are taught in a language other than the mother tongue, translanguaging has great opportunity for STEM education. When students interact with scientific concepts, it encourages appropriate language choice and content transitions between the two languages that is drawn through the Content and Language Integrated Learning (CLIL) approach. By utilizing all of their linguistic repertoire, this method supports students in understanding complex vocabulary in math or other science disciplines. According to Karabassova and Isidro (2023), translanguaging helps students in Kazakhstan negotiate their identities as they move between various language and cultural identities in addition to helping them understand abstract STEM topics.

Besides, studies indicate that translanguaging serves as a response to teachers' own language proficiency limits as well as a scaffolding method in STEM classrooms (Bedeker et al., 2024; Karabassova & Isidro, 2023). When English instruction becomes inadequate, teachers adapt students' local languages, like Kazakh or Russian, to explore technical terms (Bedeker et al., 2024). Nonetheless, there is still a fine balance when it comes to translanguaging in CLIL contexts. Teachers can use it to help students become more engaged and comprehend the material. However, there are doubts about its long-term efficacy because some educators see translanguaging as a band-aid solution rather than a long-term teaching strategy (Karabassova & Isidro, 2023). In general, the benefits of translanguaging's flexibility include:

- Improving subject comprehension that by switching between languages, students can more successfully understand challenging concepts (Karabassova & Isidro, 2023).

- Developing student self-assurance and identity: Speaking more than one language encourages students to feel like they belong and have positive multilingual identities (Mendoza et al., 2023).
- Develop metalinguistic awareness, participation, and collaboration (Mendoza et al., 2023).

Though translanguaging has advantages, literature highlights some drawbacks as well. It is not always guaranteed that minority languages will be used equally, which is a big criticism (Sah & Li, 2018). Minority languages often face marginalization even in schools that implement translanguaging strategies, since the dominant language, whether it be the national language or the language of instruction takes precedence (Goodman & Tastanbek, 2019). The national language policies of Kazakhstan, which promote the usage of Kazakh and Russian while giving priority to English in internationalization attempts, highlight this policy barrier in particular (Bedeker et al., 2024). Also, tensions arise with monolingual policies, such as English-only assessments, which may restrict translanguaging's pedagogical benefits (Baker, 2011). Thus, in CLIL classrooms, translanguaging presents both an opportunity and a difficulty because it calls for teachers to carefully balance institutional expectations and student requirements while fostering multilingualism in science education. For example, languages with a minority status in Kazakhstan, such Uyghur or Uzbek, receive little attention even when students know them (Karabassova & Isidro, 2023).

Translanguaging runs the potential of escalating already-existing disparities in linguistic capital unless deliberate efforts are made to challenge language hierarchies. Mendoza et al. (2023) highlight the importance of addressing these issues to ensure that all language varieties are valued and that equitable practices are implemented in educational contexts. Although translanguaging promotes the use of all languages, minority languages

are frequently marginalized as a result of societal power dynamics (García & Kano, 2014) that determine which languages are considered more valued. The necessity of closely analyzing how these power structures affect language usage in educational contexts is shown by this observation.

Thus, while translanguaging integrates students' linguistic resources into classroom activities and presents significant educational potential, challenges remain in ensuring the equitable use of minority languages. Goodman and Tastanbek (2019) emphasize that for translanguaging to be fully effective, it must be accompanied by a critical examination of the existing linguistic hierarchies. This highlights the essential role of teachers' perceptions in creating inclusive learning environments. Observations of classroom dynamics will be instrumental in understanding how teachers can facilitate such environments, ensuring that all languages are respected and afforded equal opportunities for use in relevant contexts.

In multilingual settings like Kazakhstan, translanguaging has the potential to empower students and provide a strong foundation for inclusion while advancing their academic success. This dual focus requires educators to intentionally promote linguistic diversity and counterbalance the dominance of certain languages, ensuring students achieve competitive academic outcomes alongside equitable opportunities for language use.

Technology in Education

Over the past few decades, there has been a global trend toward integrating technology into school curricula, particularly in the context of English-medium instruction (EMI). This integration has been facilitated by various terms related to educational technology, such as ICT (information and communication technologies), TELL (technology-enhanced language learning), TPACK (technological, pedagogical, and

content knowledge), DET (digital educational technology), among others. Significant investments have been made to equip schools with computers, interactive whiteboards, and other hardware resources, prompting a redesign of classroom environments to incorporate educational materials through technology, including Web 1.0 (online newspapers and library databases) and Web 2.0 (blogs, websites, and social networks). The integration of technologies in schools and other institutions has steadily increased since the 1980s, reflecting a growing recognition of their potential impact on teaching and learning (Howard et al., 2018).

As digitalization has spread worldwide, research has shifted focus to effective technology use within educational contexts. Preceding this, various classroom models, such as flipped classrooms, blended learning, and online instruction, have emerged, leading to adaptations in teaching practices across schools and higher education institutions. To motivate instructors to use diverse digital technologies for engaging students in foreign language learning, additional training has been provided. However, evidence suggests that technology integration cannot fully replace traditional language teaching methodologies. This limitation arises not only from the effectiveness of face-to-face instruction but also from a lack of administrative support and knowledge among stakeholders.

In Kazakhstan, policies promoting computer-assisted language learning have been in place since the 1990s, aiming to integrate into the international educational landscape (Mustafina, 2016). Teachers have received training to effectively use digital tools, and many schools in both urban and rural areas have been equipped with computers and interactive whiteboards. For example, a national report indicated that by 2009, 98% of urban and 97% of rural schools were equipped with computers and internet access

(Damitov, 2009). Indeed, teachers were supposed to integrate technology successfully into their curriculum to enhance students' active participation during the lessons.

Technology enhances STEM education by providing accessible platforms, interactive learning, and diverse assessment methods (Mishra & Koehler, 2006). However, in multilingual EMI settings, English-only digital tools, such as simulations or apps, can pose barriers for students with limited English proficiency (Drijvers et al., 2016). Teachers often adopt teacher-led approaches, such as using videos for content delivery, due to time constraints or limited technological proficiency, which may limit student-centered learning (Koehler et al., 2013). These studies underscore the need to examine how technology is integrated in EMI-STEM classrooms, particularly in private schools with robust infrastructure but varying student linguistic backgrounds.

Despite these advancements, many teachers express concerns about the challenges associated with using educational technology. Adopting new technologies can be time-consuming (Williyan & Sirniawati, 2020b), and schools often face limitations such as poor internet connectivity and compatibility issues (Nugroho & Mutiaraningrum, 2020). These challenges can demotivate teachers from utilizing various digital tools. Incorporating technology into the classroom demands a significant commitment of time and effort; as Lindquist and Long (2011) note, the anticipated pedagogical benefits may not materialize. Technology can malfunction during lessons, may not align with intended learning objectives, or can be implemented superficially without enhancing pedagogical aims (p. 233). Furthermore, challenges include a lack of training for teachers, insufficient time, and inadequate facilities to efficiently apply digital teaching methods and create digital resources within multilingual school practices (Anggeraini, 2020). As the integration of technology continues to evolve in educational settings, it is essential to explore its

interplay with translanguaging and other pedagogical approaches to ensure equitable language practices and enhance student learning experiences.

Gaps in EMI Practices for STEM Education in Kazakhstan

Research on English-Medium Instruction (EMI) in STEM education highlights the roles of technology and translanguaging, yet significant gaps remain in Kazakhstan's private secondary schools. These schools share comparable infrastructure, unlike mainstream institutions (Smagulova, 2021), but face challenges in teaching methodology and student language proficiency. Initially, this study examined technology and translanguaging as separate strategies to enhance STEM acquisition, but findings revealed that a monolingual TPACK approach, relying on English-only instruction, limits students' meaning-making, necessitating a Multilingual TPACK framework.

A key gap is the absence of studies applying the Technological Pedagogical Content Knowledge (TPACK) framework to multilingual EMI-STEM settings. While research highlights the independent roles of translanguaging and technology, there is a lack of research exploring how teachers use technology (e.g., simulations, apps) or translanguaging (e.g., Kazakh/Russian scaffolding, student-led translations) holistically to support diverse learners, nor how a Multilingual TPACK framework could enhance comprehension beyond engagement (García & Wei, 2015).

Additionally, there is limited research on teachers' perceptions of translanguaging in EMI-STEM classrooms. While studies outline EMI's challenges (Karabassova & Isidro, 2023), few examine how teachers address linguistic diversity. This study addresses these gaps through a phenomenological approach, using interviews and observations to document practices in the four private schools.

The lack of multilingual STEM resources further complicates instruction, particularly for diverse learners. By advocating for a Multilingual TPACK framework, this study contributes to strategies for enhancing comprehension and equity, informing policy (e.g., translanguaging guidelines) and professional development (e.g., training for foreign teachers in International Schools).

The Research Framework

This study is grounded in the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006), extending Shulman's (1986) Pedagogical Content Knowledge (PCK) to provide a sophisticated model for understanding the intersections of pedagogy, technology, and content knowledge. Specifically, the TPACK framework addresses the increasing need for teachers to effectively incorporate technology into their lesson plans, particularly in challenging learning environments such as STEM and language classrooms (Niyazbayeva, 2023; Taopan et al., 2020). The framework highlights that teaching with technology effectively requires more than simply technical proficiency. Teachers need to be aware about their subject matter (Content Knowledge, CK), have an understanding of how to teach it successfully (Pedagogical Knowledge, PK), and be able to use relevant technology tools (Technological Knowledge, TK).

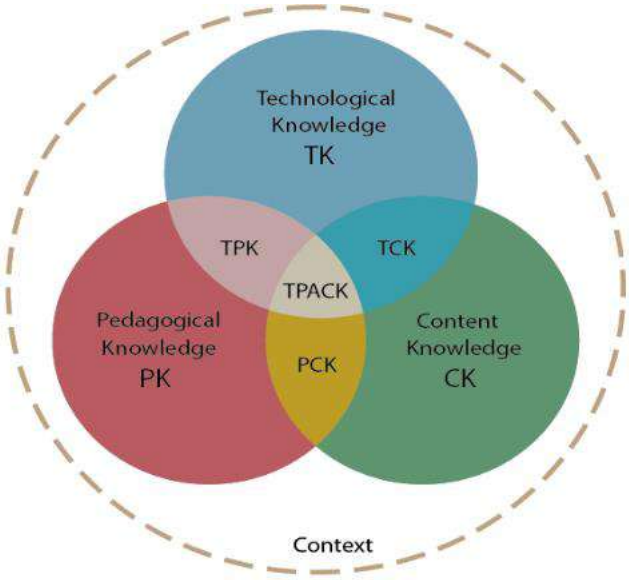
Beyond these separate concepts, the framework emphasizes the points where they intersect:

- Technological Pedagogical Knowledge (TPK) about understanding how to use technology to improve teaching methods;
- Technological Content Knowledge (TCK) as the ability to use technology to deliver information in an understandable manner.

- Pedagogical Content Knowledge (PCK) as using pedagogical techniques in line with certain subject requirements (Taopan et al., 2020; Thyssen et al., 2023).

Figure 1

The TPACK Framework



Note. The TPACK framework, illustrating the interplay of technological, pedagogical, and content knowledge is from http://tpack.org.

Thus, by dynamically combining these components, teachers are asked to transcend above isolated expertise of pedagogy, subject, or technology into the real classroom (Iswadi et al., 2019; Morales et al., 2022; Niyazbayeva, 2023; Taopan et al., 2020). While TPACK effectively integrates technological, pedagogical, and content knowledge, it does not fully account for ecological factors, such as systemic collaboration or linguistic diversity, which are critical in multilingual EMI-STEM contexts (Smagulova, 2021).

In EMI-STEM, where interdisciplinary approaches and technologically advanced environments are prioritized, the TPACK framework is especially relevant because it encourages educators to integrate their expertise across content, pedagogy, and technology. This integration helps move beyond isolated expertise, fostering a more holistic

understanding of how to effectively teach complex concepts in these fields. However, teachers may still face challenges related to inadequate resources, unstable infrastructure (such as loading internet connections), and low technology proficiency. Furthermore, the efficacy of instruction may be diminished by a mismatch between the use of technology and particular educational objectives (Morales et al., 2022; Taopan et al., 2020). Besides, teachers frequently find it challenging to incorporate these areas smoothly, particularly in multidisciplinary courses where it is necessary to overcome obstacles including time management, curricular standard alignment, and interdisciplinary communication (Chai et al., 2020; Morales et al., 2022).

On the other hand, TPACK offers equally important opportunities. Meaningful technology integration can support autonomous learning practices, multimodal learning, and increased student engagement. According to Niyazbayeva (2023), mobile solutions that adhere to TPACK principles have been shown to be successful in lowering student anxiety and increasing involvement in language learning. Similar to this, the TPACK framework in STEM education helps educators to design creative, dynamic classes that connect theory to real-world application, meeting the needs of 21st-century learning (Morales et al., 2022).

Thus, the framework supports the development of creative, student-centered learning environments that effectively and sustainably incorporate technology and the content. Because of its flexibility, teachers may create content-driven and technologically aided learning experiences that are both effective and appropriate for a variety of educational contexts, including STEM and EFL settings. Building instructors' confidence in balancing all three components must be the main goal of professional development initiatives as educators continue to implement the TPACK model.

Integrating Translanguaging within the TPACK Framework

Translanguaging, a pedagogical strategy that leverages students' linguistic repertoires to enhance comprehension and inclusivity (García & Wei, 2015, Niyazbayeva 2023), is integrated within the PK and PCK domains of TPACK. In multilingual EMI-STEM classrooms, translanguaging may involve using students' first languages to clarify concepts or foster engagement, complementing content delivery. This study does not explore the relationship between technology and translanguaging, treating them as separate strategies. Technology supports accessibility and interactivity (TCK/TPK), such as through digital simulations, while translanguaging facilitates meaning-making (PCK/PK) by connecting content to students' linguistic backgrounds. This integration not only supports comprehension and participation but also fosters a more inclusive learning environment where all students feel valued.

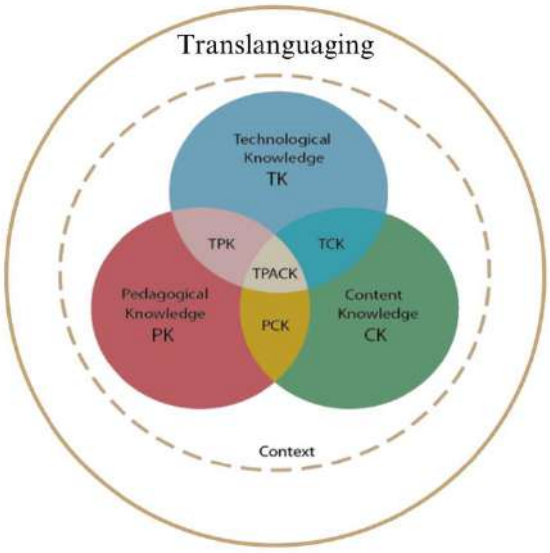
Similarly, Morales et al. (2022) highlight the importance of translanguaging as a pedagogical strategy that enables teachers to create culturally responsive classrooms. Their research demonstrates that by embracing students' linguistic diversity, educators can develop more effective teaching strategies that resonate with learners' backgrounds and experiences. In this study, translanguaging is viewed as a vital component of the TPACK framework, specifically within the pedagogical and content knowledge categories, rather than the technological domain. Teachers, especially in multilingual classrooms, will deliberately utilize students' linguistic abilities to enhance understanding and engagement. By integrating translanguaging within the pedagogical and content domains of the TPACK framework, the study underscores the significance of culturally responsive teaching methodologies. This strategy aligns with the fundamental objective of TPACK, which is to promote successful teaching through the integration of various types of knowledge,

including pedagogical techniques, content expertise, and, in this case, multilingual competencies.

The Multilingual TPACK framework (Figure 2) extends TPACK by incorporating translanguaging as a pedagogical component, recognizing that a monolingual TPACK approach may not fully support students' comprehension in diverse settings (Morales et al., 2022). While the study primarily examines the independent roles of technology and translanguaging, it considers their potential synergy, such as multilingual digital resources, as a secondary interest. This approach aligns with culturally responsive teaching, promoting equitable learning in EMI-STEM classrooms.

Figure 2

Translanguaging-Integrated Multilingual TPACK Framework



Note. The Translanguaging-Integrated Multilingual TPACK Framework, developed for this study, extends the TPACK model (Koehler et al., 2013) to incorporate translanguaging practices in multilingual EMI-STEM classrooms.

Applying TPACK in EMI-STEM education presents challenges, including English-only digital resources, teachers' limited technological proficiency, and alignment with

curriculum standards (Chai et al., 2020). These may hinder effective instruction, particularly in multilingual settings where language barriers persist (Mustafina, 2016). However, TPACK enables dynamic, multimodal lessons that enhance engagement and connect theory to practice, such as through interactive STEM activities (Morales et al., 2022). Translanguaging within TPACK fosters inclusivity by reducing cognitive load and valuing linguistic diversity (Otheguy et al., 2019).

Professional development in Multilingual TPACK can equip teachers to balance these components, supporting 21st-century STEM education (Niyazbayeva, 2023). This framework structures the study's analysis of how teachers in private EMI-STEM schools implement technology and translanguaging, informing strategies for effective and equitable instruction.

Summary

To sum up, this literature review has examined important topics about the use of EMI in STEM education in Kazakhstani classrooms, emphasizing the functions of technology and translanguaging as instruments to improve student engagement and content comprehension. This study illustrates the benefits and drawbacks of EMI-STEM in multilingual situations by looking at teachers' perspectives, the complexities of language hierarchies, and the incorporation of technology through the TPACK framework. These insights underscore the need for practical strategies to support diverse learners and inform teaching practices. The following chapter will detail the methodology employed in this study, outlining the qualitative approach used to investigate teachers' experiences and perceptions in these unique educational settings.

Chapter 3: Methodology

This study aimed to explore teachers' experiences and approaches in English-medium STEM (EMI-STEM) education within Kazakhstani lower secondary schools. Moreover, the study intended to clarify whether the use of technology and translanguaging in STEM classrooms facilitated better comprehension, engagement, and academic performance among students based on the teachers' perceptions.

Research Design

To effectively address the purpose and research questions, the qualitative approach, namely phenomenology approach was used. The research was focused on identifying the benefits and drawbacks of English-medium STEM education as a phenomenon and collecting data from participants who had experienced this phenomenon. According to Merriam and Tisdell (2016), phenomenology showed the significance that people gave to their experiences. Moreover, it helped uncover the meaning individuals attributed to experiences; hence this method worked well for investigating perceptions. This helped draw conclusions on the practical implications of STEM education and the useful approaches for educational policy and practice.

In contrast to other qualitative methods like case studies, which frequently concentrated on in-depth examination within a constrained system, or grounded theory, which aimed to produce theories from data, phenomenology focused on revealing the essence of common experiences among people. The study's goal of finding common themes in the ways that EMI-STEM instruction affected students' understanding, involvement, and academic achievement from the viewpoint of the teachers was effectively served by this design. The phenomenological method was therefore ideal for investigating the deeper meanings that Kazakhstani educators applied to their methods,

such as incorporating technology and translanguaging, and how these methods influenced student outcomes.

Research Sample

For this phenomenology study, participants were identified using purposeful sampling. Participants were selected purposefully based on their experience with EMI and CLIL that helped in selecting information-rich cases for in-depth study (Creswell & Creswell, 2017). To get more precise data, criterion-based sampling was used, which involved identifying a small number of important individuals who readily met the inclusion criteria (Merriam & Tisdell, 2016). The teachers were selected based on their teaching experience and current domain. The potential participants had at least 2 years of teaching experience, and their current teaching domain was in one of the STEM subjects—science, chemistry, physics, mathematics, or biology in English in the secondary schools. To identify potential participants, snowball sampling was used where the initial teacher participant was asked to recommend several potential participants to avoid the potential breach of anonymity and confidentiality. These initial contacts were asked to recommend other potential participants who might have fit the study's criteria. To further protect the confidentiality and anonymity of all participants, no single participant was identified by name during this process. To contrast teachers' perceptions effectively, 6 STEM-teachers in the relevant targeted subjects were recruited for interviews and class observations at four different types of schools.

Research Site

The present study aimed to investigate the perceptions of teachers in EMI-STEM classrooms in Kazakhstan. Therefore, the research focused on schools where STEM subjects were taught in English. Government initiatives had led to the integration of English Medium Instruction (EMI) in specialized schools, such as NIS and BIL, to align

with international education standards. While there had been a few studies on the perceptions of students and teachers of BIL and NIS schools (Hajar et al., 2023; Maximova, 2020), other schools apart from NIS and BILs had not been researched. Therefore, this study compared four types of schools where science, technology, engineering, and math were taught through EMI, in Kazakhstan. The four different types of schools were selected according to their language policy and content focus:

- 1 private STEM school whose curriculum prioritized STEM subjects through the adoption an international curriculum (STEM school)
- 1 technology-focused private school that integrates an international curriculum (Tech school)
- 1 private school with diverse students whose international curriculum prioritized full EMI immersion (International school)
- 1 international school following the IB model (IB school)

Private schools were selected due to their established EMI-STEM programs, offering a rich context for exploring teacher practices in non-specialized settings, unlike elite NIS/BILs. The small sample size aligns with phenomenological research, which prioritizes depth over breadth (Creswell, 2013). The variety allowed for cross-contextual insights into EMI-STEM teaching practices in multilingual settings.

Data Collection Instruments

This study applied a phenomenological qualitative approach, focusing on understanding the lived experiences of teachers through semi-structured interviews and classroom observations. These methods captured the depth and richness of teachers' experiences, focusing on their integration of technology and translanguaging strategies in STEM classrooms within English as a Medium of Instruction (EMI) settings.

Data were collected over for approximately two months, from December until the end of January, considering the school schedule. The process began by obtaining official permission from the school principals to conduct research in their schools through a formal letter issued by my institution. This letter clarified that while research would be conducted within their schools, principals and administrators would not be informed which teachers were selected as participants to uphold strict anonymity and confidentiality. Once permission from the principals was secured, I used a snowball sampling approach to identify participants, starting with teachers I was familiar with in the targeted schools. These initial contacts were asked to recommend other potential participants who may fit the study's criteria. To further protect the confidentiality and anonymity of all participants, no single participant was identified by name during this process.

After establishing initial contact with potential participants via email or WhatsApp (see recruitment letter), I arranged a call to share the study's purpose, explained the data collection procedure, and requested permission to observe their lessons. These observations focused solely on the teachers' instructional methodologies, particularly their use of technology and translanguaging strategies to enhance comprehension in CLIL environments. During classroom observations, I carefully documented the methods employed without compromising teacher identities.

Classroom observations provided complementary contextual data, allowing for a more holistic view of instructional dynamics of the teachers. Specifically, non-participant observations focused on real-time integration of technology and translanguaging practices as they occur in the classroom. This method enabled for the collection of rich, detailed information on the organization of the environment, the interaction between individuals, and the implementation of the curriculum. The main areas of observation were: (1) the use of technology to enhance student comprehension, (2) the use of translanguaging

techniques to promote comprehension, and (3) the strategies teachers used to balance instruction in English with students' native languages in STEM settings. By integrating these observational insights with the interview data, the study sought to offer a comprehensive understanding of the usage of languages and technology experienced by teachers in the context of EMI in STEM education. The teacher observation protocol is included in the appendix B. Due to logistical constraints, classroom observations were limited, relying primarily on teacher interviews. To enhance data validity, future studies could triangulate interviews with student focus groups and lesson artifact analysis (e.g., worksheets, digital tool outputs) to capture direct evidence of translanguaging and technology use (Creswell & Creswell, 2017).

After completing the classroom observations, I conducted follow-up interviews with the teachers to explore their perspectives on the use of technology and translanguaging in enhancing student understanding. Semi-structured interviews provided participants with the flexibility to freely express their experiences (Creswell & Creswell, 2017). This approach was ideal for capturing the richness of their experiences, as it enables participants to elaborate on their responses and provide detailed insights into their educational context. The list of interview questions is included in the appendix A.

The interview questions included reflective prompts about the observed lessons therefore were managed after the observations. In order to maintain confidentiality and create a safe environment, the interviews took place offline, in a peaceful setting outside the school, like a café or another venue selected by the participant. Each interview lasted approximately one hour, giving teachers the freedom to voice their opinions without worrying about being overheard by administrators or other teachers.

Data Analysis

After transcribing all interviews and finalizing observation notes, I applied thematic analysis using the six-phase model by Braun and Clarke (2006), informed by a descriptive phenomenological orientation. Although Braun and Clarke's approach is not inherently phenomenological, it can be adapted to foreground participants' lived experiences—as in this study, which focuses on how teachers make meaning of their integration of technology and translanguaging in EMI classrooms. The data will be coded using a framework informed by key themes in EMI and translanguaging literature, with a focus on: (1) how technology supports students in understanding STEM subjects, (2) translanguaging strategies to foster engagement and learning, and (3) maintaining a balance between native languages and English in classroom instruction.

The analysis began with repeated readings of transcripts and observation notes, followed by manual coding using color-coded highlights and notes in printed and digital documents. Codes such as "switching to L1 for clarity," "students using apps collaboratively," and "teacher modeling with visuals" were developed inductively. These were then reviewed, refined, and merged into broader themes like "translanguaging as instructional scaffolding" and "technology for multimodal engagement."

To make the analytical process clearer, a summary table (Table 1) is included to illustrate how sample codes were grouped into broader themes. This visual representation demonstrates the progression from raw data to thematic categories and clarifies how patterns were identified and refined.

Table 1

Coding and Thematic Analysis of Teachers' Practices in EMI-STEM Classrooms

Sample	Initial code	Subtheme	Final theme
"If I have a task and they do not know one word, I do not write the translation. I write the definitions. Let them read and understand" (Teacher E, Math).	Translanguaging for comprehension	L1 for concept clarity	Translanguaging as pedagogical scaffolding (PK)
"Sometimes I can distribute iPads to students so that they can see visuals of that new topic and play, for example Colorado to understand the topic" (Teacher A, Physics)	Visual scaffolding	Dual-language support	Technology as content comprehension (TCK)

Note. Codes from 2024 interviews and observations with six STEM teachers in four non-specialized private schools in Astana were thematically analyzed per Merriam and Tisdell (2016), capturing translanguaging and technology practices in EMI-STEM classrooms.

Interview data were coded using TPACK domains (TK, PK, CK) and extended to include translanguaging as a pedagogical component, aligning with the Multilingual TPACK framework to analyze how teachers integrate linguistic diversity with technology and content (Morales et al., 2022).

Ethical considerations

Ethical considerations were central to ensuring the integrity of the study and the well-being of all participants. Prior to data collection, all consent materials—including information sheets and consent forms—were submitted to the university's ethics committee for approval, ensuring adherence to strict ethical standards. Consent forms, provided in English, Russian, and Kazakh, outlined the study's objectives, methods,

potential risks, and the voluntary participation. Participants were assured of confidentiality, anonymity, and their right to withdraw at any time without consequence. Two signed copies of the consent form were retained—one for the participant and one for the researcher.

To maintain anonymity, the names of schools, teachers, and any identifiable class information were replaced with pseudonyms, and were not identified in any reports or publications. While complete anonymity could not be fully guaranteed due to the snowball sampling—where participants might have been familiar with each other— but every effort was made to ensure that personal information remained private in the study's interpretation. Therefore, participants were asked to recommend several potential participants to maintain confidentiality and anonymity of the selected teachers.

Strict confidentiality measures were implemented throughout the data collection and storage process. All signed consent forms were collected in printed format and stored securely in a locked drawer, accessible only to me, the researcher. Digital data—including audio recordings, transcripts, interview data, and observation notes—were stored in encrypted files on a password-protected device. No one other than the researcher had access to this data. In compliance with research ethics requirements, the data were retained for five years after the completion of the study to allow for any necessary additional analysis. All information, including digital files and hard copies, was safely deleted. To guarantee total confidentiality, all digital data, including audio recordings, were deleted from all devices, and paper records were destroyed.

Risks of the Research

The research posed minimal risks. Classroom observations had the potential to disrupt lessons or make participants uncomfortable, potentially influencing their behavior.

Parents might also have expressed concerns about their children being observed. To address this, transparent communication was established with all stakeholders. Teachers and parents received detailed explanations of the study's purpose, and their consent was obtained before observations. During observations, the researcher remained unobtrusive, sitting quietly to minimize classroom disruption.

Another potential risk involved participants feeling anxious about sharing personal information or discussing their teaching methods. To mitigate this, interview questions were designed to be open-ended, non-evaluative, and polite. Participants were informed that they could skip any question or withdraw from the study at any time. Additionally, interviews were conducted in the participant's preferred language—English, Russian, or Kazakh—to ensure comfort. All information was anonymized using pseudonyms, and sensitive questions were avoided to prevent discomfort.

Benefits of the research

This study was relevant as it focused on how technology and translanguaging could enhance student performance and comprehension in secondary STEM education. By addressing significant gaps in knowledge about the impact of these two approaches on learning outcomes, the research explored how they could be integrated effectively. As Kazakhstan continues to expand the use of EMI and CLIL, challenges such as language proficiency, teacher preparedness, and the implementation of effective educational strategies remained. This study examined teachers' experiences to develop a deeper understanding of how these challenges influenced student achievement and engagement.

In addition, the research provided valuable insights into the practical application of translanguaging and digital tools within CLIL classrooms, offering solutions for improving teaching strategies in multilingual and diverse settings. The analysis focused on how these

tools supported multilingual communication and interactive learning, contributing to a more inclusive and effective learning environment.

While teachers participating in the study may not have experienced immediate direct benefits, reflecting on their teaching practices during the research process could have positively impacted their professional development. Engaging in this reflective process may have prompted teachers to critically evaluate and improve their use of technology and translanguaging strategies, potentially leading to more effective instruction and enhanced student outcomes in the future. Furthermore, the insights gained from this research could have informed broader pedagogical practices, benefiting other educators and contributing to the overall advancement of education in multilingual contexts.

Conclusion

This chapter presented a qualitative research design informed by a hermeneutic phenomenological approach to investigate English-medium instruction (EMI) in STEM classrooms in Kazakhstan. The study explored the lived experiences of STEM teachers, focusing on how translanguaging and technology were used to enhance student comprehension and engagement. Teachers with at least two years of EMI-STEM experience were selected through purposeful criterion-based sampling, with snowball sampling used to identify additional participants while supporting anonymity.

Data were collected through semi-structured interviews and non-participant classroom observations, focusing on strategies that supported multilingual communication and content understanding. The study involved four types of schools: a private STEM-focused school, a private Tech-focused school, EMI-immersed International school, and the IB International school offering partial EMI-STEM instruction, ensuring a diverse and contextually rich perspective on EMI implementation.

To analyze the data, thematic analysis was employed as a flexible tool within a phenomenological framework, drawing on Braun and Clarke's six-phase process. This approach enabled the researcher to identify and interpret recurring patterns across participants' narratives and classroom practices, grounding themes in the subjective meanings expressed by teachers. Observational data were used to triangulate and deepen insights from the interview accounts.

Ethical procedures included obtaining informed consent in English, Russian, and Kazakh, ensuring anonymity through pseudonyms, and securing both digital and physical data in accordance with institutional guidelines. These practices supported the ethical integrity of the study and respected the rights of all participants.

Chapter 4: Findings

This chapter presents the findings from four private secondary schools in Kazakhstan that implement English-medium instruction (EMI) in STEM subjects. These schools were purposefully selected to reflect under-researched educational contexts beyond the widely studied NIS and BIL schools. The sample includes a STEM-oriented private school (STEM school), a technology-focused private school (Tech school), an international school offering the IB curriculum (IB school), and a private EMI-immersed international school with a diverse student population (International school). By analyzing teacher practices and perspectives across these varied contexts, this chapter explores how translanguaging and technology are used to support student comprehension and engagement in EMI-STEM classrooms. The results are structured thematically corresponding with the research questions, focusing on (1) teachers' perceptions about EMI-STEM, (2) challenges and opportunities, and (3) strategies teachers employ to enhance student comprehension and engagement, particularly through translanguaging and technology integration. By employing a phenomenological approach, the study emphasizes teachers' lived experiences, incorporating insights from both interviews and classroom observations to provide a holistic understanding of the implementation of EMI-STEM education in Kazakhstan.

The Technological Pedagogical Content Knowledge (TPACK) framework was used primarily to organize and analyze data related to Research Question 3, which focused on instructional strategies involving technology and translanguaging. TPACK provided a useful lens for understanding how teachers navigate the interplay between technological tools, content delivery, and pedagogical choices in multilingual settings. While TPACK was not applied directly to RQ1 and RQ2—which focus more broadly on experiences and systemic challenges, connections to core elements of the framework, particularly

Pedagogical Content Knowledge (PCK), appear throughout the findings. These connections are especially evident in how teachers adapt their instructional approaches to scaffold STEM learning in multilingual environments. It is further explored in the discussion chapter to synthesize and interpret findings across all research questions.

Teachers' Experiences with EMI-STEM Education

The data collection shows that teachers across the different school settings aimed to integrate STEM subjects holistically by using a variety of instructional techniques. Their strategies, including scaffolding, visual aids, problem-solving activities, realia using, technology, and explicit vocabulary instruction, reflected a shared goal of making EMI-STEM education more accessible and engaging for students. Thematic analysis of the data revealed two central areas of focus: first, teachers' perspectives on EMI-STEM instruction in Kazakhstan, including the challenges and opportunities they encounter; and second, the strategies they use to promote student comprehension and engagement, particularly through the use of translanguaging and technology.

Teachers' Perspectives of STEM in Kazakhstan

Teachers across different school settings agreed that STEM education in Kazakhstan is still in an experimental phase, with ongoing efforts to develop a consistent and effective approach. While government initiatives have promoted STEM education in specialized institutions, teachers noted that a lack of standardization and clear guidelines has led to inconsistencies in how STEM subjects are applied. Teacher A (Physics, STEM school) shared, "We participated in a conference in Singapore last summer, and even there, there wasn't a clear answer to what STEM education should look like. It depends on many factors, including the culture and available resources." This suggests that Kazakhstan is not alone in facing challenges in STEM education, as even internationally, educational practices continue to evolve.

Several teachers pointed out that STEM in Kazakhstan remains largely theoretical, with insufficient emphasis on practical, hands-on learning. Teacher B (Biology, Tech school) noted: “Kazakhstan is only now introducing STEM education among the teachers. One of the biggest problems, I guess, is that teachers usually teach science only theoretically.” Similarly, Teacher F (Chemistry, STEM school) expressed the importance of integrating theory with practice: “In my understanding, STEM teaching is an integration of theory with practice directly. Many students don’t see the point in learning theory because they don’t understand how it applies to real life”.

Another commonly discussed issue was teacher preparedness and professional development. While training opportunities exist, teachers felt they were often short-term and lacked practical applications. For example, Teacher C (Biology, International School) remarked: “There are a lot of one-day seminars on STEM, but nothing long-term or in-depth. Teachers are sent to courses, but not all of them feel motivated to apply what they learn.” This indicates a gap between theoretical training and classroom implementation, in addition, the lack of follow-up support and opportunities for collaboration leaves teachers to apply these new methods alone, which may reduce their confidence or motivation to implement changes. Combined with institutional pressures, such as curriculum requirements and the emphasis on exam preparation, teachers reported feeling anxious to experiment with innovative STEM practices, ultimately limiting the long-term impact of such training.

Participants believed that exposure to English-language resources and scientific content better prepares students for higher education and future careers. Teacher F (Chemistry, STEM school) noted: “The source of knowledge is extensive everywhere. In English, there are so many resources, and through STEM education, students access

deeper, more in-depth knowledge." While Teacher E (Math, STEM school) highlighted the differences between Kazakh, Russian and English resources:

> When you think of Kazakh or Russian, these are some approaches that have been formed over the years. They are not bad, but they are the same. But when English came into my life, I saw that mathematics can be taught in a different way.

The observation data shows the integration of various engaging techniques that teachers apply in their lessons, such as inquiry-based learning, comparison of theory and life-experience, and student-centered learning (Observation data, 13.01, 16.01, 14.02). Each of the six participating teachers was observed once, resulting in a total of six classroom observations. Therefore, it is important to improve the conceptual clarity, linguistic accessibility, and subject relevance of instructional materials in students' first languages, while also incorporating evidence-based international approaches, such as student-centered learning, formative assessment, and inquiry-based instruction, to enhance engagement and deepen students' comprehension.

Overall, teachers viewed Kazakhstan's STEM education as a work in progress. The most significant long-term benefit of EMI-STEM education is its role in preparing students for university and career opportunities. Since many higher education institutions in Kazakhstan and abroad offer STEM programs in English, students who have studied in EMI settings are at a distinct advantage. Teacher A, a physics instructor at a STEM-focused school, supported this view, saying, "Most universities require English proficiency for STEM majors, so students who learn these subjects in English now will have a much smoother transition later." Beyond academics, EMI-STEM education also enhances students' career prospects, as many industries prioritize candidates with English proficiency.

While they acknowledged EMI-STEM's potential to enrich students' learning and prepare them for global opportunities, teachers emphasized the need for, more practical, hands-on approaches, stronger teacher training programs, improved access to technology and resources across schools, and clearer frameworks for implementing STEM nationwide.

Teachers' Perceptions Towards the Interdisciplinary Approach

Teachers in EMI-STEM classrooms widely viewed STEM as an interconnected discipline rather than a set of isolated subjects, recognizing the natural links between science, technology, engineering, mathematics and language. This perspective reflects a shift away from subject-specific instruction toward cross-disciplinary teaching, where concepts are explored through multiple lenses. Teacher A (Physics, STEM school) illustrated this belief, stating:

> Nature doesn't care about subjects — physics, chemistry, and biology all happen at the same time. I think whatever topic you teach there is always possibility to make connections even to languages, even to history, for example, even when you teach specific law you can always make a reference to history and show some history facts to students.

This view highlights how some teachers see STEM subjects as inherently interconnected, offering opportunities to present scientific concepts in a more holistic way.

However, while the interdisciplinary approach was seen as beneficial, many teachers felt that traditional STEM in Kazakhstan remains largely theoretical, with insufficient hands-on experimentation and real-world application. Teacher B (Biology, Tech School) emphasized, "Kazakhstan is only now introducing STEM education among teachers, and one of the biggest problems is that science is still taught too theoretically. We need to focus more on practical skills."

Several teachers agreed with this statement, mentioning that students often memorize scientific concepts without engaging in active problem-solving or inquiry-based learning. One example came from a Grade 9 biology lesson on enzymes where the teacher used visual aids and realia, such as classroom objects, to explain enzyme-substrate interactions. However, the lesson lacked active investment of the students, who were taking lecture notes rather than conducting hands-on activities (Observation data, Teacher C, Biology, International School, 14.01). While these strategies effectively clarified abstract concepts, the absence of practical work limited opportunities for students to apply their knowledge in authentic scientific contexts.

Moreover, Teacher D (Physics, IB school) noted that while interdisciplinary teaching could expand understanding, the current system still prioritizes subject-specific assessments: “We try to make connections where possible, but each subject has its own curriculum and exams. It’s difficult to break away from traditional teaching when students are evaluated separately in physics, chemistry, and biology.”

However, the biology teacher from an international school mentioned that there is a standardized collaboration between content and language teachers: “We have a department, English Language department. I give that department the list of the words what I want these students to learn and understand” (Teacher C, Biology, International school). This practice applies differentiation of levels in a school system supporting students with lower language proficiency level. Similarly, another Biology teacher from International IB school emphasized the attempt to a similar practice that they tried to compare curriculums with the language teachers and prepare students’ linguistic comprehension before the content material has been introduced but it did not happen in practice. Meanwhile, other teachers highlighted that collaboration between subject teachers is rare. Although interdisciplinary connections could enrich learning, there are few

opportunities for teachers to plan integrated lessons together. Teacher F (Chemistry, STEM school) mentioned:

> In theory, connecting subjects makes perfect sense — chemistry explains the molecular basis of physics concepts, and biology shows how those processes function in living organisms. But in practice, each teacher is responsible for their subject, and we don't always have time to collaborate.

Overall, all four private schools shared similar infrastructure and resources, facilitating EMI-STEM implementation. International School's foreign teachers collaborated with the English department, while STEM, Tech, and IB school teachers relied on personal adaptations, reflecting slight differences in pedagogical approach. While teachers strongly supported the interdisciplinary nature of STEM, they emphasized that effective implementation requires curriculum adjustments, professional development in cross-disciplinary teaching, and greater institutional support. The next sections will explore how teachers address these challenges through specific instructional strategies, language support mechanisms, and technology integration in EMI-STEM classrooms.

Challenges and Opportunities in EMI-STEM

Language Barriers Among Students

A major challenge identified by teachers in EMI-STEM classrooms was the dual difficulty students faced in learning both the subject content and the language of instruction. Many students had limited prior exposure to English outside of school, making it difficult for them to study complex scientific concepts. Teachers highlighted that even students who were proficient in STEM subjects in their native language often struggled when those same topics were taught in English. As one physics teacher explained, "There are two layers of difficulty—first, the complexity of the subject itself, and second, the

language barrier. Even if a student is good at physics in Russian, they may struggle in English" (Teacher A, Physics).

This highlights the additional cognitive load placed on students in EMI-STEM settings, where they must simultaneously develop subject knowledge and language proficiency. Teachers also noted that the language barrier required additional instructional time, as they often had to slow down content delivery to explain basic language structures before addressing scientific concepts. Teacher B (Biology) elaborated:

> They don't use English at home or in their daily life, only at school. Sometimes, they don't even know simple verbs. So, it's always such a time-consuming process when you should teach them from the basics — first, you know, verbs, and then you can go on to the terms. You teach the content, and you teach the English also.

However, the pressure to cover the curriculum meant that teachers often had to prioritize content over language development. Teacher D (Physics) pointed out: "If there is a lot of content, then there is not much time left for the language." This challenge was also apparent in the Grade 7 physics lesson on liquid pressure. The teacher initially explained the concept in English, but when students struggled with the formula for pressure ($P = dgh$), they became disengaged. Noticing this, the teacher switched to Russian to clarify the idea:

> T: "What can you say about this picture?"
>
> S (in Russian): "Одинаково вода вытекает со всех сторон." (The water flows out equally from all sides.)
>
> T: "В жидкостях давление давит во все стороны, вода вытекает со всех сторон. Pressure in all directions." (Observation data, Teacher D, Physics, IB school, 16.01)

This immediate use of translanguaging helped students refocus, yet it also highlighted the ongoing struggle to balance content delivery with language comprehension.

In comparison, teachers also found themselves not confident enough in teaching English as they teach science: “I'm not the English teacher, I'm just a scientist. So, sometimes I can be mistaken in English also” (Teacher B, Biology; Teacher F, Chemistry). This lack of confidence added to the emotional burden on teachers, who felt overwhelmed by the need to prepare lessons that addressed both language and content simultaneously.

Moreover, some teachers believed that introducing a third language too early added unnecessary pressure on students, potentially compromising their understanding of the subject. Teacher E (Mathematics) expressed concern that content knowledge should take priority over language acquisition and contradicts the interdisciplinary approach:

> When children learn a foreign language, it is an additional burden for them. While the child thinks in Russian or Kazakh, you should teach in this language. Until they learn to think in a foreign language, or until there is no obstacle for them in a foreign language, then you can teach a third language. As a teacher of mathematics, I always adhere to the importance of understanding the subject. Language plays a secondary role, but the subject should be taught in the native language.

In summary, teachers perceived language barriers as a major obstacle to student success in EMI-STEM classrooms, often requiring extra time, effort, and emotional investment to balance subject learning and language acquisition. Many teachers expressed the need for greater support and training to navigate these dual challenges effectively while ensuring that students grasped complex STEM concepts.

Newcomers’ Adaptation Period

A particularly challenging situation arises with newcomer students, who have recently transitioned to EMI and lack prior exposure to English instruction. These students

require significantly more time to adjust, and their initial struggles often leave them feeling left behind. Teacher F (Chemistry, STEM School) noted, *"*We have students who joined in grade 7 or 8 and never studied in English before. It's overwhelming for them because they are not only learning chemistry but also a new language at the same time."

Classroom observations revealed that teachers frequently provided additional explanations and relied on peer support strategies to ensure comprehension. In instances where students struggled to follow along, teachers would pause to clarify concepts, simplify instructions, or use translanguaging to reinforce understanding, often encouraging more proficient peers to assist with translations. One teacher also mentioned, "I can see that the main difference is that the students whom I taught before, they think faster, quicker. They don't ask so many questions, like they just read the instructions. The students who are new, they always too many times ask the questions too many times" (Teacher B, Biology, Tech school). Students who were exposed to EMI-STEM for a long time and newcomers, who need to adapt to that curriculum they had never faced.

Time-allocation Issues

From the teachers' perspective, the language barrier is also a time-consuming challenge that affects the efficiency of lesson delivery. Many students require explanations in both English and their first language, which slows the pace of instruction. Teacher D (Physics, IB School) explained, "I often have to say the same thing twice—first in English, then in Russian or Kazakh. Otherwise, half the class doesn't understand." This additional effort limits the time available for interactive discussions, inquiry-based learning, or hands-on experiments, as teachers must allocate more time to linguistic scaffolding. However, most of the teachers expressed that despite the extra workload, they see this as a meaningful responsibility. For many, the priority is establishing students grasp the content, even if it means sacrificing instructional time or adapting lesson plans on the spot. Teacher

B (Biology) shared: “Yes, it takes more time. But if I don’t explain, they’ll leave the classroom not understanding anything. I’d rather spend the time now than have them fall behind later.” Similarly, Teacher F (Chemistry) described this process as an act of care and commitment rather than a burden: “Of course, it adds to our workload, but these students need our support. If using Kazakh or Russian helps them understand faster, I don’t hesitate.” These perspectives reveal that teachers take on the additional linguistic demands willingly, viewing it as part of their role in helping students navigate complex STEM content in an EMI environment. The use of translanguaging is not seen as a shortcut or inconvenience, but rather as a strategic tool to build comprehension and confidence, even if it requires slowing the pace of lessons.

Another challenge is the adaptation of teaching materials and assessments. Since most EMI-STEM resources are designed for native English speakers, teachers must modify textbooks, worksheets, and exams to make them accessible to students with varying English proficiency levels. This increases teachers’ workload significantly. Teacher D (Physics) shared,

> It also takes some time to find the video or content of the desired level. For example, there are different channels explaining different topics on physics, for example, but the level of English there is different, respectively, so, each video must be viewed, to find which one is suitable for the content for us, and which has English more or less suitable for the level of the 7th and 8th graders.

It was also seen from some observations, as teachers frequently paused lessons to rephrase complex concepts and provided additional visual aids or translated glossaries beforehand to help students navigate the material. Furthermore, Teacher D (Physics) explained the usage of worksheets that are prepared for the lesson as meaningful to differentiate various language levels in class:

> So that those who find it difficult, those who quickly perceive the material and quickly understand it, so that they don't wait for everyone else, but can go on their own, for example. Then, if there is a task and there is a large set of words, there must be translations at the bottom to reduce the number of questions from children in my direction.

These actions reflect a broader, shared commitment to ensuring that language barriers do not prevent students from engaging with STEM content.

This need for adaptation is also compounded by limited instructional time allocated for STEM subjects, especially in schools where lesson hours are constrained. Teacher E (Mathematics, STEM School) emphasized the difficulty of balancing language and content instruction within the limited weekly hours: “For example, in our school, physics is only allocated two hours a week. It’s already hard to cover the main program in that time, let alone teach it in English and develop students' language skills”.

Similarly, Teacher F (Chemistry, STEM School) suggested that adding extra hours or offering EMI instruction as an optional course could decrease some of this pressure: “If we’re expected to teach both the content and the language, there should be an additional hour added. Either that or EMI should be offered as an elective so we can properly focus on both aspects without rushing.”

Teacher D (Physics, IB School) also mentioned this issue, explaining that the current curriculum structure limits the depth of instruction: “In IB, we have to balance content delivery with IB-specific skills and assessments — all in just two hours a week. It’s nearly impossible to give equal attention to content, language skills, and inquiry-based learning with such limited time.”

In assessments, teachers also faced the challenge of distinguishing between language-related errors and gaps in subject knowledge. As Teacher A (Physics, STEM

School) explained: “Sometimes students know the concept but struggle to express it in English. When grading, I have to carefully evaluate whether they misunderstood the content or just lacked the right words.” This need for careful assessment highlights how teachers take on dual roles — both content instructors and language facilitators — in an effort to make STEM education more inclusive. Their willingness to adapt materials and scaffold assessments presents a collective effort to create more equitable learning environments, where students can access content regardless of their language proficiency.

Integration of Different Curriculums

Compounding these issues, the curriculum itself is overloaded, placing pressure on both students and teachers. EMI-STEM students must learn complex subjects in English while simultaneously preparing for national exams, such as PISA, which assess their knowledge in their first language. Teacher E (Mathematics, STEM School) pointed out, “Students are exposed to terminology in English, but when they take national exams in Kazakh or Russian, they sometimes struggle to recall the equivalent terms.” This added complexity often meant that lessons focused more on memorizing terminology across languages rather than developing practical skills or engaging in inquiry-based learning.

Besides, teachers described the challenge of navigating multiple educational frameworks without clear guidance. Teacher E elaborated on the confusion this creates:

> Right now, I work with the 10th grade. We have American math, British math, and Kazakh math. The students want to pass both international and national exams, but some topics don’t align. As a teacher, you get lost. You need someone to guide you. Any program, any movement, should have a clear goal — not just for the teachers, but for the students.

Teacher E’s experience stands out for its emphasis on the systemic tension between EMI instruction and national curricular expectations. Her reflection on navigating multiple

curricula—Kazakh, American, and British—illustrates a broader issue of curricular misalignment that complicates teaching in EMI-STEM settings. This suggests that EMI is not only a language issue but a structural and pedagogical coordination challenge. The absence of a unified curriculum or support system left teachers feeling overwhelmed, as they had to juggle multiple educational objectives with limited instructional time. As Teacher D (IB School) noted: "If there's no direction, then it's difficult for the teacher. You end up spending more time figuring out what to teach rather than actually teaching." This may cause teachers' burnout.

As a result, both students and teachers faced increased pressure to keep up with the curriculum while balancing linguistic needs. Teachers expressed the need for greater alignment between EMI instruction and national exams, as the lack of consistency created confusion and added complexity to lesson planning. They also highlighted the importance of clearer guidelines on bilingual competence development to ensure that students could master subject knowledge without compromising their understanding due to language barriers. Additionally, teachers called for institutional support to help navigate the demands of covering multiple curricula within limited instructional time. Without these supports, the current system risks prioritizing memorization and test preparation over the development of critical thinking and practical STEM skills.

Opportunities in EMI-STEM Education

Despite the challenges, teachers highlighted several significant opportunities that EMI-STEM education offers to students. One of the primary benefits is the availability of vast educational resources in English. Unlike in Kazakh or Russian, where STEM materials can sometimes be outdated or complicated, English provides access to a wide range of up-to-date textbooks, research articles, and multimedia content. Teacher D (Physics, IB School) explained, "In English, there are endless resources—videos,

simulations, and interactive websites that explain complex topics better than any traditional textbook." Teachers frequently used online platforms such as YouTube, PhET simulations, and virtual lab environments to supplement instruction, making difficult scientific concepts more accessible (See sub-section on technologies).

Additionally, STEM videos in English often offer clearer explanations than those available in students' first languages. Many teachers noted that scientific concepts are often explained in a more engaging and interactive manner in English, using real-world applications, animations, and step-by-step demonstrations. Teacher B (Biology, Tech School) shared, "Sometimes, even if students don't fully understand the English language, they grasp the concept better because of how well it is illustrated." Observations indicated that students appeared more attentive and responsive when watching visually rich STEM videos, compared to reading traditional textbooks.

Another key opportunity in EMI-STEM education is the integration of STEM projects that connect learning to daily life. Teachers reported that EMI classrooms encouraged project-based learning, where students applied theoretical knowledge to real-world problems. Teacher F (Chemistry, STEM School) noted, "Students don't just memorize formulas—they conduct experiments, design models, and explain their findings, which improves both their understanding of science and their English skills." In one observed lesson, students worked in teams to design eco-friendly water filtration systems, applying chemistry and engineering principles while presenting their findings in English (Observation data, Teacher B, Biology, Tech school, 13.01).

Moreover, some teachers believed that proficiency in STEM subjects could strengthen language acquisition. Teacher A (Physics, STEM School) explained that for students with a strong background in science, the familiarity with content could serve as a scaffold for learning English:

> If a student has good intuition for science subjects — let's say they studied physics in Russian in grades seven and eight and then moved to STEM School in ninth grade — their understanding of physics can actually help them learn English faster.

This perspective positions EMI-STEM not only as a platform for developing scientific literacy but also as a vehicle for language learning, where subject knowledge supports the acquisition of academic English.

In addition, teachers emphasized that EMI-STEM education equips students with valuable skills for future academic and career opportunities. Access to English-language scientific discourse opens doors to international universities, global job markets, and cutting-edge research, positioning students to succeed in an increasingly interconnected world.

While EMI-STEM presents language-related challenges, the benefits of access to high-quality resources, engaging STEM content, hands-on project-based learning, and enhanced career prospects outweigh the difficulties. All participants, despite these challenges, generally view EMI-STEM as an investment in students' futures, equipping them with the language skills and scientific knowledge needed for a globalized environment. International and IB schools' diverse student populations simplified language challenges, requiring adaptive strategies. STEM and Tech schools' less diverse students faced fewer linguistic barriers, allowing teachers to focus on content.

Teachers' Strategies to Encourage Students' Comprehension and Engagement

Teachers in EMI-STEM classrooms apply a variety of strategies to sustain student engagement and improve academic outcomes. Given the dual challenge of understanding both complex STEM concepts and English as the medium of instruction, interactive tasks, real-world applications, and multimodal teaching emerged as the most commonly used

methods. According to teachers, these strategies not only enhanced comprehension but also appeared to encourage students to participate more actively in lessons.

One widely used approach was interactive learning through group work and inquiry-based activities. Teachers encouraged students to collaborate, discuss, and problem-solve together, which they believed provided more opportunities for students to engage with the material. Teacher E (Mathematics, STEM School) explained, “I don’t just give students equations to solve—I let them figure out real-life applications through teamwork. If they discuss it together, they remember it better.” In an observed lesson, students worked in small groups to analyze data and create a mathematical model to predict future population growth (Observation data, Teacher E, Math, STEM school, 31.01). This approach encouraged discussion and critical thinking, making the lesson more engaging for students of varying proficiency levels.

Another strategy mentioned by some teachers was connecting STEM concepts to real-world applications to make lessons more relevant and meaningful. For example, Teacher F (Chemistry, STEM School) described using everyday scenarios to deepen curiosity: “When I ask students why sugar dissolves faster in hot tea than in cold water, they get curious and start thinking about reaction rates. When learning is tied to things they experience every day, they naturally engage more”.
This approach aimed to help students see the practical value of scientific theories, making abstract concepts more concrete and relatable.

Observations indicated that some students appeared more engaged during discussions that connected chemistry concepts to real-world experiences (Teacher B, Biology, Tech school, 13.01). In these instances, the teacher motivated students to contribute examples from their own lives and asked follow-up questions, suggesting a connection between the lesson content and their curiosity.

Teachers also relied on multimodal teaching, incorporating visuals, videos, and hands-on activities to cater to different learning styles. In a biology lesson observed at the Tech School, Teacher B used a combination of diagrams, real plant samples, and short video clips to explain photosynthesis (13.01). “Some students understand better through visuals, others through hands-on work. I try to mix different formats so that everyone has a way to engage with the material,” she explained. Students who had struggled with textbook-based explanations of photosynthesis showed increased engagement when examining real plant leaves under a microscope and identifying different structures.

Despite these efforts, teachers actively adjusted their approaches to maintain engagement across students with varying language proficiencies. In one physics lesson, the teacher noticed a group of students disengaging from a problem-solving activity due to difficulty understanding the task requirements in English. Recognizing the barrier, the teacher promptly re-explained the instructions in Russian, which helped the students quickly refocus and collaborate with their peers (06.12). This demonstrated the teacher’s responsiveness to language challenges and reinforced the use of translanguaging as a deliberate strategy to support participation and ensure comprehension.

Differentiation Strategies in EMI-STEM Classrooms

To address challenges, teachers reported using a range of differentiation strategies, with translanguaging emerging as a common approach. Many teachers used students’ first languages (Kazakh or Russian) to check understanding, provide explanations, or scaffold learning when necessary. “I always mix languages—if students don’t understand a concept in English, I explain it in Russian. Otherwise, they lose time trying to decipher the language instead of focusing on the content” (Teacher D, Physics, IB school).

Observations confirmed that teachers frequently switched between English and students’ first languages, particularly during complex explanations or when responding to

students' questions (Teacher A, Teacher B, Teacher D, Teacher E, Teacher F). In several observed lessons, students themselves initiated translanguaging by asking for clarifications in Kazakh or Russian, after which teachers briefly explained in the requested language before switching back to English.

Another frequently used strategy was simplifying instructional language while maintaining academic terminology. Teachers reported that they often rephrased complex explanations into simpler English but ensured that key subject-specific terms remained unchanged. “I don’t translate scientific terms, but I simplify the sentences around them. That way, students focus on learning the new vocabulary while still understanding the concept” (Teacher B, Biology, Tech school). Observations showed that teachers frequently used shorter, more direct sentences, avoided unnecessary lexis, and provided visual aids to support comprehension. For instance, in a biology class, the teacher introduced the term "photosynthesis" and kept the scientific term in English. However, they simplified the surrounding explanation: "Plants make food using light. This process is called photosynthesis” (Observation data, Teacher B, Biology, Tech school, 13.01). Visual aids, like diagrams, helped to provide better explanation, helping students connect the term with its meaning. In another lesson, the teacher avoided complex sentence structures, opting for shorter, clearer instructions like: "First, measure the water. Then, add the salt. Finally, stir" (Observation data, Teacher D, Physics, IB school, 16.01). This allowed students to focus on key content without getting lost in language complexity.

Peer support was also encouraged as a strategy to help students navigate language difficulties. In some classrooms, teachers deliberately paired students with stronger English skills with those who struggled, allowing them to work collaboratively on tasks. “Students learn best from each other—sometimes they explain things in a way that makes more sense to their peers” (Teacher C, Biology). This was evident in observed group

activities, where students frequently assisted each other by paraphrasing instructions or summarizing key points in their first language before switching back to English for discussion.

To sum up, while language barriers remain a significant challenge in EMI-STEM education, teachers employ various strategies to overcome these difficulties. Translanguaging, simplification of instructional language, and peer collaboration help students bridge the gap between content knowledge and language proficiency. These findings indicate that rather than strictly enforcing English-only policies, teachers recognize the value of linguistic flexibility in supporting students' learning and engagement in STEM subjects.

Teachers' Use of Translanguaging

Teachers across different school contexts demonstrated a generally positive attitude toward translanguaging, recognizing its effectiveness in supporting student comprehension. Rather than viewing it as a barrier to English acquisition, teachers strategically used students' first languages (Kazakh or Russian) to scaffold learning, clarify complex concepts, and maintain lesson flow. Observations confirmed that translanguaging was used in multiple classrooms, though its frequency varied across schools and contexts. Teachers employed translanguaging most often during whole-class instruction when introducing new terminology or clarifying complex concepts. In one-on-one interactions, it was used more selectively, typically to address misunderstandings or provide individualized support. In several lessons, students also initiated translanguaging, asking questions or seeking clarification in Kazakh or Russian, which teachers briefly responded to before switching back to English.

A key application of translanguaging in scaffolding was seen in cases where students needed additional linguistic support to grasp scientific concepts. In a physics

lesson, for example, Teacher D used translanguaging to bridge students' prior knowledge with new academic content. The teacher first explained in Russian, "В жидкостях давление давит во все стороны" ("Pressure in all directions"), reinforcing the concept in English. When a student asked for clarification, Teacher D continued by providing another example: "In an aquarium, в бассейнах, жидкость действует в определенной глубине" ("In pools, liquid acts at a certain depth"). This gradual shift between languages helped scaffold the student's understanding of the concept.

Teachers also used translanguaging to facilitate vocabulary acquisition, helping students connect new terms with familiar concepts. In a biology lesson, Teacher B encouraged a student to recall the word growth by prompting them in Russian before guiding them to the English equivalent:

> Teacher B: Young plants and animals get bigger. This is called…
>
> Teacher B: Bigger значит—? (Bigger means—?)

Similarly, in chemistry, translanguaging was used to explain abstract concepts. Teacher F (Chemistry, STEM school) highlighted how switching between languages allowed students to first articulate their reasoning in their first language before expressing it in English:

> When we discuss reaction rates, I ask students in Kazakh or Russian: 'Why does sugar dissolve faster in hot tea than in cold water?' Once they explain in their first language, I guide them to express the same idea in English: 'Because of increased molecular movement.' This way, they understand the logic before struggling with the terminology.

Beyond scaffolding, translanguaging was also seen as a practical way to manage classroom performance efficiently. Teachers reported that allowing occasional use of students' first languages prevented unnecessary delays. Teacher E (Mathematics) explained, "If a student asks for clarification in Russian, I answer in Russian. Otherwise,

they might waste several minutes trying to figure out what I mean in English." Similarly, Teacher F (Chemistry) noted, "If I see students hesitating, I briefly switch to Kazakh, confirm they understand, and then continue in English. It keeps the lesson moving. However, teachers acknowledged limitations in the use of translanguaging, particularly in assessments. Since most formal evaluations followed English-only policies, teachers had to find ways to balance language support with test preparation. Teacher A (Physics, STEM school) stated, "Officially, we can't provide translations in assessments, but if it were allowed, I would do it for students who truly struggle with the language but know the subject." Similarly, Teacher D (Physics, IB school) mentioned simplifying the wording of test questions while keeping key academic terms in English to ensure students focused on content rather than decoding complex language. Observations confirmed that during test review sessions, some teachers used Kazakh or Russian to clarify difficult concepts, though they reminded students that the actual exams would be in English. Despite these efforts, teachers recognized that language barriers continued to impact student performance, especially when assessments required understanding nuanced instructions or expressing answers in academic English.

Overall, translanguaging was widely accepted as a valuable instructional tool, particularly in scaffolding difficult concepts, reinforcing key vocabulary, and maintaining student engagement. Teachers demonstrated a thoughtful integration of pedagogical and content knowledge by using students' first languages strategically to clarify complex STEM concepts while key subject-specific terms remained in English. By doing so, they navigated the interplay of language and content instruction that is central to EMI-STEM education. STEM and Tech schools' less diverse students enabled frequent Kazakh/Russian translanguaging. International School's foreign teachers used minimal translanguaging, relying on realia and student translations due to diverse student languages

and their own limited Kazakh/Russian proficiency. IB School teachers embraced student-led translations, reflecting openness to linguistic diversity. Collaboration with the English department was unique to International and IB schools. Translanguaging's role in scaffolding content, rooted in teachers' experiential challenges (RQ1), contrasts with technology's focus on content delivery, as seen in RQ3b. While translanguaging leverages linguistic diversity to enhance comprehension, technology often operates independently, highlighting a gap in their integration.

Teachers' Use of Technology

Teachers across different school contexts acknowledged the importance of technology in EMI-STEM education, particularly in making complex scientific concepts more accessible. However, direct integration of technology in daily lessons was limited, with most teachers using it as a supplementary tool rather than a core instructional strategy. Interviews revealed that while teachers frequently relied on YouTube videos, virtual labs, and educational apps such as Quizlet, Kahoot, and Canva, these tools were primarily used for content delivery rather than fostering interactive engagement.

One of the most commonly used technological tools was YouTube, which teachers found particularly helpful for demonstrating scientific experiments, explaining abstract concepts, and reinforcing difficult topics. Teacher A (Physics, STEM school) noted, "We don't always have the necessary lab equipment, so I show students video demonstrations of experiments. It helps them visualize concepts that would be impossible to replicate in the classroom." Similarly, Teacher F (Chemistry, STEM school) emphasized that videos often provided clearer explanations than traditional textbooks: "Many chemical reactions happen too quickly to observe in real-time. Showing a slow-motion video of a reaction helps students grasp what's actually happening". So, teachers used technology to enhance content delivery and student comprehension, utilizing digital tools to make complex

concepts more accessible. The ability to pause, replay, and analyze visual content gave students the opportunity to engage more deeply with the material, promoting a richer understanding of scientific processes.

Teachers also mentioned using virtual laboratories and simulations to help students explore scientific concepts that require specialized equipment. However, these tools were mostly assigned for independent learning rather than actively incorporated into lessons. Teacher C (Biology, International School) explained, "I suggest interactive simulations for students to try at home. It's useful, but we rarely have time to integrate them into classroom activities." This suggests that while virtual labs are available, time constraints and curriculum demand limit their full integration into STEM instruction.

Beyond content delivery, some teachers utilized educational apps such as PhET (https://phet.colorado.edu/), Kahoot (https://kahoot.com/), and Blooket (https://www.blooket.com/) for assignments, vocabulary reinforcement, and review activities. Teacher D (Physics, IB school) shared, "Students find it easier to memorize scientific terms when they use Quizlet. It's more engaging than simply reading definitions." Similarly, Kahoot was often used to make review sessions more interactive: "It adds an element of competition, which keeps students motivated," said Teacher E (Mathematics). Despite these benefits, teachers acknowledged that such tools were mainly used outside of core instruction, either as homework or as a quick activity at the end of a lesson.

However, teachers also pointed out barriers to using technology more extensively in EMI-STEM classrooms. The most frequently mentioned challenge was time constraints, as covering subject content in English already required additional explanation and scaffolding. Teacher F (Chemistry) explained, "I would like to use more digital tools, but when you're already spending extra time making sure students understand the concepts in

English, there's not always room for more activities." Additionally, some teachers mentioned a lack of access to devices and reliable internet in certain schools, which made consistent technology use difficult.

Overall, while teachers recognized the value of technology in enhancing STEM learning, its use remained largely focused on content delivery rather than hands-on student interaction. From a TPACK perspective, teachers primarily benefit their technological knowledge (TK) to support content knowledge (CK) by using digital tools like YouTube videos and simulations to demonstrate scientific concepts and reinforce subject-specific vocabulary. However, the integration of technology into pedagogical practices (PK) was less pronounced. Most technology use was teacher-led, serving as a means to present information and clarify complex ideas, rather than encouraging student-driven exploration or interactive digital learning experiences. This suggests that while teachers are aware of technology's potential, its full integration into classroom practices — where technology, pedagogy, and content knowledge work in tandem — remains an area for further development.

Summary

This chapter explored the key findings from teacher interviews regarding the implementation of EMI-STEM education in Kazakhstani secondary schools. The findings were organized around the study's research questions, addressing teachers' experiences, challenges, engagement strategies, and the role of translanguaging and technology in STEM instruction.

Teachers generally viewed STEM education as an integrated discipline, using scaffolding, real-world applications, and multimodal teaching to support student comprehension. However, language barriers posed a significant challenge, particularly for newcomer students with limited English proficiency. To address this, teachers relied on

translanguaging, simplifying instructional language, and peer support to help students engage with complex STEM content. While translanguaging was widely used for scaffolding and maintaining lesson flow, its application was limited in formal assessments due to institutional policies favoring English-only testing.

Teachers also highlighted the opportunities provided by EMI-STEM education, particularly in terms of access to high-quality resources, interactive learning materials, and future university and career prospects. Despite these advantages, the use of technology in the classroom remained primarily teacher-led, with YouTube videos, virtual labs, and educational apps being used for content delivery rather than interactive engagement. Time constraints and curriculum demands were cited as the main barriers to fully integrating technology into instruction.

Overall, the findings indicate that while EMI-STEM education presents both challenges and opportunities, teachers play a crucial role in bridging the language gap, fostering engagement, and adapting instructional strategies to support student learning. From a TPACK perspective, teachers demonstrated their ability to intertwine technological, pedagogical, and content knowledge to navigate the complexities of EMI-STEM instruction. However, the observations also reveal that technology was primarily used as a content delivery tool rather than being fully integrated into interactive, student-centered learning. These insights lay the foundation for the next chapter, which will discuss these findings in relation to existing literature, highlighting their implications for STEM education policy and practice through the lens of the TPACK framework.

Chapter 5: Discussion

This chapter explores the extent to which Multilingual Technological Pedagogical Content Knowledge (TPACK), as an integrated model combining translanguaging and traditional TPACK, analyzes instructional practices and existing literature. Drawing on the key literature and findings from this study, the chapter examines teachers' perceptions of technology and translanguaging, with particular attention to how these perceptions shape pedagogical strategies that enhance student engagement and comprehension as secondary outcomes. While the original TPACK framework emphasizes the intersection of content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) (Koehler et al., 2013), the multilingual adaptation used in this study includes translanguaging to account for the linguistic diversity (Cenoz & Gorter, 2017) present in Kazakhstani classrooms.

Findings revealed that translanguaging and technology were commonly used across schools, but largely functioned as separate practices. School-specific approaches to translanguaging varied, as did levels of access to technological resources. However, there was a consistent lack of intentional integration between these two strategies, representing a missed opportunity to enhance EMI-STEM instruction in multilingual settings. Following the three overlapping dimensions of the TPACK framework, the discussion begins with an analysis of translanguaging as a pedagogical tool (PK), followed by its role in scaffolding content knowledge (CK), and concludes with an examination of technology use alongside translanguaging (TK), highlighting their separate integration as a limitation.

The study's phenomenological approach is examined in relation to recommendations that address the disconnect between translanguaging and technology. The chapter also reflects on how the study's phenomenological approach helped uncover these patterns and concludes by linking the findings to key literature (e.g., Drijvers et al.,

2016; Macaro, 2018), offering implications for policy, teacher training, and future research grounded in teachers' lived experiences.

Translanguaging and Pedagogical Knowledge

Teachers in Kazakhstan view English-medium STEM (EMI-STEM) pedagogy as a developing yet challenging area of practice. Despite the government's efforts to promote EMI-STEM as a means of enhancing global competitiveness (Karabassova, 2018), teachers reported that its implementation remains experimental and inconsistent. While mainstream schools struggle with curriculum adaptation, limited resources, and language-related barriers (Smagulova, 2021), teachers in private STEM and international schools described greater access to international curricula, professional development, and instructional flexibility. However, these advantages did not eliminate the core challenge of balancing language and content in linguistically diverse classrooms. In non-specialized private schools, teachers reported greater challenges with linguistic diversity compared to specialized institutions like NIS, as students' varied English proficiency levels necessitated informal translanguaging.

The findings indicate that translanguaging plays a central role in how teachers navigate these challenges. Rather than viewing translanguaging as a policy deviation, teachers used it as a pedagogical strategy to clarify content, support comprehension, and maintain student engagement, especially for learners with varying levels of English proficiency. Common strategies included simplifying explanations, incorporating multilingual visual aids, and allowing students to process ideas in Kazakh or Russian before expressing them in English. These practices reflect teachers' efforts to scaffold both language and content, drawing on their awareness of students' linguistic profiles (García & Wei, 2015; Mendoza et al., 2023).

However, translanguaging practices varied across school contexts. In STEM and tech-focused schools, translanguaging was common and teacher-led, whereas in international schools, often staffed by foreign teachers with limited knowledge of local languages, it was more student-driven, relying on visuals and peer translation. In IB schools, translanguaging occurred mostly in Russian, reflecting its dominant sociolinguistic status (Goodman & Tastanbek, 2019). Teacher C, for example, used visual supports extensively to compensate for her limited Russian and Kazakh. These adaptations demonstrate flexibility, but also expose a disconnect between official EMI policies, which emphasize English-only instruction (Karabassova & Isidro, 2023), and classroom realities where translanguaging is both necessary and effective.

Despite broad support for translanguaging, some educators expressed hesitation, noting that overreliance on students' first languages might hinder long-term development of academic English. These tensions reflect the broader policy-practice divide, in which teachers must balance language development goals with content accessibility. Moreover, although translanguaging was part of daily instruction in many schools, assessments, particularly in STEM and tech schools, remained strictly in English, reinforcing the hidden nature of translanguaging practices (Bedeker et al., 2023). Only the IB school explicitly incorporated translanguaging into both instruction and evaluation.

Overall, these findings echo literature positioning translanguaging as a pedagogically informed response to the complexities of EMI (García & Wei, 2015; Otheguy et al., 2019). As Karabassova and Isidro (2023) argue, translanguaging serves as both a scaffolding tool for students and a coping mechanism for teachers, especially when navigating misalignments between students' linguistic repertoires and policy-driven expectations for English proficiency.

Translanguaging operates within teachers' Pedagogical Knowledge (PK) in the TPACK framework. It supports differentiated instruction and provides a flexible tool for addressing the needs of multilingual learners in EMI-STEM classrooms. However, this pedagogical adaptability remains largely teacher-driven and informal, with little formal training or institutional support for translanguaging practices.

Translanguaging and Content Knowledge

The literature review identified translanguaging as a pedagogical tool for scaffolding content knowledge in multilingual EMI contexts, yet highlighted a lack of research on its use in complex STEM subjects, particularly in underexplored environments such as Kazakhstan's private schools (Cenoz & Gorter, 2017; Macaro et al., 2018). This study addresses that gap by examining how teachers apply Multilingual TPACK, specifically the intersection of content knowledge (CK) and translanguaging, to support student comprehension in EMI-STEM settings. To provide a more nuanced understanding, this section is divided into two subsections: teacher-driven translanguaging, where scaffolding originates from the teacher's instructional design, and student-driven translanguaging, where learners initiate language use to facilitate peer learning and conceptual processing.

Teacher-driven Translanguaging

The findings show that teachers in STEM and Tech schools responded to students' difficulties with English-only instruction by using multilingual scaffolding strategies to support content understanding. These included the use of bilingual terminology, culturally familiar expressions, and the strategic incorporation of students' home languages to explain complex concepts, especially in terminology-heavy subjects such as chemistry and biology. These approaches helped reduce students' cognitive load and supported smoother conceptual transitions (Otheguy et al., 2019; García & Wei, 2015).

Teachers also utilized tools such as multilingual glossaries to reinforce key terminology in both English and students' first languages. These resources not only enhanced retention but also promoted learner confidence, as evidenced in lesson observations from several classrooms. In international school contexts, where teachers were often unfamiliar with local languages, strategies such as realia and peer translation were used to achieve similar goals. In the IB school, student-led translation played a more central role in classroom discourse, contributing to peer learning and fostering metalinguistic awareness discussed in Mendoza et al. (2023). These practices also align with Li Wei's (2018) view of translanguaging as a means to leverage linguistic repertoires for content mastery, filling the literature gap by showcasing context-specific scaffolding in Kazakhstan's EMI-STEM settings.

Students-driven Translanguaging

In addition to teacher-led strategies, the study found that students themselves used peer-based translanguaging to understand challenging STEM subjects. Students frequently used Kazakh or Russian to clarify concepts during group projects and problem-solving tasks before presenting them in English. Teachers saw this as proof of active learning and meaning-making rather than as a breach from EMI norms.

This behavior reflects what García and Wei (2015) describe as "translanguaging instinct" that is the natural tendency of multilingual learners to draw on their entire linguistic repertoire when making sense of unfamiliar or abstract content. Rather than viewing language boundaries as fixed, students fluidly moved between languages to construct understanding, negotiate meaning, and support one another's learning. This aligns with research showing that translanguaging supports deeper comprehension and metacognitive development in STEM learning environments (García, 2012; Li, 2018).

However, some teachers expressed concern about students becoming overly reliant on their first language, potentially at the expense of developing academic English. This tension reflects broader debates in EMI contexts, where institutional language policies often promote English-only instruction, while classroom realities demand more nuanced approaches (Karabassova & Issidro, 2023). Nonetheless, the majority agreed that, under the right guidance, translanguaging was a productive bridge between familiar knowledge and new STEM content, particularly in secondary education where content becomes increasingly abstract.

These findings demonstrate that both teachers and students actively engage in translanguaging to scaffold content understanding in EMI-STEM classrooms. Teacher-led strategies emphasized intentional instructional scaffolds, while student-driven practices reflected learners' instinctive use of their full linguistic repertoires to construct meaning. Although concerns about overreliance on L1 persist, the overall evidence suggests that translanguaging, when purposefully guided, enhances conceptual learning and peer collaboration. These context-specific examples extend existing research by illustrating how translanguaging operates within the content knowledge (CK) domain of the Multilingual TPACK framework in Kazakhstan's EMI-STEM settings. This foundation sets the stage for examining how technological tools were used, often separately from linguistic strategies, and the implications of this disconnect.

Technology in EMI-STEM Classrooms

Although classroom observations provided limited evidence of how technology was used in EMI-STEM classrooms, teacher interviews revealed frequent usage of digital tools like YouTube, PhET simulations, and virtual labs to enhance EMI-STEM engagement and comprehension, supporting content delivery (CK) but underutilizing pedagogical integration (TPK) (Mishra & Koehler, 2006). However, translanguaging and

technology remained separate strategies, with English-only resources challenging diverse learners, missing opportunities for multilingual scaffolding.

Digital Tools as Content Scaffolding

Teachers in EMI-STEM classrooms widely acknowledge the value of digital resources in enhancing student content comprehension and learning investment. To help students overcome language barriers, many teachers searched for bilingual or subtitled content wherever possible. Teachers across four schools used digital resources like YouTube videos and PhET simulations to visualize or scaffold complex STEM content, particularly for students struggling with English-only instruction (Teacher, A; Teacher D; Teacher E; Teacher F). Similarly, students were able to investigate chemistry and physics issues in a risk-free, interactive setting through virtual labs, which helped them visualize concepts that might be challenging to understand through textbook instruction in English alone. This is consistent with the TPACK framework's knowledge Knowledge (CK) dimension, where technology facilitates deeper engagement with knowledge through multimodal presentation (Mishra & Koehler, 2006). Besides, these practices align with Jiang et al.'s (2024) findings on technology's role in multimodal content delivery, yet extend their work by highlighting the need for multilingual adaptations, as teachers sought bilingual or subtitled resources to complement translanguaging, Li Wei's (2018) emphasis on leveraging linguistic repertoires too. However, the predominance of English-dominant tools limited integration with translanguaging, confirming Kelly-Holmes (2019) observation of linguistic barriers in monolingual technology use.

Barriers to Integrate Translanguaging and Technology

Teachers identified structural barriers, such as time-intensive resource adaptation, limited professional development, limited availability of multilingual STEM resources aligning with the Williyan and Sirniawati (2020b), and Kelly-Holmes (2019) that hindered

integrating translanguaging and technology in EMI-STEM classrooms, perpetuating their use as separate strategies (PK/PCK for translanguaging, TK/CK for technology). This disconnect, illuminated by phenomenological insights (e.g., Teacher A's YouTube use), limits multilingual learners' support, underscoring the need for cohesive Multilingual TPACK strategies (Morales et al., 2022). In under-resourced schools, the use of interactive platforms was constrained by basic infrastructure issues, such as slow internet or outdated labs and resources (Nugroho & Mutiaraningrum, 2020). Meanwhile, even in well-equipped settings, English-only tools like PhET simulations were inaccessible for students with limited English proficiency (Teachers E & F), hindering translanguaging integration. This aligns with Kelly-Holmes' (2019) findings on linguistic barriers in monolingual technology, emphasizing the need for multilingual digital resources to support CK delivery.

Additionally, Adapting English-only resources and researching multilingual tools consumed significant time, restricting translanguaging's pedagogical application (TPK). Teachers' reliance on translation apps risked students prioritizing quick translations over academic English development, echoing UNESCO's (2021) and Williyan and Sirniawati's (2020b) observations of systemic deficiencies in EMI technology. This barrier underscores the need for accessible multilingual STEM resources to enhance PCK and reduce cognitive load (García & Wei, 2015).

Another major obstacle is the lack of training in multilingual digital pedagogy forced teachers to learn tools via trial and error, limiting student-centered, translanguaging-enhanced activities. This aligns with OECD's (2014; 2020) global findings on the need for continuous professional development in digital literacy for EMI-STEM educators. Teachers defaulted to passive methods (e.g., PowerPoint), underutilizing gamification due to unfamiliarity (Teachers D & E). Without guidance, technology failed to support deep

inquiry, as students treated game-based platforms as entertainment (Teachers D & F), highlighting the need for TPACK-focused training. Even the most competent teachers may resort to parallel practices rather than integrating their knowledge domains if they do not receive clear guidance on how to connect technological, pedagogical, and language strategies.

The findings highlight a critical disconnect in EMI-STEM classrooms. Translanguaging and technology, while both valuable, are used independently rather than as integrated components of a cohesive pedagogy. This separation limits their potential to fully support multilingual learners, as translanguaging scaffolds linguistic comprehension (PK/PCK) while technology enhances content delivery (TK/CK) without synergy. Addressing this disconnect is essential for moving toward better integration, where these strategies reinforce each other to create inclusive, effective STEM learning environments. The phenomenological insights, which illuminated teachers' nuanced experiences (e.g., Teacher A's use of YouTube for physics demonstrations, Teacher F's bilingual chemistry explanations), provide a foundation for actionable implications that align with the Multilingual TPACK framework (Morales et al., 2022).

Missed Opportunities for Integrating Translanguaging

Despite the widespread use of technology, the results showed little indication that teachers intentionally combined digital tools and language comprehension. Although some students checked foreign phrases on their own using bilingual dictionaries or online translation apps, this did not take place during teacher-directed teaching. Some teachers allowed students to have quick conversations in their first languages before tasks or summarized English-language video content in Kazakh or Russian, but these activities were not regularly organized or structured around the use of technology.

This suggests a gap in teachers' Technological Pedagogical Knowledge (TPK): while teachers demonstrated competence in selecting tech resources and adapting explanations to students' needs, they lacked the training or frameworks to combine digital tools with multilingual strategies. As a result, EMI-STEM learning is supported by both technology and translanguaging, but they do not reinforce each other, leading to a fragmented instructional approach.

These results are in line with those of Mustafina (2016) and Morales et al. (2022), who claim that although digital tools have a lot of promise in EMI environments, they are often applied passively or without linguistic modification. The study's teachers were also concerned that students would become dependent on translation applications, emphasizing word-for-word conversion over conceptual understanding. This underscores the conflict between deeper academic learning and technological convenience (Mustafina, 2016). To bridge this gap, professional development should prioritize training combining translanguaging and technology within TPACK's domains. Teachers could adapt English-only tools like PhET with bilingual annotations or use Padlet for multilingual discussions, enabling lessons that support translanguaging and reduce cognitive load (García & Wei, 2015). The Ministry of Education and Science of RK must develop multilingual STEM resources and revise assessments to value translanguaging, aligning with classroom realities for equitable EMI-STEM education.

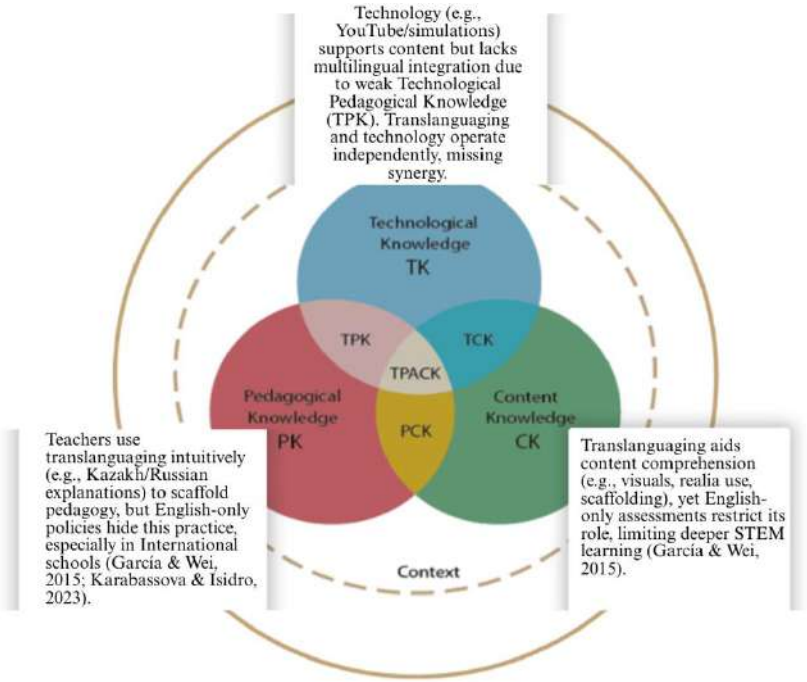
Recommendations for EMI-STEM Education in Kazakhstan

The main recommendation is a Multilingual TPACK framework integrating translanguaging and technology to bridge their disconnect in EMI-STEM classrooms, enhancing student engagement and comprehension. Phenomenology, focused on understanding the essence of lived experiences (Merriam & Tisdell, 2016), was ideal for exploring how EMI-STEM teachers in Kazakhstan's private schools perceive teaching in

multilingual classrooms. Unlike surveys, which collect broad but surface-level data, or case studies, which examine specific contexts, phenomenology captures teachers' subjective experiences through in-depth interviews, aligning with the research questions on their experiences and practices (translanguaging and technology use). This method's strength was evident in interviews with six teachers across four schools (STEM, Tech, International, Innovation). For example, Teacher F's use of Kazakh equivalents to teach chemistry revealed how linguistic diversity shapes pedagogical choices, a nuance that quantitative methods might overlook. This depth informed the study's findings, such as the disconnect between translanguaging and technology, guiding a framework that leverages teachers' experiential knowledge.

Figure 3

Multilingual TPACK Framework for EMI-STEM Education



Note. The Multilingual TPACK Framework, developed for this study to integrate translanguaging (PK/PCK) and technology (TK/CK) in EMI-STEM education, extends Koehler et al. (2013) to address multilingual support gaps.

Figure 3 shows translanguaging (PK/PCK) and technology (TK/CK) operating separately, limiting multilingual support. Intuitive translanguaging (e.g., Kazakh explanations) is obscured by English-only policies (Karabassova & Isidro, 2023), while assessments restrict comprehension (García & Wei, 2015). Technology's content support (e.g., PhET) lacks TPK for multilingual integration (Kelly-Holmes, 2019), necessitating a framework for synergy.

To integrate translanguaging and technology in Kazakhstan's EMI-STEM classrooms, the Ministry of Education should recognize translanguaging as a valid strategy, implementing a framework guiding L1 use (e.g., Kazakh, Russian) to support STEM mastery and English proficiency (García & Wei, 2015). This framework should include bilingual materials like glossaries and lab instructions to reduce cognitive load, allow L1 in formative assessments (e.g., oral explanations) while maintaining English summative outputs, and launch pilot programs to test bilingual strategies, informing national reforms (Karabassova, 2018; Williyam & Sarinawati, 2020b). Additionally, developing multilingual resources, such as PhET simulations with Kazakh/Russian annotations and collaborative platforms like Padlet, can enhance CK and PCK, addressing resource scarcity (García & Wei, 2015; Kelly-Holmes, 2019). Furthermore, ongoing, context-specific training within TPACK should move beyond trial-and-error, focusing on designing multilingual lessons with digital tools (e.g., translation apps, videos, gamified apps), adapting English-only tools with bilingual prompts, and using "translanguaging moments" (e.g., L1 clarifications) to scaffold learning, extending TPACK to address linguistic diversity (Mishra & Koehler, 2006; OECD, 2020; García & Wei, 2015).

Building on this framework, the following recommendations address policy, infrastructure, and teacher development to integrate translanguaging and technology, aligning with TPACK and findings. The Table 1 below outlines the proposed framework,

detailing strategies for integrating translanguaging in EMI-STEM classrooms. Each component aligns with TPACK domains to ensure cohesive implementation.

Table 2

Translanguaging Integrated Framework

Component	Description	TPACK	Strategies
Multilingual Resource Development	Create and improve STEM materials in English and students' L1 (e.g., Kazakh, Russian).	Technological Knowledge (TK) + Content Knowledge (CK)	- Develop bilingual glossaries for key STEM terms. - Adapt platforms like PhET simulations with L1 subtitles or annotations. - Partner with ed-tech providers to produce multilingual content.
Structured L1 Use Guidelines	Define when and how to use L1 to scaffold comprehension without undermining English goals.	Pedagogical Knowledge (PK) + Translanguaging Knowledge	- Use L1 for initial concept explanation, transitioning to English for reinforcement. - Encourage L1 discussions in group activities, followed by English summaries. - Implement "translanguaging moments" (e.g., 10-minute L1 clarifications).
Technology-Enhanced Translanguaging	Leverage digital tools to support multilingual learning interactively.	TK + PK + Translanguaging Knowledge	- Use collaborative platforms like Padlet for students to post questions in L1 and English, with teachers providing bilingual feedback to scaffold STEM concepts." - Use gamified apps with bilingual prompts to engage students.
Multilingual assessment	Design assessments that value multilingual processes while prioritizing English outputs.	PK + CK + Translanguaging Knowledge	- Allow L1 planning in formative assessments, with final submissions in English. - Use bilingual rubrics to evaluate content and language progress. - Incorporate oral assessments to capture translanguaging fluency.

Note. The Translanguaging Integrated Framework, informed by study findings and Koehler et al. (2013), proposes TPACK-aligned strategies for multilingual EMI-STEM classrooms.

Kazakhstan's EMI-STEM policies prioritize English proficiency, often neglecting multilingual resources that enhance STEM understanding and English development (García & Wei, 2015). Teachers intuitively use translanguaging (e.g., Kazakh explanations) and technology but lack training to integrate them cohesively, relying on trial-and-error . To address this, professional development should embed translanguaging within TPACK, offering ongoing, context-specific training on designing multilingual lessons with digital tools (e.g., translation apps, Padlet), balancing content and English goals, and adapting tools like PhET with bilingual annotations (Mishra & Koehler, 2006; OECD, 2020). TPACK's limitation in not addressing linguistic diversity requires extending it to guide L1 use in digital pedagogies, preventing English-centric marginalization (García & Wei, 2015). The Ministry of Education should incorporate bilingual materials (e.g., glossaries, lab instructions) and allow L1 in formative assessments (e.g., simplifying languages, definitions or translations) to reduce cognitive load while maintaining English summative outputs (UNESCO, 2021). Structured training with guidebooks and model lessons, plus pilot programs testing bilingual strategies, can inform inclusive reforms, ensuring translanguaging supports equitable STEM education (Williyam & Sarinawati, 2020b). These strategies, detailed in Table 1, align with Multilingual TPACK for student-centered learning.

Conclusion

This chapter critically examined EMI-STEM teachers' perceptions and practices in Kazakhstan through the Multilingual TPACK framework. It revealed that translanguaging scaffolds STEM content via students' linguistic repertoires (e.g., bilingual PhET annotations) while technology enhances visual engagement, yet their independent operation stems from insufficient training and policy support (García & Wei, 2015). Phenomenological insights from teachers' experiences underscored translanguaging's

flexibility and technology's potential, highlighting a disconnect that a refined TPACK framework can address. By extending TPACK to incorporate translanguaging, this study advocates for comprehensive teacher training, inclusive policies, and multilingual resources to foster equitable STEM education. These recommendations, tailored to Kazakhstan's multilingual context, inform a national framework that integrates translanguaging and technology, promoting effective EMI-STEM learning locally and globally.

Chapter 6: Conclusion

This study explored how EMI-STEM teachers in Kazakhstan use translanguaging and technology in multilingual classrooms in private schools. The findings revealed that while most teachers value the use of students' first languages to support STEM learning, there is no consistent approach or policy guiding translanguaging practices. Teachers often relied on their intuition and context, leading to varied classroom strategies. Similarly, digital tools were widely used, but their effectiveness was limited by infrastructure challenges, English-only content, and lack of training in multilingual EdTech use. The study found that translanguaging and technology were often used separately rather than as part of an integrated pedagogy. When aligned, these approaches supported both STEM understanding and English development, highlighting the potential of a TPACK framework adapted for multilingual contexts.

Strengths and Limitations of the Study

This study has a number of important advantages. First, it uses rich qualitative data from in-depth interviews with EMI-STEM teachers, which offers a profound understanding of their educational thought and daily experiences. This helped capture the complex realities of teaching STEM subjects in English within a multilingual context. Second, the study incorporates perspectives from a variety of academic fields, including biology, chemistry, physics, and mathematics, which broadens its scope and demonstrates how technology and translanguaging are approached across disciplines. Thirdly, the study provides a more nuanced perspective on how language, pedagogy, content, and technology interact in EMI-STEM contexts by combining the TPACK framework with translanguaging theory. This theoretical integration gives the analysis both clarity and rigor.

However, the study has several limitations. It included a small sample drawn only from private schools. Since EMI-STEM instruction is mostly provided in private institutions in Kazakhstan, the study does not include public or rural school contexts, which may differ significantly. This limits the representativeness of the findings. Besides, there were limited opportunities for classroom observations, so much of the data relies on what teachers reported rather than direct evidence of their classroom practice. While these accounts were honest and detailed, they still reflect self-perceptions rather than observed behaviors. Future research could employ mixed-methods designs to include public and rural schools, capturing a wider range of EMI-STEM contexts. Longitudinal classroom observations could further validate teachers' self-reported practices.

Finally, the TPACK framework's individual-oriented focus limits the study's ability to address for ecological and relational aspects of teacher practices, such as systematic collaboration among teachers, which was minimal and unsystematic in this study (Smagulova, 2021). Future research to explore TPACK from an ecological perspective, incorporating sociocultural factors like ideology, identity, and relational practices to better understand the broader dynamics of EMI-STEM education (Morales et al., 2022).

Implications and Future Research Directions

The findings of this study contribute important insights into how EMI-STEM teachers in Kazakhstan manage the intersection of content, language, and technology in multilingual classrooms. One of the central implications is the need for a more integrated pedagogical approach that aligns technological tools with both content delivery and language development. While teachers showed strong commitment to enhancing student learning through digital tools and translanguaging, these practices often operated in parallel rather than in coordination. This gap limits the full pedagogical potential of either

strategy and reveals a space where teacher professional development can have meaningful impact.

Additionally, this study found that the use of translanguaging remains largely hidden or informal, particularly because assessment practices continue to be designed monolingually. While some teachers accepted translanguaging as a necessary support strategy, especially to respond to students' linguistic needs, others viewed it as restricted or even contradictory to EMI principles. This contradiction points to a broader systemic tension: while classrooms may be linguistically diverse, current EMI policies and assessments do not fully accommodate or legitimize multilingual practices. Addressing this gap is essential for creating more equitable and effective EMI-STEM learning environments.

Furthermore, the report highlights that unless teachers are prepared to use technology effectively, its usage in EMI-STEM classrooms is not necessarily effective. Students, particularly those with poor English proficiency, find it difficult to interact with STEM content when digital resources are not accompanied by linguistic help. Academic focus can also be weakened by the unstructured usage of translanguaging that disregards subject-specific learning objectives. These results support the usefulness of the TPACK framework, especially when applied with a translanguaging perspective. Effective EMI-STEM teaching requires balanced attention to technological knowledge, pedagogical strategies, subject mastery, and multilingual awareness.

At the policy level, this study highlights the need to better align national EMI-STEM goals with classroom realities. While educational reforms emphasize digital tools and English instruction, their implementation is still uneven because of infrastructure, teacher training, and multilingual pedagogy limitations. If EMI-STEM policies are to

result in meaningful educational outcomes, this alignment gap needs to be addressed. The Ministry of Education should allocate funding for developing bilingual STEM resources, such as Kazakh-English glossaries, aligning with UNESCO's (2021) call for equitable multilingual education.

The study makes various recommendations for future research directions. First, there is a need to investigate EMI-STEM teaching in public and rural school contexts, which were outside the scope of this research. These settings likely face distinct challenges regarding infrastructure, training access, and language use. In addition, further research conducted in classrooms, particularly those that directly observe student interactions, may provide a greater understanding of how technology and translanguaging work in real-world settings. Exploring student perspectives would also improve the understanding of how they experience and respond to these strategies. Finally, longitudinal studies should monitor how EMI-STEM practices change over time, especially in reaction to specific initiatives or changes in regulation.

Summary

Conducting this research has been both an academic and personal journey. As a student navigating Kazakhstan's multilingual education system myself, I have long been curious about how language, technology, and subject knowledge intersect in real classrooms. I gained a deeper comprehension of EMI-STEM education as well as a more critical viewpoint on the challenges faced by educators as a result of this study. I learned how much they care about their students and how adaptable they are, especially in the face of inadequate resources or supervision, from hearing their stories.

This thesis helped me grow as a researcher. I gained knowledge on how to plan a study, gather and evaluate qualitative data, and make the connection between theory and

practice. More significantly, I discovered the importance of complexity—multilingual education cannot be solved in a one-size-fits-all manner. Policies must take into account the diversity of strengths and problems that each teacher and student bring to the table.

Looking back, I'm proud of how this research turned out. It pushed me to think more critically, to ask better questions, and to write with purpose. I hope that my findings can spark further conversations among educators, researchers, and policymakers about how to better support EMI-STEM classrooms in Kazakhstan and beyond.

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Appendix A: AI Declaration Form

Exploring Teachers' Perceptions of Translanguaging and Technology in English-Medium STEM classrooms in Kazakhstani Secondary Schools

Declaration of the Use of Generative AI

I hereby declare that I have read and understood NUGSE's policy concerning appropriate use of generative AI tools and composed this work independently (please check one):

☒ with the use of generative artificial intelligence tools, or

☐ without the use of generative artificial intelligence tools.

During the preparation of this thesis, I used Grammarly, ChatGPT, and Scribbr to clarify sentence structure, analyze feedback, and ensure grammatical accuracy.

I also declare that I

☒ am aware of the capabilities and limitations of generative AI tool(s),

☒ have verified that the content generated by AI systems and adopted by me is factually correct,

☒ am aware that as the author of this thesis I bear full responsibility for the statements and assertions made in it,

☒ have submitted complete and accurate information about my use of generative AI tools in this work, and

☒ acknowledge that there may be disciplinary consequences if I have breached NU Student Code of Conduct or not followed NUGSE's guidelines regarding appropriate AI use.

Name: Zhibek Baigulova Signature: 

Date: 28.05.2025

Appendix B: Consent Letters

Exploring Teachers' Perceptions of Translanguaging and Technology in English-medium STEM classrooms in Kazakhstani Secondary Schools

DESCRIPTION:

You are invited to participate in a research study that explores the experiences and approaches of teachers in STEM education where English is the medium of instruction (EMI-STEM) in Kazakhstani secondary schools. As a participant, you will be asked to answer 10-15 interview questions. You may choose to respond in the language you feel most comfortable with—English, Kazakh, or Russian. With your permission, the interviews will be audio-recorded to facilitate accurate data collection and analysis. You may opt-out of recording if you prefer. Your name and the name of your school will be altered and anonymized at all stages of the research.

I will directly request your permission to observe classroom sessions. Your involvement in the study will remain confidential; no information about your participation will be shared with school administrators or colleagues. All electronic forms of informed consent and audio recordings will be stored on the researcher's personal computer and will be password-protected. All written and printed documents will be stored in a secure location Physical documents will be stored securely in a locked drawer accessible only to the researcher. All data will be retained for a period of six months after the completion of the study, after which electronic materials will be permanently deleted, and physical copies will be destroyed.

TIME INVOLVEMENT: Your participation will take approximately 45-60 minutes.

RISKS AND BENEFITS: The risks associated with this study are minimal. There may be a slight disruption to the learning process during observations, which could affect the flow of the lesson or cause discomfort for the participants. Additionally, risks may involve concerns about sharing personal information with others and the lack of confidentiality and anonymity. To minimize these risks, clear and transparent communication channels will be provided to all stakeholders. If necessary, parents will be fully informed about the nature of the study and its objectives, and their consent, along with that of the teachers, will be obtained before any observations take place. A welcoming introductory speech will be given to both teachers and students to explain my presence, but during the observation, I will sit quietly in the corner to minimize disruptions and avoid interfering with classroom management.

The name of the institution will remain unknown, and your name will be concealed using initials or a pseudonym when writing the thesis. Interview recordings will be stored in a secure location. Information obtained during the interview will not be shared with professors or university administration. A convenient time for interviews will be arranged with each participant to avoid interfering with their work.

The benefits of this study lie in gaining insights into how the use of technology and translanguaging can contribute to students' better understanding of the learning material. Although there is no direct benefit for participants, reflecting on their teaching practices

may positively impact their professional development. Your decision to participate or not participate in this study will not affect your employment or the grades of your students.

PARTICIPANT'S RIGHTS: If you have read this form and have decided to participate in this project, please understand your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. The alternative is not to participate. You have the right to refuse to answer particular questions. The results of this research study may be presented at scientific or professional meetings or published in scientific journals.

CONTACT INFORMATION:

Questions: If you have any questions, concerns or complaints about this research, its procedures, risks and benefits, contact the Master's Thesis Supervisor for this student work, Philip Montgomery, philip.montgomery@nu.edu.kz, +7(7172) 705898.

Independent Contact: If you are not satisfied with how this study is being conducted, or if you have any concerns, complaints, or general questions about the research or your rights as a participant, please contact the NUGSE Research Committee at (gse_researchcommittee@nu.edu.kz, +7 (7172) 70 91 05).

Please sign this consent from if you agree to participate in this study.

- I have carefully read the information provided;
- I have been given full information regarding the purpose and procedures of the study;
- I understand how the data collected will be used, and that any confidential information will be seen only by the researchers and will not be revealed to anyone else;
- I understand that I am free to withdraw from the study at any time without giving a reason;
- With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

Signature: _____ Date: _____

The extra copy of this signed and dated consent form is for you to keep.

According to the law of the Republic of Kazakhstan an individual under the age of 18 is considered a child. Any participant falling into that category should be given the Parental Consent Form and have it signed by at least one of his/her parent(s) or guardian(s). In addition, the child must give assent to participate in the research. Both parent consent and child assent scripts should be included with this application.

ФОРМА ИНФОРМАЦИОННОГО СОГЛАСИЯ

Изучение восприятия учителями использования транслингвизма и технологий в STEM-классах с обучением на английском языке в казахстанских средних школах

ОПИСАНИЕ: Вы приглашены принять участие в исследовании, посвященном изучению опыта и подходов учителей в STEM-образовании с обучением на английском языке (EMI-STEM) в казахстанских средних школах. В качестве участника вам будет предложено ответить на 10-15 вопросов интервью. Вы можете выбрать язык, на котором вам удобнее всего отвечать - английский, казахский или русский. С вашего разрешения интервью будут записываться на аудио, что облегчит сбор и анализ точных данных. При желании вы можете отказаться от записи. Ваше имя и название вашей школы будут изменены и анонимными на всех этапах исследования.

Я попрошу у вас разрешения наблюдать за занятиями в классе. Ваше участие в исследовании останется конфиденциальным; никакая информация о вашем участии не будет передана администрации школы или коллегам. Все электронные формы информационного согласия и аудиозаписи будут храниться на персональном компьютере исследователя и будут защищены паролем. Все письменные и печатные документы будут храниться в надежном месте. Все данные будут храниться в течение шести месяцев после завершения исследования, после чего электронные материалы будут окончательно удалены, а физические копии уничтожены.

ВРЕМЯ УЧАСТИЯ: Ваше участие потребует около 45-60 минут.

РИСКИ И ПРЕИМУЩЕСТВА:

Риски, связанные с участием в этом исследовании, минимальны. Возможно незначительное нарушение учебного процесса во время наблюдений, что может повлиять на ход урока или вызвать дискомфорт у участников. Также риски могут заключаться в опасениях, поделиться личной информацией с другими; и недостаток конфиденциальности и анонимности. Чтобы минимизировать эти риски, будут обеспечены прозрачные и четкие каналы связи со всеми заинтересованными сторонами.

При необходимости родители будут полностью проинформированы о характере исследования и его целях, и их согласие, наряду с согласием учителей, будет получено до начала наблюдений. Приветственная вступительная речь будет представлена как учителям, так и ученикам, чтобы объяснить моё присутствие, но во время наблюдения я буду сидеть тихо в углу, чтобы минимизировать помехи и не вмешиваться в управление классом.

Название учебного заведения будет неизвестно; ваше имя будет скрыто инициалами псевдонимом, используемым при написании тезиса. Записи интервью будут храниться в защищенном месте. Информация, полученная в ходе интервью, не будет передана профессорам и администрации университета. Комфортное время проведения собеседований оговаривается с каждым участником и не мешает работе участников.

Преимущества данного исследования заключаются в получении информации о том, как использование технологий и транслингвизма может способствовать лучшему пониманию учебного материала учащимися. Несмотря на отсутствие прямой выгоды для участников, рефлексируя над своими преподавательскими практиками могут положительно сказаться на профессиональном развитии. Ваше решение участвовать или не участвовать в этом исследовании не повлияет на ваше трудоустройство или оценки ваших учеников.

ПРАВА УЧАСТНИКОВ: Если Вы прочитали данную форму и решили принять участие в данном исследовании, Вы должны понимать, что Ваше участие является добровольным и что у Вас есть право отозвать свое согласие или прекратить участие в любое время без штрафных санкций и без потери социального пакета, который Вам предоставляли. В качестве альтернативы можно не участвовать в исследовании. Также Вы имеете право не отвечать на какие-либо вопросы. Результаты данного исследования могут быть представлены или опубликованы в научных или профессиональных целях.

КОНТАКТНАЯ ИНФОРМАЦИЯ:

Вопросы: Если у Вас есть вопросы, замечания или жалобы по поводу данного исследования, процедуры его проведения, рисков и преимуществ, Вы можете связаться с руководителям магистерского тезиса исследователя: Филипом Монтгомери, philip.montgomery@nu.edu.kz, +7(7172) 705898.

Независимые контакты: Если Вы не удовлетворены проведением данного исследования, если у Вас возникли какие-либо проблемы, жалобы или вопросы, Вы можете связаться с Комитетом Исследований Высшей Школы Образования Назарбаев Университета, отправив письмо на электронный адрес gse_researchcommittee@nu.edu.kz, +7 (7172) 70 91 05.

Пожалуйста, подпишите данную форму, если Вы согласны участвовать в исследовании.

- Я внимательно изучил представленную информацию;
- Мне предоставили полную информацию о целях и процедуре исследования;
- Я понимаю, как будут использованы собранные данные, и что доступ к любой конфиденциальной информации будет иметь только исследователь;
- Я понимаю, что вправе в любой момент отказаться от участия в данном исследовании без объяснения причин;
- С полным осознанием всего вышеизложенного я согласен принять участие в исследовании по собственной воле.

Подпись: _____ Дата: _____

ЗЕРТТЕУ ЖҰМЫСЫ КЕЛІСІМІНІҢ АҚПАРАТТЫҚ ФОРМАСЫ

Қазақстандық орта мектептерде ағылшын тілінде оқытатын STEM-сыныптарда мұғалімдердің транслингвизм мен технологияларды пайдалануын қабылдауын зерттеу

СИПАТТАМА: Сізді Қазақстандағы орта мектептерде ағылшын тілінде оқытылатын STEM пәндері (EMI-STEM) мұғалімдерінің тәжірибелері мен әдістерін зерттеуге қатысуға шақырамыз. Қатысушы ретінде сізден 10-15 сұрақтан тұратын сұхбатқа жауап беру ұсынылады. Сіз өзіңізге ыңғайлы тілді таңдай аласыз - ағылшын, қазақ немесе орыс. Сіздің рұқсатыңызбен сұхбаттар жауаптарыңыз аудиоға жазылады, бұл жазбалар деректерді жинау және алынған нәтижелерді талдау процесін сипаттау үшін пайдаланылады. Сіздің атыңыз бен мектебіңіздің атауы зерттеудің барлық кезеңдерінде өзгертіліп, жасырын болады.

Мен сізден сыныптағы сабақтарды бақылауға рұқсат сұраймын. Сіздің зерттеуге қатысуыңыз құпия болып қалады; сіздің қатысуыңыз туралы ешқандай ақпарат мектеп әкімшілігіне немесе әріптестеріңізге берілмейді. Барлық электронды ақпараттық келісім нысандары мен аудиожазбалар зерттеушінің жеке компьютерінде сақталады және құпиясөзбен қорғалады. Барлық жазбаша және басылған құжаттар қауіпсіз жерде сақталады. Барлық деректер зерттеу аяқталғаннан кейін алты ай бойы сақталады, содан кейін электрондық материалдар біржола жойылады және физикалық көшірмелер жойылады.

ӨТКІЗУ УАҚЫТЫ: Сіздің қатысуыңыз шамамен 45-60 минут уақытыңызды алады.

ЗЕРТТЕУ ЖҰМЫСЫНА ҚАТЫСУДЫҢ ҚАУІПТЕРІ МЕН

АРТЫҚШЫЛЫҚТАРЫ:

Бұл зерттеуге қатысудың қаупі минималды. Сабақ барысындағы бақылау кезінде оқыту процесі аздап бұзылуы мүмкін, бұл сабақтың өтуіне әсер етуі немесе қатысушыларға қолайсыздық тудыруы мүмкін. Сондай-ақ, жеке ақпаратты басқалармен бөлісу және құпиялылықтың болмауы қауіпті болуы мүмкін. Бұл тәуекелдерді азайту үшін барлық мүдделі тараптармен ашық және нақты байланыс арналарын қамтамасыз ету жоспарланып отыр. Қажет болған жағдайда, ата-аналар зерттеудің сипаты мен оның мақсаттары туралы толық хабардар етіледі және бақылау басталғанға дейін олардың келісімі, сондай-ақ мұғалімдердің келісімі алынады. Мұғалімдер мен оқушыларға менің сабаққа қатысатынымды білдіру үшін кіріспе сөз айтылады, бірақ бақылау кезінде мен бұрышта тыныш отырып, сабаққа кедергі келтірмеуге және сыныпты басқаруға араласпауға тырысамын. Оқу орнының атауы көрсетілмейді; сіздің атыңыз диссертация жазу кезінде лақап атпен жасырылады. Сұхбат жазбалары қауіпсіз жерде сақталады. Сұхбат барысында алынған ақпарат университеттің профессорлары мен әкімшілігіне берілмейді. Әрбір қатысушымен келісілген ыңғайлы уақыт сұхбатты жүргізуге белгіленеді және қатысушылардың жұмысына кедергі келтірмейді. Бұл зерттеудің артықшылықтарына технологиялар мен транслингвизмді қолдану оқушылардың оқу материалдарын жақсырақ түсінуіне қалай ықпал ететінін білу жатады. Қатысушыларға тікелей пайда болмаса да, оқыту тәжірибесін қайта қарау кәсіби

дамуға оң әсер етуі мүмкін. Бұл зерттеуге қатысу немесе қатыспау туралы шешіміңіз жұмысыңызға немесе оқушыларыңыздың бағасына әсер етпейді.

ҚАТЫСУШЫ ҚҰҚЫҚТАРЫ: Егер Сіз берілген формамен танысып, зерттеу жұмысына қатысуға шешім қабылдасаңыз, Сіздің қатысуыңыз ерікті түрде екенін хабарлаймыз. Сонымен қатар, қалаған уақытта айыппұл төлемей және сіздің әлеуметтік жеңілдіктеріңізге еш кесірін тигізбей зерттеу жұмысына қатысу туралы келісіміңізді кері қайтаруға немесе тоқтатуға құқығыңыз бар. Зерттеу жұмысына мүлдем қатыспауыңызға да толық құқығыңыз бар. Сондай-ақ, қандай да бір сұрақтарға жауап бермеуіңізге де әбден болады. Бұл зерттеу жұмысының нәтижелері академиялық немесе кәсіби мақсаттарда баспаға ұсынылуы немесе шығарылуы мүмкін.

БАЙЛАНЫС АҚПАРАТЫ:

Сұрақтарыңыз: Егер жүргізіліп отырған зерттеу жұмысының процесі,қаупі мен артықшылықтары туралы сұрағыңыз немесе шағымыңыз болса, келесі байланыс құралдары арқылы зерттеушінің магистрлық тезисі бойынша жетекшісімен хабарласуыңызға болады. Қауымдастырылған магистрлік жұмысының жетекшісі Филип Монтгомер, philip.montgomery@nu.edu.kz,+7(7172) 705898.

ДЕРБЕС БАЙЛАНЫС АҚПАРАТТАРЫ: Егер берілген зерттеу жұмысының жүргізілуімен қанағаттанбасаңыз немесе сұрақтарыңыз бен шағымдарыңыз болса, Назарбаев Университеті Жоғары Білім беру мектебінің Зерттеу Комитетімен көрсетілген байланыс құралдары арқылы хабарласуыңызға болады: электрондық поштамен gse_researchcommittee@nu.edu.kz, +7 (7172) 70 91 05.

Зерттеу жұмысына қатысуға келісіміңізді берсеңіз, берілген формаға қол қоюыңызды сұраймыз.

- Мен берілген формамен мұқият таныстым;
- Маған зерттеу жұмысының мақсаты мен оның процедурасы жайында толық ақпарат берілді;
- Жинақталған ақпарат пен құпия мәліметтерге тек зерттеушінің өзіне қолжетімді және мәлім
- болатынын толық түсінемін;
- Мен кез келген уақытта ешқандай түсініктемесіз зерттеу жұмысына қатысудан бас тартуыма
- болатынын түсінемін;
- Мен жоғарыда аталып өткен ақпаратты саналы түрде қабылдап, осы зерттеу жұмысына қатысуға өз келісімімді беремін.

Қолы: _____ Күні: _____

Appendix C: Recruitment letter for a gatekeeper

Subject: Information on Research Study Participation – EMI-STEM Education

Dear [Principal's name],

I hope this message finds you well. My name is Zhibek, and I am conducting a research study as part of my master's thesis on teachers' experiences and approaches in English-medium STEM (EMI-STEM) education in Kazakhstani lower secondary schools. The study aims to explore how teachers use technology and translanguaging practices in their STEM classrooms, as well as their experiences teaching in an EMI context.

I am writing to inform you that I will be inviting teachers from your school to participate in this study. Their involvement will include an observation and a follow-up 45-60 minute interview, scheduled at their convenience. With their consent, the interview will be audio-recorded for accurate data collection; if preferred, I will take notes instead.

Teachers will have the option to conduct the interview in Kazakh, Russian, or English, based on their preference. Participation is entirely voluntary, and they may withdraw from the study at any point without any consequences. All collected data will be kept confidential, and both the teachers' and your school's identities will remain anonymous in the final research report. To prevent confidentiality and anonymity of teachers, I kindly ask you not to announce their participation to the staff or students.

If any issues or concerns arise regarding the participation of teachers in the study, please let me know at your earliest convenience so I can address them promptly.

Thank you for your attention to this matter. If you have any questions or require further information, please do not hesitate to contact me at zhibek.baigulova@nu.edu.kz.

Kind regards,

Zhibek Baigulova

A master's student of Graduate School of Education

Nazarbayev University

Appendix D: Interview questions

You are invited to participate in a research study on exploring teachers' experience and approaches in English-medium STEM (EMI-STEM) education within Kazakhstani lower secondary schools. The interview will last approximately 45-60 minutes and will focus on your teaching practices and experiences with technology and translanguaging in STEM lessons. The interview will be audio-recorded, but only with your explicit permission. This recording will be used solely to describe the data collection and analyze findings. If you are not comfortable with recording, you may opt out of it, and notes will be taken instead.

Your name and the name of your school will be anonymized at all stages of the research. All consent forms (available in Kazakh, Russian, and English) and audio recordings will be stored on the researcher's personal computer, which will be password-protected. Physical documents will be stored securely in a locked drawer accessible only to the researcher. All data will be retained for a period of six months after the completion of the study, after which electronic materials will be permanently deleted, and physical copies will be destroyed.

Before we proceed, I kindly ask you to sign the consent form, which confirms the following:

1. I assure you that all information remains confidential;

2. You can quit participating at any moment if it makes you uncomfortable;

3. The audio recording will be transcribed and subsequently destroyed, with access limited to me alone.

I appreciate your willingness to take part in this interview. If you have a question related to the study, you can send them on the following email zhibek.baigulova@nu.edu.kz.

Questions:

A. Interviewee Background

1. Briefly describe your role.

Probes: How are you involved in teaching? How long have you been teaching _____? EMI in STEM?

2. What motivates you to teach [subject: Math/Science/Physics/Biology/Chemistry] in a Kazakhstani secondary (private/public) school?

B. STEM in Kazakhstan

2. Could you share your thoughts and experiences on STEM education in Kazakhstan?

3. How do you approach teaching STEM subjects in English? Are you familiar with or using CLIL (Content and Language Integrated Learning) in your classroom? How? (trainings)

4. How do you feel about teaching STEM in English? What languages do you apply in your classroom? How? When do you use that languages?

C. Benefits and Challenges of EMI in STEM

5. Have you encountered any benefits of teaching STEM subjects in English?

Probes:

If so, could you give a specific example where EMI was particularly beneficial in a STEM class?

6. Have you encountered any challenges or drawbacks when teaching STEM subjects in English?

Probes:

Could you describe these challenges in more detail and share how you or your school have addressed them?

7. How have students responded to learning STEM subjects in English? Have you noticed any differences in their learning outcomes, engagement, or overall performance?

D. Teaching Methods in STEM Education

8. Could you please share your experiences of teaching approaches that you use in your STEM classes?

Probes: Are there specific teaching strategies, tools, or resources that you find particularly effective for teaching STEM to students who are still developing their English proficiency?

9. Have you received any professional development or training specifically for teaching STEM subjects in an EMI or CLIL context? When? How long?

Probes:

How effective has this training been in helping you adjust to EMI teaching?

10. What resources, materials, or technologies have you used for teaching STEM subjects in English? What further resources would you suggest for improvement?

E. Future Implications of EMI and CLIL in STEM Education

11. In your opinion, how does teaching STEM in English impact students' language development and readiness for higher education or future careers?

12. What recommendations do you have to support your students better?

Вопросы для интервью

Вас приглашают принять участие в исследовании, направленном на изучение опыта и подходов учителей в обучении на английском языке в STEM-дисциплинах (EMI-STEM) в казахстанских средних школах. Интервью продлится примерно 45-60 минут и будет сосредоточено на ваших педагогических практиках и опыте использования технологий и транслингвальности на уроках STEM.

Во время интервью будет проводиться аудиозапись, но только с вашего согласия. Запись будет использоваться исключительно для описания процесса сбора данных и анализа полученных результатов. Если вы не согласны на аудиозапись, вместо этого будут вестись письменные заметки.

Ваше имя и название вашей школы будут анонимизированы на всех этапах исследования. Все формы согласия (доступные на казахском, русском и английском языках) и аудиозаписи будут храниться на личном компьютере исследователя, защищённом паролем. Бумажные документы будут находиться в надёжно запертом ящике, доступ к которому будет только у исследователя. Все данные будут храниться в течение шести месяцев после завершения исследования, после чего электронные материалы будут безвозвратно удалены, а бумажные документы уничтожены.

Прежде чем мы начнем, прошу вас подписать форму согласия, которая подтверждает следующее:

1. Я гарантирую, что вся информация останется конфиденциальной.

2. Вы можете прекратить участие в исследовании в любой момент, если почувствуете дискомфорт.

3. Аудиозапись будет расшифрована и впоследствии удалена. Доступ к данным будет иметь только исследователь.

Благодарю вас за готовность принять участие в этом интервью. Если у вас возникнут вопросы, связанные с исследованием, вы можете направить их на следующий электронный адрес: zhibek.baigulova@nu.edu.kz.

Вопросы:

А. Анкета интервьюируемого

Кратко опишите вашу роль.

Дополнительные вопросы: Как вы участвуете в преподавании? Как долго вы преподаете _____? EMI в STEM?

Что мотивирует вас преподавать [предмет: математика/естественные науки/физика/биология/химия] в казахстанской средней (частной/государственной) школе?

B. STEM в Казахстане

2. Поделитесь своими мыслями и опытом о STEM-образовании в Казахстане.

Как вы подходите к преподаванию STEM-предметов на английском языке? Знакомы ли вы с CLIL (интегрированным обучением содержанию и языку)? Используете ли вы его в своем классе? Как? (тренинги)

Как вы относитесь к преподаванию STEM на английском языке? Какие языки вы используете на уроках? Как? Когда вы их применяете?

C. Преимущества и трудности EMI в STEM

5. Сталкивались ли вы с какими-либо преимуществами преподавания STEM-предметов на английском языке?

Дополнительные вопросы: Если да, можете ли вы привести конкретный пример, где EMI было особенно полезно в STEM-классе?

6. Сталкивались ли вы с какими-либо трудностями или недостатками при преподавании STEM-предметов на английском языке?

Дополнительные вопросы: Можете ли вы описать эти трудности подробнее и рассказать, как вы или ваша школа их решали?

7. Как студенты реагируют на изучение STEM-предметов на английском языке? Заметили ли вы какие-либо изменения в их результатах обучения, вовлеченности или общем успеваемости?

D. Методы преподавания в STEM-образовании

8. Расскажите пожалуйста о своих методах преподавания для применения EMI в STEM-образовании.

Дополнительные вопросы: Есть ли специфические стратегии преподавания, инструменты или ресурсы, которые вы находите особенно эффективными для обучения студентов STEM, которые все еще развивают свои навыки владения английским языком?

9. Получали ли вы какое-либо профессиональное развитие или обучение специально для преподавания STEM-предметов в контексте EMI или CLIL? Когда? Как долго?

Дополнительные вопросы: Насколько это обучение было эффективным в помощи вам адаптироваться к преподаванию EMI?

10. Какие ресурсы, материалы или технологии вы использовали для преподавания STEM-предметов на английском языке? Какие дополнительные ресурсы вы бы порекомендовали для улучшения?

E. Будущие последствия EMI и CLIL в STEM-образовании

11. Как, по вашему мнению, преподавание STEM на английском влияет на развитие языка у студентов и их готовность к высшему образованию или будущим карьерам?

12. Какие рекомендации вы могли бы дать для лучшей поддержки ваших студентов?

Мұғалімдерге арналған жеке жартылай құрылымдалған сауалнама

Сізді қазақстандық орта мектептерде ағылшын тілінде оқытылатын STEM пәндеріндегі (EMI-STEM) мұғалімдердің тәжірибелері мен әдістерін зерттеуге қатысуға шақырамыз. Сұхбат шамамен 45-60 минутқа созылады және сіздің педагогикалық тәжірибеңізге және STEM сабақтарында технологиялар мен транслингвализмді қолдану тәжірибесіне назар аударады.

Сіздің келісіміңізбен сұхбат барысында аудиожазба жасалады. Жазба тек деректерді жинау процесін сипаттау және алынған нәтижелерді талдау үшін қолданылады. Егер сіз аудиожазбаға келіспесеңіз, оның орнына жазбаша жазбалар жазылады.

Зерттеудің барлық кезеңдерінде сіздің атыңыз бен мектебіңіздің аты анонимді болады. Зерттеу жұмысы келісімнің барлық ақпараттық формалары (қазақ, орыс және ағылшын тілдерінде) және аудиожазбалар зерттеушінің жеке компьютерінде сақталады және құпиясөзбен қорғалады. Барлық жазбаша және басылған құжаттар қауіпсіз жерде сақталады. Барлық деректер зерттеу аяқталғаннан кейін алты ай бойы сақталады, содан кейін электрондық материалдар біржола жойылып, қағаз құжаттар жойылады.

Бастамас бұрын сізден келісім формасына қол қоюыңызды сұраймын:

1. Мен барлық ақпараттың құпия болуын қамтамасыз етемін.

2. Егер сіз өзіңізді жайсыз сезінсеңіз, кез келген уақытта зерттеуге қатысуды тоқтата аласыз.

3. Аудио жазба транскрипцияланып, кейіннен жойылады. Деректерге тек зерттеуші қол жеткізе алады.

Осы сұхбатқа қатысуға дайын болғаныңыз үшін рахмет. Егер сізде зерттеуге қатысты сұрақтарыңыз болса, оларды келесі электрондық пошта мекенжайына жібере аласыз: zhibek.baigulova@nu.edu.kz.

А. Интервью қатысушысы туралы ақпарат

Рөліңізді қысқаша сипаттап беріңіз.

Тақырыптар: Сіз оқытумен қалай айналысасыз? Сіз _____ пәнін қанша уақыт бойы оқыттыңыз? EMI STEM-де?

Қазақстандық орта (жеке/мемлекеттік) мектепте [пән: математика/ғылым/физика/биология/химия] оқытуды не нәрсе ынталандырады?

B. Қазақстандағы STEM

2. Қазақстандағы STEM білім беру туралы ойларыңыз бен тәжірибелеріңізбен бөлісе аласыз ба?

STEM пәндерін ағылшын тілінде оқытуға қалай қарайсыз? Сіз CLIL (Мазмұн мен Тілді Интеграцияланған Оқыту) туралы білесіз бе немесе сыныбыңызда оны қолданасыз ба? Қалай? (тренингтер)

STEM пәндерін ағылшын тілінде оқытуға қалай қарайсыз? Сыныбыңызда қандай тілдерді қолданасыз? Қалай? Қашан қолданасыз?

C. STEM-де EMI-дің артықшылықтары мен қиындықтары

5. STEM пәндерін ағылшын тілінде оқытудың қандай да бір артықшылықтарына тап болдыңыз ба?

Тақырыптар: Егер солай болса, STEM сабағында EMI-дің әсіресе пайдалы болған нақты мысал келтіре аласыз ба?

6. STEM пәндерін ағылшын тілінде оқыту кезінде қандай да бір қиындықтар немесе кемшіліктерге тап болдыңыз ба?

Тақырыптар: Бұл қиындықтарды толығырақ сипаттап беріп, сіз немесе мектебіңіз оларды қалай шешкенін бөлісе аласыз ба?

7. Студенттер ағылшын тілінде STEM пәндерін үйренуге қалай жауап берді? Олардың оқу нәтижелері, қызығушылығы немесе жалпы жетістіктерінде қандай да бір айырмашылықтарды байқадыңыз ба?

D. STEM білім берудегі оқыту әдістері

8. STEM білім беруде EMI-ді қолдануға арналған оқыту әдістеріңіз туралы айтыңыз.

Тақырыптар: Әлі де ағылшын тілін меңгеріп жатқан студенттерге STEM оқытудың тиімді деп есептейтін арнайы оқыту стратегиялары, құралдары немесе ресурстары бар ма?

9. EMI немесе CLIL контекстінде STEM пәндерін оқытуға арнайы кәсіби даму немесе оқыту алдыңыз ба? Қашан? Қанша уақыт?

Тақырыптар: Бұл тренинг EMI оқытуға бейімделуге қаншалықты тиімді болды?

10. STEM пәндерін ағылшын тілінде оқыту үшін қандай ресурстар, материалдар немесе технологиялар қолдандыңыз? Жақсарту үшін қандай қосымша ресурстар ұсынасыз?

E. STEM білім берудегі EMI және CLIL-дің болашақ ықпалы

11. Сіздің пікіріңізше, ағылшын тілінде STEM оқытудың студенттердің тіл дамытуы мен жоғары білімге немесе болашақ мансапқа дайындығына әсері қандай?

12. Оқушыларыңызды жақсырақ қолдау үшін қандай ұсыныстарыңыз бар?

Appendix E: Observation protocol

Basic Information:

Observer's name: Zhibek Baigulova

Date and time of observation: (To be arranged)

Class details: Grades 7-9, subject (e.g., STEM), and number of students present.

Teacher's name (if consented): Teacher A

Classroom Context:

Description of the physical environment, seating arrangement, and learning resources.

Lesson topic:

Lesson objectives:

Language(s) used during instruction:

Use of teaching tools (e.g., textbooks, digital resources, visual aids):

Focus Areas:

a. Teacher Instruction:

Teaching methods: What strategies does the teacher use (e.g., direct instruction, group work)?

What languages does the teacher use? In what time?

Explanation of concepts: How does the teacher clarify difficult content?

Engagement: How does the teacher keep students focused and engaged?

b. Classroom Interaction:

Teacher-student interaction: How often does the teacher engage with students individually or in groups?

Questioning techniques: Does the teacher ask questions to check for understanding?

c. Teacher;s technology use:

Does the teacher use online resources or applications to support multilingual learning? (e.g., language learning apps, multimedia resources)

If yes, What technology does the teacher use during the lesson?

Teacher's reflection (if applicable): Post-lesson, what reflections or feedback does the teacher provide on the lesson's effectiveness?

Challenges observed (if any): Were there difficulties encountered during the lesson (e.g., student confusion, classroom management issues)?

Summary:

Overall impressions: Provide a summary of the teacher's effectiveness in delivering the lesson and engaging students. Suggestions for improvement: Offer any potential suggestions for the teacher to enhance student comprehension or engagement in future lessons.