A Quasi-Experimental Pre-Post Test Study on the Utility of the Flipped Learning Approach for Learning Grammatical Concepts: Results for High School Students in Central Kazakhstan

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A QUASI-EXPERIMENTAL PRE-POST STUDY FOR GRAMMAR

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For the Full Board Review
№ 151 – November 28, 2022

Having reviewed the information and put it for consideration of the NU IREC Chair Professor Elaine Sharplin, the Institutional Research Ethics Committee has **DECIDED**:

To approve Tatyana Nam's research proposal "A Quasi-Experimental Study on the Utility of the Flipped Learning Approach for Learning Grammatical Concepts: Results for High School Students in Central Kazakhstan".

Date of Approval: December 5, 2022

IREC №: 622/03102022

IREC Secretary

Dilara Sarbassova,
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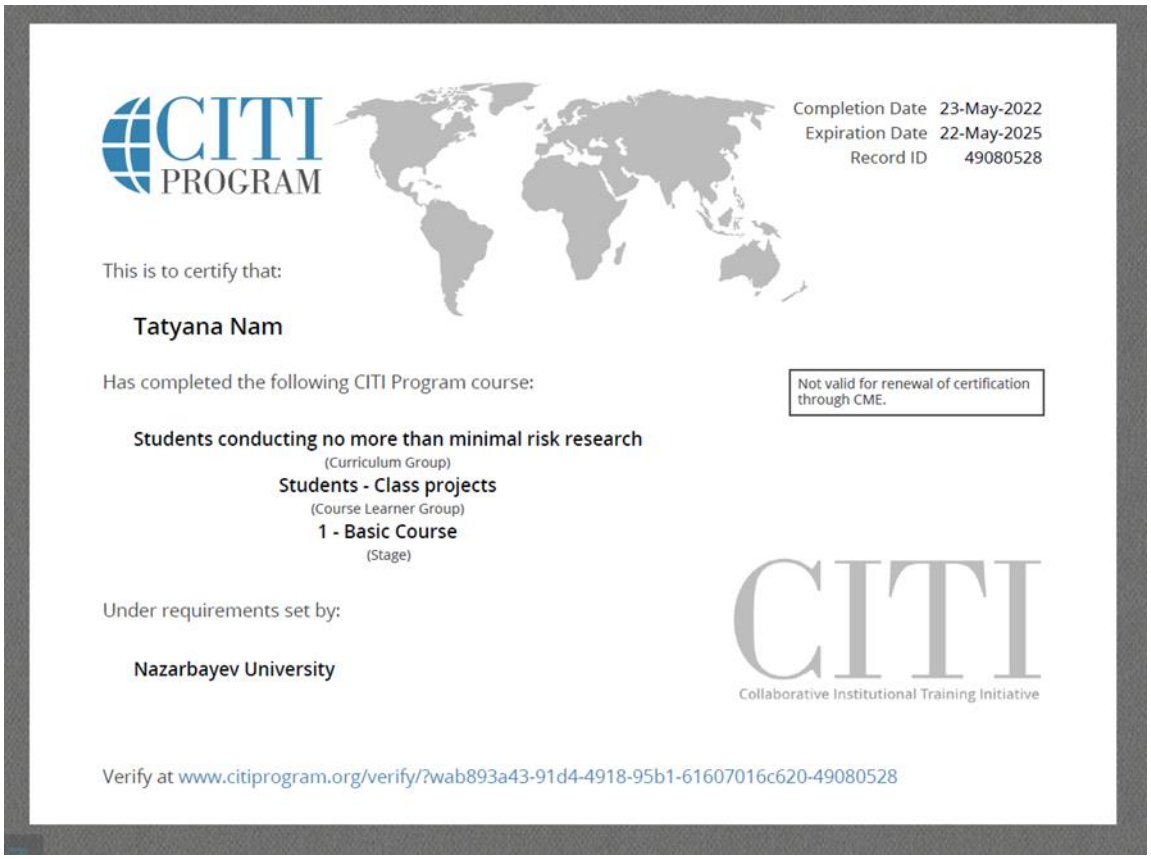

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ABSTRACT

A Quasi-Experimental Pre-Post Test Study on the Utility of the Flipped Learning Approach for Learning Grammatical Concepts: Results for High School Students in Central Kazakhstan

For the last few years, there has been considerable interest in the teaching and learning approach commonly known as the flipped classroom. The flipped classroom model comprises Internet technology to facilitate classroom learning and allows teachers to interact more with students instead of lecturing. This new approach could be implemented using teacher-created videos that students watch outside of class time. Such a model is called *the flipped class*, as the entire classroom and homework process is "flipped".

The flipped classroom teaching model is a new approach to teaching grammar that might have a fruitful long-term effect on Grade 9 learners in Kazakhstan. This research aims to explore the effects of the flipped classroom model on 63 intermediate-level students in learning grammatical concepts in one gymnasium in Central Kazakhstan. This involved tracking the progress of students in flipped and traditional classroom settings using a quasi-experimental design.

The quantitative focused investigation involved a quasi-experimental design for identifying evidence as to the impact of the flipped approach on students' academic improvement in learning grammar. For this, four experimental sub-groups (n = 63) studied grammatical concepts using the flipped classroom strategy while the four control classes (n = 41) studied the same grammatical concepts using the traditional teacher-centred in-class approach.

For this research, the same pre- and post-tests were administrated on the experimental and control groups. The internal reliability of the tests' items was assessed with the help of Cronbach's alpha and deemed highly reliable, and students were afforded pre- and post-test

ability estimates based on common-item linked equating design. All analysis was calculated with the assistance of the CTT (Willse, 2018) and TAM (Robitzsch et al., 2020) R packages.

The results indicated that learners taught in the flipped classroom progressed at statistically significantly faster rate than learners in the traditional classroom. Additionally, by explaining the grammar content vis-à-vis short but concise online videos in the flipped classroom model, the instructor (the researcher) was afforded ample face-to-face time to apply collaborative instruction with learners.

The study's results showed that flipped instruction could more effectively improve students' grammar abilities and contribute to better learning outcomes. Therefore, the findings of this research suggest that the flipped classroom, as implemented in the current study, may be a useful option for teachers to support student learning of English grammar concepts. Further studies should be undertaken in other contexts to confirm these early results. In addition, researchers might also be interested in investigating whether flipped classrooms can sustain learner engagement in the longer term.

Keywords: The flipped classroom model, pre-post quasi-experimental designs, grammatical concepts, academic performance, student assessment, grammar competency, Rasch modelling, linked test equating.

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Аңдатпа

Грамматикалық ұғымдарды зерттеудегі «төңкерілген тәсілдің» тиімділігі туралы квазиэкспериментік зерттеу: Орталық Қазақстандағы жоғары сынып оқушыларына арналған тест нәтижелері

Соңғы бірнеше жылда оқыту мен оқудағы «айналдырылатын сынып» үлгісі сияқты ортақ тәсілге үлкен қызығушылық болды. Ауыстырылған сынып үлгісі оқуды жеңілдететін және мұғалімдерге дәріс емес, студенттермен көбірек араласуға мүмкіндік беретін интернет технологиясын пайдалануды қамтиды. Бұл жаңа тәсілді оқушылар сабақтан тыс уақытта көретін және ең алдымен үйренетін мұғалім жасаған нұсқаулық бейнелер арқылы жүзеге асыруға болады. Оқытудың мұндай инновациялық сценарийі «айналмалы» сынып деп аталады, өйткені теориялық материал сабақ басталар алдында өз бетінше оқытылады, ал бос уақыт білім мен дағдыларды жаңа жағдайда қолдануға бағытталған.

«Төңкерілген сынып» моделі – Қазақстандағы 9-сынып оқушыларына жемісті және ұзақ мерзімді әсер ете алатын грамматиканы оқытудың жаңа тәсілі. Бұл зерттеу Орталық Қазақстандағы бір гимназияда грамматикалық ұғымдарды меңгеретін алпыс үш (63) орта деңгейдегі ағылшын тілін үйренушілерге аударылған сынып үлгісінің әсерін зерттеуге арналған. Бұл зерттеу квазиэкспериментік дизайнды пайдалана отырып, аударылған және дәстүрлі сыныптағы оқушылардың үлгерімін бақылауды қамтыды.

Зерттеудің сандық құрамдас бөлігі студенттердің грамматиканы меңгерудегі академиялық үлгеріміне аударылған тәсілдің әсерінің дәлелдерін анықтау үшін квазиэкспериментік дизайнды қамтыды. Ол үшін төрт эксперименттік топша (n = 63) «Төңкерілген сынып» стратегиясын пайдалана отырып, грамматикалық ұғымдарды

меңгерді, ал төрт бақылау сыныбы (n = 41) негізгі тұлға мұғалім болған сыныпта дәстүрлі тәсілді қолдана отырып, бірдей грамматикалық ұғымдарды меңгерді.

Бұл зерттеу үшін эксперименталды және бақылау топтарында бірдей алдын ала және кейінгі сынақтар орындалды. Тест тапсырмаларының ішкі сенімділігі Кронбахтың альфа сынағы арқылы бағаланды және оның сенімділігі жоғары деп табылды, ал студенттерге жалпы тапсырмалармен байланысты теңестіру схемасы негізінде тестілеуге дейінгі және тесттен кейінгі қабілеттілік ұпайлары берілді. Барлық талдаулар CTT (Wheels, 2018) және TAM (Robitz et al., 2020) R пакеттері арқылы есептелді.

Нәтижелер аударылған сыныптағы студенттердің дәстүрлі сыныптағы оқушыларға қарағанда статистикалық тұрғыдан айтарлықтай жылдам ілгерілегенін көрсетті. Сонымен қатар, грамматика мазмұнын қысқа, бірақ ықшам онлайн бейнероликтер арқылы аударылған сынып үлгісінде түсіндіру арқылы мұғалімнің (зерттеуші) бірлескен оқуды ұйымдастыру үшін студенттермен тікелей байланыста болуына жеткілікті уақыт болды.

Зерттеудің нәтижелері аударылған оқыту оқушылардың грамматикалық қабілеттерін тиімдірек жақсартып, оқу нәтижелерінің жақсырақ болуына ықпал ететінін көрсетті. Сондықтан, осы зерттеудің нәтижелері ағымдағы зерттеуде енгізілген аударылған сынып мұғалімдерге студенттерге ағылшын тілінің грамматикасының ұғымдарын үйренуге көмектесетін пайдалы нұсқа болуы мүмкін екенін көрсетеді. Бұл нәтижелерді растау үшін басқа контексттерде қосымша зерттеулер жүргізу қажет. Сонымен қатар, зерттеушілер аударылған сыныптар студенттерді ұзақ мерзімді перспективада қызықтыра алатынын зерттеуге қызығушылық танытуы мүмкін.

Түйінді сөздер: айнылған сынып үлгісі, квазиэкспериментік жобаларға дейін және кейін, грамматикалық түсініктер, оқу жетістіктері, оқушыны бағалау, грамматикалық құзіреттілік, Раш модельдеу, байланыстырылған тест сәйкестігі.

Аннотация

Квази-экспериментальное исследование об эффективности применения «перевернутого подхода» в изучении грамматических понятий: результаты тестов для старшеклассников в Центральном Казахстане

В последние годы наблюдается значительный интерес к такому распространенному подходу в преподавании и обучении, как технология «перевернутый класс». Модель «перевернутый класс» включает в себя использование интернет технологий, которые облегчают обучение учащихся и позволяют учителям уделять больше времени на взаимодействие с учениками вместо чтения лекций при обучении грамматики. Этот новый подход может быть реализован с помощью созданных учителем обучающих видеороликов, которые учащиеся смотрят и первично изучают во внеурочное время. Такой инновационный сценарий обучения называется «перевернутым» классом, так как теоретический материал изучается самостоятельно до начала урока, а высвобожденное время направлено на применение знаний и умений в новой ситуации.

Модель обучения в «перевернутом» классе - это новый подход к обучению грамматики, который может оказать плодотворное и долгосрочное влияние на учащихся 9-х классов в Казахстане. Уровень знания английского языка у учащихся средний, при изучении грамматических понятий в отдельно взятой гимназии в Центральном Казахстане. Это исследование включало отслеживание прогресса учащихся в «перевернутом» и традиционном классах с использованием квази-экспериментального дизайна.

Количественный компонент исследования включал в себя квази-экспериментальный дизайн для выявления доказательств влияния «перевернутого» подхода на академический прогресс учащихся в части изучения грамматического

аспекта. Для этого четыре экспериментальные подгруппы (n = 63) изучали грамматические понятия, используя стратегию «перевернутого» класса, в то время как четыре контрольных класса (n = 41) изучали те же грамматические понятия, используя традиционный подход в классе, в котором главной фигурой являлся учитель.

Для этого исследования в экспериментальной и контрольной группах были проведены одни и те же предварительные и последующие тесты. Внутренняя надежность тестовых заданий была оценена с помощью альфа-критерия Кронбаха и признана высоконадежной, а учащимся были предоставлены оценки способностей до и после теста на основе схемы уравнивания, связанной с общими элементами. Весь анализ был рассчитан с помощью R-пакетов CTT (Уилз, 2018) и TAM (Робитс и др., 2020).

Результаты показали, что учащиеся, обучавшиеся в «перевернутом» классе, прогрессировали статистически значительно быстрее, чем учащиеся в традиционном классе. Кроме того, объясняя содержание грамматики с помощью коротких, но лаконичных онлайн-видео в модели «перевернутого» класса, у учителя (исследователя) появилось достаточно времени для прямого контакта со студентами, чтобы организовать совместное обучение.

Результаты исследования показали, что «перевернутое» обучение может значительно улучшить грамматические способности учащихся и способствовать эффективным результатам обучения. Таким образом, результаты этого исследования показывают, что «перевернутый» класс, реализованный в текущем исследовании, может быть полезным вариантом для учителей, чтобы помочь учащимся изучать концепции английской грамматики. Дальнейшие исследования должны быть проведены в других контекстах, чтобы подтвердить эти результаты. Кроме того, исследователи также могут быть заинтересованы в изучении того, смогут ли

«перевернутые» классы поддерживать вовлеченность учащихся в долгосрочной перспективе.

Ключевые слова: модель «перевернутый» класс, квази-экспериментальные проекты до и после, грамматические понятия, академическая успеваемость, оценка учащихся, грамматическая компетентность, моделирование Рач, приравнивание связанных тестов.

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LIST OF ABBREVIATIONS

BIL	Bilim Innovation Lyceums
CEFR	Common European Competencies
CLT	Communicative Language Teaching
de	Design Effect
FC	Flipped Classroom
IELTS	International English Language Testing System
ICC	Intraclass Correlation Coefficient
IML	Instructional Methodological Letter
MoES	Ministry of Science and Higher Education of Kazakhstan
PIAAC	The Program for the International Assessment of Adult Competencies
PISA	The Program for International Student Assessment
RAT	Readiness Assessment Tests
SAT	Scholastic Assessment Test
TIMSS	The Trends in International Mathematics and Science Study
TOEFL	Test of English as a Foreign Language
TOEIC	Test of English for International Communication
ZPD	Zone of Proximal Development

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1. Introduction

Kazakhstan, a developing country in Central Kazakhstan, is undertaking efforts to integrate into the global economy. Having a high level of English proficiency is regarded as an essential factor in enabling the country to engage with the global community. Hence, the State Program of Kazakhstan (2022) seeks to cultivate citizens who are proficient in multiple languages, including the ability to communicate effectively in various domains. Notably, the State Program for the Development of Education and Science (MoES, 2020) in Kazakhstan, and its outward-facing multi-lingual language policy, was highly supported by former President Nursultan Nazarbayev who established "a global competitive" discourse that considers English as the language of integration into the global economy (Goodman et al., 2012).

The authorities are making efforts to consistently come up with new ideas regarding the "English language" to enhance the English language skills of Kazakhstani students in the current era of globalization. Nevertheless, according to Batyrova (2021), students from Kazakhstan are encountering challenges in utilizing English for effective communication. It has been argued that one of the reasons for poor English ability is the prevailing teacher-centered instructional method deeply engrained in educational settings (OECD, 2015). Thus, English teachers have often been encouraged to adopt new and innovative teaching methods.

Grammar represents a vital base for English language acquisition. Ur (2012) defines grammar as "the way words are put together to make correct sentences" (p. 12). Moreover, students are often considered to be competent users of English if they can deliver grammatically correct utterances (Saidah, 2019). Ur (2012) also places more serious attention on grammar emphasizing the importance for how teachers deliver the grammatical content. In this way he explicates that it is an imperative for the instructors to use effective, modern approaches to teach grammatical content. Teaching grammar by way of applying old-

fashioned strategies may be boring and discouraging to students. As research has suggested, the instructional style in which a teacher merely presents isolated grammar rules can make learning less interesting and passive (Jean & Simard, 2011). In addition, in a traditional class, where the teacher simply attempts to transmit knowledge, students often fail to concentrate and recall the information one hour later (Santos & Serpa, 2020). As a result, it is widely believed that employing traditional teaching methods can induce feelings of inactivity and disinterest among students, ultimately impeding their ability to learn. The reason for this is that instruction focused on the teacher tends to prevent students from engaging in active communication and participation with both their teachers and classmates, ultimately resulting in a decline of their interest in the subject matter over time (Joksimovic et al., 2019). Research has suggested that having no sufficient time to interact and reflect results in poor development of students' active learning skills. Therefore, it has been argued that grammar should be taught in accordance with instructional techniques and communicative contexts to allow students to scaffold their learning productively.

There exist multiple arguments for shifting from the conventional to the more advanced and innovative approaches to teaching grammar. There is a debate suggesting that incorporating digital technologies and innovative teaching methods are crucial elements for enhancing students' proficiency and interest in acquiring English grammar. (Chen et al., 2017; Afzali & Izadpanah, 2001; Nouri, 2016; Strohmeyer, 2016); According to Prensky (2005), modern students possess strong skills in computer-based communication and can easily adjust to technological changes. This proficiency has given rise to a generation of "digital natives" who are enthusiastic about utilizing electronic tools for educational purposes.

One of the novel pedagogical approaches to support student-centred active learning is the flipped classroom (FC), i.e., when "what is normally done in class is flipped: instead of

students listening to a lecture, they read materials and watch videos before coming to class" (Herreid & Schiller, 2013, p. 62). The "flipped classroom" involves students receiving initial exposure to new concepts outside the class with the help of videos or reading materials—thereafter, they assimilate knowledge through problem-solving or interactive activities during their time in class. According to Bloom's taxonomy (2001), students tend to perform lower levels of cognitive work outside of classrooms, and, with the support of their teachers and peers, concentrate on higher forms of cognitive work during in-class activities.

Since 2012, the concept of flipped classroom instruction has generated research interest, leading to numerous studies investigating its impact on students of varying levels and subjects. Empirical research in support of the FC approach has been presented in numerous narrative reviews (Chen et al., 2017; Afzali & Izadpanah, 2001; Nouri, 2016; Strohmeyer, 2016; Heyborne et al., 2016).

Research supporting the use of the FC spans multiple subject areas, including English. Moreover, the FC approach has also been shown to support learning in multiple productive- and receptive-based sub-domains of language learning, e.g., listening skills (Ahmad, 2016), speaking (Abdullah et al., 2019), reading (Xinying, 2017), and writing (Qader & Arslan, 2019), including grammar (Al-Harbi & Alshumaimeri, 2016). However, the findings in the Al-Harbi & Alshumaimeri (2016) study were based on quasi-experimental post-test only design and involved a small sample size (control $n = 23$, experiment $n = 20$). Therefore, given the lack of a pre-post design, the study itself did not explicitly identify the different rate of improvement in English grammar for the students in the experimental flipped classroom condition. Therefore, the current study serves to fill the gap in the literature by (1) drawing upon a larger sample of students, and (2) employing a quasi-experimental pre-post research design to examine the potential benefits of the flipped classroom approach more rigorously.

The following subsections of this chapter provide details vis-à-vis background information, the problem statement, and the study's purpose.

1.1 Background Information

According to Lage et al. (2000), a flipped or inverted classroom means that activities that were traditionally done in the classroom are now done outside of it, and vice versa. Strayer (2012) adds that flipped learning involves teachers assigning students to read and study the course material before attending class, so that they can deepen their understanding of the concepts during class time. He emphasizes the importance of utilizing interactive technologies consistently and systematically in the educational process. This involves the teacher preparation and dissemination of brief instructional videos for students to view prior to class, and teacher management and facilitation of a range of interactive or problem-solving exercises during class. Ultimately, flipped learning transforms the method of instruction to one that is centered on the student, providing them with the chance to delve into concepts and foster a more profound understanding of the material.

Jon Bergman and Aaron Sams, two unassuming chemistry teachers from Colorado, are credited as the pioneers of the flipped classroom. They introduced a new approach to teaching that revolutionized the traditional model. Their teaching method involves transmitting knowledge outside the classroom, and then allowing students to internalize it during class time. In their book, Flip Your Classroom: Reach Every Student in Every Class Every Day, Bergman and Sams emphasized that the flipped classroom model allows for a more personalized approach to learning. According to Bretzman (2013), students are able to choose the content they want to focus on and complete the portions they prefer. Additionally, it may be that some learners struggle with in-class activities. In this case, they are able to internalize the content of the class material by watching videos and other instructional content depending on their pace, abilities, and talents. The focus on customizing instruction

allows for differentiated instruction in which teachers are more responsive to each student's learning style, previous knowledge, accessibility, or cultural background (Alias, 2014). Hence, the flipped learning strategy aligns with a key objective of Kazakhstan's State Program (2022), which emphasizes the importance of individualized learning to foster the interests and needs of children.

The success of flipped teaching largely depends on the competence and readiness of the teachers leading the lessons, according to research by Xiu and Thompson (2020). Specifically, teachers must be equipped with the knowledge and skills necessary to teach grammatical concepts effectively in a technology-based environment. Strayer (2012) further emphasizes the importance of integrating the online and in-person components of flipped teaching seamlessly to avoid technological obstacles. As a result, flipped instructors must assume a greater responsibility for preparing their classes, given the significant role they play in the success of the approach. In this regard, the teacher should be ready for the complex and unpredictable questions raised by the students during class time. Previous studies on grammar instruction have suggested that teachers' videos become scaffolding tools that further elucidate a grammatical structure within in-class activities (Noroozi, 2022).

In the current digital age, videos have become an essential tool for delivering educational content. However, the effectiveness of these videos depends on how well they are designed and delivered. To ensure that students derive the maximum benefit from these videos, teachers should make sure that their videos are precise and easy to understand. Studies have shown that videos that are too long or difficult to comprehend may lead to student fatigue, anxiety, and learning difficulties. Therefore, it is recommended that videos be limited to a duration of 5 to 10 minutes and that they include interactive elements to keep students engaged. Ultimately, videos that are well-designed and delivered can be an effective

tool for facilitating active learning and encouraging students to take an active role in their education.

According to research conducted previously, the implementation of flipped learning has the potential to enable teachers to integrate a range of teaching approaches and tasks, ultimately leading to an improvement in students' academic performance both inside and outside the classroom (Flipped Learning Network, 2014). To ensure that students receive quality education, it is recommended that teachers establish routine and repetitive activities that help students practice and reinforce their understanding of the content (McLaughlin et al., 2016). In addition, teachers should create opportunities for students to engage with the learning material, starting from the fundamental concepts before class and progressing towards a more in-depth comprehension of the lesson material (Bezzazi, 2019). This pedagogical approach can help students develop a deeper understanding of the material and acquire the necessary skills to apply the knowledge gained in real-life scenarios. It is essential that teachers adapt and tailor their teaching practices to cater to the diverse needs and learning styles of their students, as this can ultimately result in improved learning outcomes. The studies demonstrate that flipped instruction can develop learner autonomy, improve learners' attitudes, and facilitate their confidence and level of commitment (Han, 2015; Hung, 2015).

Several studies have investigated the effectiveness of the flipped learning approach in teaching grammar, and they have consistently found that students respond positively to this method. For instance, Donam and Webb (2016), Lee and Wallace (2017), Singay (2020), Afzali and Izadpanah (2001), Noroozi (2022), Al-Harbi, and Alshumaimeri (2016), and Al-Naabi (2020) all reported favorable attitudes and perceptions towards flipped learning. One common benefit of the flipped approach is that learners can better understand grammatical content and acquire associated knowledge. Additionally, Singay (2020) found that students

who watched video assignments prior to class were more likely to participate actively in classroom activities. Overall, the findings suggest that flipped learning is a promising approach to teaching grammar that can enhance students' learning experiences. Moreover, their inclination towards acquiring knowledge of English grammar was fueled by the flipped classroom setting that allowed them to engage and cooperate with their classmates more frequently. Hence, the attainment of aptitude in language acquisition is mainly influenced by the mindset of learners.

Despite the potential benefits of flipped classrooms, certain studies suggest that some students may face difficulties in this new form of learning. One of the primary challenges is the students' resistance to adapt to a different teaching method (Chen, 2016). In Kazakhstan, students often rely on teachers for guidance and may struggle to adjust to a novel approach that comes with new practices and responsibilities. Furthermore, students might encounter inconvenience and difficulty in completing out-of-class activities. As Strayer (2009) notes, the flipped classroom demands a lot from students in terms of their new roles, responsibilities, and participation. It requires them to be more self-directed and proactive in their learning, which can be challenging for some learners. In other words, they may be unprepared to read or watch the pre-class content and complete activities individually. The research carried out by Missildine and colleagues (2013) revealed that students were not fond of the flipped instructional method due to the multitude of preparatory tasks they had to complete before class. Furthermore, a few students desired immediate clarification of a concept or direct assistance from their teacher instead of relying solely on the flipped approach (Bhagat et al, 2016).

Despite the potential disadvantages, the flipped classroom has emerged as a highly effective teaching strategy for improving students' English grammar skills. The unique structure of the flipped classroom offers a multitude of benefits for students, which can

contribute to their overall academic success. One significant advantage of the flipped classroom is its ability to offer a diverse range of learning opportunities for students. As a result, students can tailor their learning experience to meet their individual needs and learning styles. Moreover, the flipped classroom can enhance student engagement and motivation, which can significantly improve their grammar performance.

Additionally, the flipped classroom model can benefit teachers as well. By using technology and multimedia resources to deliver grammar instruction, teachers can create a more dynamic and interactive classroom environment. This, in turn, allows teachers to efficiently utilize classroom time and resources, enabling them to focus on more personalized instruction and assessment. As such, the flipped classroom has the potential to revolutionize the way we approach English grammar instruction, creating more engaging and effective learning experiences for both teachers and students alike.

1.2 Problem Statement

As an experienced English teacher, I have devoted significant time to reflecting on my teaching practices and principles, particularly as I encounter students with diverse ages, needs, abilities, and backgrounds. I strongly believe that each student deserves a chance to be heard, understood, and supported in their learning journey. However, this can be challenging as I strive to identify and implement the most suitable teaching methods for each individual.

Throughout my teaching career, I have maintained a keen interest in exploring innovative teaching techniques. Specifically, I have dedicated considerable thought to devising effective strategies for teaching grammar. By doing so, I aim to ensure that my students not only understand the technical aspects of the language but also develop their skills in using it effectively.

From an academic standpoint, grammar serves as a fundamental foundation for students to cultivate their proficiency in communication. After undergoing eleven years of

English language education as a student, it has become evident that a significant number of students struggle with employing grammatical principles for effective communication. Furthermore, in my personal observation, students often express apathy towards traditional grammar instruction methods. This is particularly prevalent in EFL (English as a Foreign Language) classes in Kazakhstan where the predominant teaching technique involves a teacher-centered approach, with the teacher and textbook being the sole sources of knowledge. The traditional approach to teaching grammar presents several shortcomings for learners.

When the teacher is the sole focus of attention in a classroom, students' capacity to comprehend information can decline, leading to boredom and lack of interest. In a conventional classroom setting, there is minimal interaction between the teacher and students, as well as among students themselves, which can cause them to become passive, reducing their engagement and interest in learning the language. Furthermore, conventional teaching methods restrict students' ability to pose questions or respond to the teacher's inquiries. Lastly, students are expected to work independently on homework assignments in conventional classrooms, which requires them to apply the knowledge presented in lectures without direct instructional guidance. This approach may lead to cognitive overload and hinder students' capacity to store knowledge in their long-term memory (Alten et al., 2019).

In order for students to acquire English grammar skills and utilize them in various contexts, it is imperative for educators to employ effective language learning strategies. The traditional approach to language learning may be supplemented by the flipped approach, which could prove to be a more effective and stimulating means of learning grammar. Despite being a recent pedagogical method in Kazakhstani educational institutions, some have advocated for the inclusion of the flipped approach as a novel practice in the ongoing reform efforts of the Kazakhstani education system.

Prior research has indicated that the flipped classroom approach can enhance the effectiveness of students' English grammar learning (Chen, 2016; Chua, 2020; Roehling, 2017; Valentino, 2015). The existing literature highlights four potential benefits of the flipped classroom approach, including: (1) facilitating increased grammar proficiency among students; (2) enabling learners to apply their knowledge of English grammar in practical communicative settings; (3) allowing students in Kazakhstan to manage their own learning pace; and (4) fostering greater student engagement in the learning process (Bergmann & Sams, 2012; Berret, 2012).

As per the regulations set forth in The State Program of Kazakhstan, student performance will be closely monitored via a unique and independent educational monitoring system. This system, known as the “Educational Monitoring System,” has been designed to track the academic progress, specifically competence in real-life scenarios, of students in 4th and 9th Grades, with a specific focus on the English language. The primary goal of this system is to determine the functional literacy skills of students and evaluate their ability to apply what they have learned in practical situations.

To ensure that the quality of education remains high and adheres to State Standards, the Minister of Education issued a decree on May 5th, 2021, which mandates a yearly assessment of students. This assessment will serve as a means to monitor and evaluate the overall standard of education in the country. By implementing these measures, the government aims to promote educational excellence and provide students with the necessary tools and skills to succeed in the future.

Consequently, it is anticipated that students from Kazakhstan will need to possess a specific level of competency in English grammar to succeed in the upcoming national English tests. It is essential for students to be proficient in English grammar as it forms a fundamental part of their language skills, which are vital in ensuring their academic and

professional success. Acquiring a strong grasp of English grammar will enable students to communicate effectively, both orally and in writing, and will facilitate their ability to comprehend and analyze English texts. Therefore, it is imperative that students in Kazakhstan prioritize the development of their English grammar skills to achieve excellence in the national English examinations and to further their educational and career aspirations.

There is a lack of international research on whether the flipped approach is a useful strategy for improving English grammatical proficiency. Moreover, no empirical work has been undertaken in Kazakhstan to address this research question. The present study provides Kazakhstani educators and other stakeholders with insights into the utility of such teaching practices, the unique opportunity to reflect upon and adapt innovative teaching approaches, and, ultimately, instructional and pedagogical guidelines for the Kazakhstani educational context.

In the current body of research, there is a lack of empirical studies that investigate the impact of the flipped approach on the development of English grammar among Kazakhstani learners. In response to this gap, a quasi-experimental pre-post design study has been conducted to address this issue. The primary objective of this study is to explore the potential contribution of the flipped approach to the enhancement of English grammar skills among Kazakhstani learners.

1.3 Purpose of the Study

Building upon previous research on the effectiveness of the flipped classroom model in language learning, particularly in relation to English grammar, the present study aims to explore the extent to which students in secondary schools in Kazakhstan can enhance their understanding and proficiency in English grammar by adopting the flipped model approach. This study aims to examine the impact of the flipped classroom model on the learning outcomes of Kazakhstani students and to evaluate the effectiveness of this pedagogical

approach in the context of English grammar. By analyzing the results of this research, we can gain a better understanding of the potential benefits and limitations of the flipped classroom model in language education and identify areas for further improvement.

1.4 Research Questions

To accomplish the purpose of the research, multiple research questions needed to be addressed. To ensure that the results of the research might be generalizable to the wider population, it is important to ensure first that the pre- and post-test instruments are both valid and reliable. Thereafter, an examination of pre- and post-test ability for the respective student groups can be made. Henceforth, the following research questions and sub-questions are as follows:

RQ1: To what extent are the pre-and post-tests of student grammatical ability valid and reliable?

RQ2(a): What is the pre-test grammatical ability of the (i) experimental and (ii) control groups?

RQ2(b): What is the post-test grammatical ability of the (i) experimental and (ii) control groups?

RQ2(c): Compared to the traditional classroom, does the flipped classroom approach result in improved growth in student grammatical knowledge?

1.5 Significance of the Study

As far as the author knows, no investigation has been carried out in Kazakhstan on the effectiveness of the FC method for teaching English grammar. Hence, this study is anticipated to provide a significant and distinctive addition to the existing body of knowledge.

Language teachers in Kazakhstan may benefit from the research findings as it introduces new and engaging teaching methods for specific language concepts, particularly grammar. The results of the study may also aid secondary school students in Kazakhstan, as personalized and self-directed teaching approaches can help students learn at their own pace and style. Furthermore, such techniques can develop the students' self-regulated learning skills, allowing them to regulate their learning experiences and performances (Mohanty & Parida, 2016).

Based on the sharing of the specialist statistical techniques employed in this study, Kazakhstani researchers will also be able to conduct similar strong research designs that track levels of improvement in student learning under experimental and control conditions. Ultimately, the research findings highlight the significance of incorporating both traditional and inverted learning methods in educational practices. This could serve as a wake-up call for policymakers to recognize the value of this approach. Moreover, it may also help researchers gain a better understanding of the potential benefits of implementing the flipped learning model for teaching grammar in Kazakhstan. As a result, there is an opportunity to enhance the overall quality of education in the region by utilizing a combination of both teaching styles.

1.6 Summary

In the following chapter, we will consider the importance of language learning and present empirical studies of foreign and local researchers that is generally in support of the effectiveness of applying the flipped classroom approach for learning grammatical concepts. The first section of the literature review provides a detailed characterization of CLT as one the more effective approaches to be combined with the flipped classroom pedagogical strategy and also details the possible benefits for the students compared to traditional

teaching approaches. The second part of the literature review explores relevant theories and provides a unified conceptual framework for the present study.

2. Literature Review

This chapter reviews the extant literature on the flipped classroom approach and its impact on students' grammatical competency. This review of literature provides a summary of the research that investigates whether flipped learning is a more effective approach compared to traditional learning and whether it can result in better outcomes in terms of students' acquisition of English grammar. The literature review focusses on outcome-oriented research that reports on empirical findings of the flipped approach for teaching grammar. Specifically, the review considers some practices of the flipped approach applied by foreign and local researchers and illustrates the results of this intervention. In addition, so as to underpin the current study, the literature review presents significant theories related to applying the flipped classroom approach in teaching grammar, namely, constructivist learning theory, Bloom's taxonomy, and sociocultural theory.

The text initially discusses the importance of grammar in language acquisition and presents research on innovative and pragmatic approaches for teaching grammar, contrasting them with the conventional method. It then introduces the concept of the flipped classroom technique in the context of grammar education and gives an overview of empirical and quasi-experimental studies that suggest the efficacy of this approach.

This chapter then compiles and presents some of the Kazakhstani studies conducted on the application of the flipped approaches at different educational levels. This review contains some specific studies applicable to the Kazakhstani learning environment. The research summarized in this literature review was primarily derived from Scopus-ranked journals (see Scimago Journal Rank; SJR, 2022) as such research was deemed to be of higher quality. Furthermore, Randolph (2009) provides a framework for conducting literature reviews by specifying six characteristics of the literature and offering selective

categories for each one. Accordingly, Table 1 presents the selected categories (underlined) for the current review of the literature.

Table 1

Cooper's Taxonomy of Literature Reviews

Characteristic	Categories
Focus	Research outcomes Research methods Theories Practices or applications
Goal	Integration (a) Generalization (b) Conflict resolution (c) Linguistic bridge-building Criticism (d) Identification of central issues
Perspective	Neutral representation Espousal of position
Coverage	Exhaustive Exhaustive with selective citation Representative Central or pivotal
Organization	Historical Conceptual Methodological
Audience	Specialized scholars General scholars Practitioners or policy makers General public

Note. Specific category chosen for teach characteristic is underlined; reprinted from *"A Guide to Writing the Dissertation Literature Review," by J. Randolph, 2009, Practical Assessment,* Research and Evaluation, *14*(13). Copyright 2019. Each selected category relevant to the current literature review is underlined.

Each chosen category for the six characteristics will be described in turn. The literature review focuses on the relationship between the flipped intervention and the student outcomes (see Table 1, Research Outcomes), since the research is focused on exploring the impact of flipped classroom model on the students' grammar ability (generally performance in standardized tests). Therefore, the literature review identifies and reviews different studies, and the findings of such studies, so as to provide a picture of the effectiveness of flipped

learning for student English grammar. As for the Goal, the integration of the literature mainly pertains to a Generalization as the researcher synthesizes the studies related to the impact of the flipped instruction on grammar proficiency and findings on its outcomes after the flipped approach was implemented. The Perspective is neutral as the author attempts to remain unbiased throughout the study. The Coverage category is directed to the pivotal characteristic. Only central articles related to the impact of flipped learning on student grammar ability will be carefully selected and presented in the review. Therefore, this literature review will systematically present studies that investigate the role of the flipped classroom pedagogical approach on learners' grammatical ability.

The organizational component of this literature review is constructed conceptually. The first part of the literature review starts with a broad summary of teaching approaches though finishes with a summary of student perceptions of flipped learning. The second part of the literature review focuses on related theories and conceptual frameworks of the current study starting with constructivist learning theory and finishing with socio-cultural theory.

Finally, the research is intended for General Scholars, Practitioners, or Policymakers who might find such an innovative approach as flipped classroom instruction practical and effective for integrating into school classroom practices. Practitioners may benefit from modifying practices and drawing upon valuable insights into alternative effective pedagogical approaches for teaching English grammar. General Scholars might also gain a more thorough understanding of the potential utility of the flipped approach for teaching EFL learners. Policymakers may also expand the recommendation of its use for supporting student learning in the Kazakhstani educational system.

2.1 Defining and Learning Grammar

Several scholars have presented different interpretations of grammar from diverse standpoints. For instance, some conceive of grammar as a collection of regulations (Millrood, 2001), while others perceive it as an internalized system (Hartwell, 1985). Moreover, there are those who consider grammar as an abstract form of knowledge (Azar, 2007; Brown, 2012). Despite the variation, all views about grammar converge on the principle that grammar should convey a speaker's meaning to other people.

According to Azar (2007), who is both a scholar and practitioner, grammar plays a crucial role in enabling learners to comprehend the fundamental features of language, such as how it is perceived, written, and read coherently. Azar further argues that without grammar, individuals would have to rely on isolated words or sounds to communicate.

Scholars have emphasized the importance of grammar for effective communication in both speaking and writing. By providing a framework for organizing words and phrases into coherent sentences, grammar helps learners convey their ideas with accuracy and clarity. As Brown (2012) highlights, grammar serves as the structural foundation for expressing ourselves in language. Therefore, if learners aspire to use a language proficiently in academic contexts, they need to possess a strong grasp of grammatical concepts. A thorough understanding of grammar not only enables learners to express their thoughts with precision but also facilitates their comprehension of the language. Thus, it is crucial for language learners to prioritize the study and mastery of grammar to achieve fluency and proficiency.

In order to achieve proficiency in grammar, educators must implement an effective pedagogical approach that takes into consideration the individual learning styles, academic backgrounds, skill levels, and objectives of their students. Nonetheless, individuals who have received inadequate guidance regarding grammatical principles are unable to utilize the

English language with precision. Therefore, much research has been devoted to understanding different approaches for teaching grammar.

2.2 Grammar Teaching Approach: Communicative Language Teaching (CLT)

Most teachers admit that aspects of grammar can be dry, and students frequently find them boring nowadays. Teachers know that traditional approaches to the teaching of grammar are not the best way to make students reflect and interrogate the language they use, thus depriving them of the opportunities to have ample discussions, interactions, and active learning experiences. By recognizing this, various innovative approaches to learning have been adopted, making learning grammar more interactive and enjoyable. According to Prince (2004), active learning enables students to play out meaningful actions during lessons under the teacher's guidance. Prince posits that student activities are usually student-centered and positively affect active learning.

With respect to learning grammar, Ritchhart et al. (2011) stated that there must be a shift from mechanical memorization of facts towards "active and constructive processes or deep learning (p. 7). Such an idea leads to a rethinking a role of the learner and the teacher in the classroom. Teaching approaches should be aimed at involving students in active and constructive processes. Among such approaches is a communicative language teaching approach (CLT) for teaching grammar, which gives students an opportunity to use grammar creatively and socially (Hummel, 2014). It targets learning the language based on interactions between learners and reinforces them to experience the language authentically. Due to the evolving technological practices, educators who adhere to this approach aim to make learning practices even more appealing. Video has become one of the most effective teaching tools for adopting CLT when applied correctly (Hartsell & Yuen, 2006; Shephard, 2003). Specifically, the flipped classroom approach enables the integration of such technology as video in the

teaching process. Once combined effectively, the flipped and the CLT approaches represent a potentially very useful alternative for learning grammar.

Mahboob and Rahman (2016) state that the principal aim of the CLT is to enhance four distinct aspects of proficiency, namely, strategic competence, discourse competence, grammatical competence, and socio-cultural competence. The CLT approach is based on the practical use of the language for task-oriented purposes and the learning of grammatical rules and vocabulary is simply inherent to the approach. Therefore, the CLT focuses on the development of meaning rather than structure, and learners should be provided with such activities as role-plays, dialogues, games, and problem-solving tasks, which develop students' communicative abilities in "whole task" settings. However, vocabulary and grammatical competencies enable learners to voice correctly constructed statements in the appropriate social context demonstrating their ability to accurately keep up with the discourse. In CLT, students are afforded the opportunity to apply grammar and vocabulary in authentic situations, conceivably enhancing their speaking abilities. A plethora of research has supported the utility of CLT for teaching grammar and vocabulary.

One of the studies to support the effectiveness of the CLT and the flipped method was conducted by Phoeun and Sengsri (2021), which demonstrated that speaking abilities are tightly connected with mastering grammar and vocabulary. The research involved a pretest-posttest design with assessments of (a) speaking and (b) writing administered prior to and after the CLT/flipped intervention. Analysis indicated that the mean score of the posttest for speaking (M = 15.66/25) was higher than that of the pre-test (M = 12.66/25), and that this difference was statistically significant ($t[19] = 6.55$, $p < .001$). Similarly, the post-test for writing ($M = 51.95/60$) was higher than that of the pre-test (42.71/60), and this difference was also statistically significant, and that this difference was statistically significant ($t[19] = 7.82$,

$p < .001$). However, the study only used a very small sample size and lacked a control group for comparison.

Numerous academic investigations propose that the teaching of grammar can aid in the process of language acquisition. According to Mahmood and Rahman's (2016) research, instruction on grammar has the potential to improve learners' proficiency in mastering complex grammatical concepts. As per Llantada's (2007) argument, the ideal order for teaching English skills places grammar as the fifth priority. The author stresses that learners are more likely to attain grammatical proficiency if exposed to meaningful and captivating activities.

The attainment of grammatical proficiency and comprehension of the structure of the target language constitute fundamental aspects of language instruction. Thus, Byrd (2004) highlights that the primary objective of teaching grammar is to equip students with the ability to achieve their communicative objectives. Byrd states that in teaching grammar, the teacher should make the proper decisions and actions to help students become fluent and accurate in their use of a language.

According to Karimova et al.’s (2018) quantitative investigation, a majority of Kazakhstani teachers (105 out of 160) are still utilizing conventional teaching methods in their English language classrooms. These traditional methods involve instructing students to repeat rules after the teacher, practice grammar exercises, and memorize vocabulary words. Moreover, about 50% of the participating Kazakhstani teachers rarely reported utilizing any creative activities.

Bekova and her colleagues (2015) conducted a study in Kazakhstan, where they explored the impact of CLT (Communicative Language Teaching) on the English language learning process. The study indicated that improving speaking skills is essential for EFL

(English as a Foreign Language) Kazakhstani students. The researchers discovered that students initially appreciated the use of memorization and retelling exercises, but as they progressed in their language learning, they preferred communicative activities that emphasized real-life interactions. In other words, the study found that the traditional teaching methods focused on mechanical exercises may not be as effective as teaching approaches that emphasize communication and interaction between learners. Therefore, it is vital to develop language learning programs that prioritize communicative language learning practices to enhance students' language proficiency effectively.

Bekova et al. (2015) suggest that teachers should devise efficacious methods and inventive resources to foster classroom interaction. They assert that an unengaged student body may prompt teachers to implement proactive measures. Therefore, the authors propose that CLT could potentially serve as a beneficial approach to teach grammar within the Kazakhstan education system. However, the Bekova et al. study did not track student achievement, nor did it compare levels of improvement in student grammatical ability for traditional and CLT-based pedagogical approaches.

2.3 Studies on Student Performance for Learning Grammar

Recent studies demonstrated that the Flipped Classroom strategy might positively impact students' performance and proficiency levels in learning the English language, resulting in more communication with peers and the teacher. A review of the literature on the effectiveness of the flipped approach is now provided.

The results indicated that using the flipped classroom method had a positive impact on students' learning and interest, and many research studies have shown that the flipped approach leads to better academic results for students. These studies include Singay (2020), Noroozi (2022), Al-Harbi and Alshumaimeri (2016), and Pudin (2017). According to these studies, the experimental groups exhibited greater levels of student learning compared to the

control groups. A case in point is the research conducted by Melendez and Iza (2017), which indicated that the flipped methodology had a positive impact on students' comprehension of the subject matter through the integration of pre-class and in-class activities. In addition, the final scores suggested that the flipped methodology increases students' abilities to acquire grammatical concepts (Meléndez & Iza, 2017). Research by Al-Harbi & Alshumaimeri (2016) also suggested that the flipped classroom strategy positively impacted student's performance in classes devoted to English grammar. In this research, the effectiveness of the flipped classroom was assessed by administering standardized tests, which consisted of 40 multiple choice questions, and were created by Macmillan publishers. The study used a pretest-posttest research design to compare the performance of the experimental (n = 20) and control (n = 23) groups. The scholars analyzed the results of the pre- and post-grammar tests and concluded that the adoption of the flipped classroom strategy appeared to have a positive impact on the students' grammar performance. This finding is presented on page 60 of the study. However, because the sample size was considered relatively small (differences were not statistically significant), it was difficult for the authors to generalize strongly about the broader population of English language learners.

In a separate scholarly investigation, Li (2016) discovered that the implementation of a flipped instructional approach had the potential to enhance grammar instruction. The study involved two comparable Grade 8 classes, consisting of a total of 42 students, who were divided into two groups: an experimental group that received flipped instruction and a control group that received traditional instruction. Following a semester-long experiment, a standardized grammar test was administered to students in two different class conditions. The results of an independent sample t-test indicated that students in the experimental flipped condition achieved higher scores on the grammar test than those in the traditional control condition. This suggests that the implementation of the flipped teaching strategy led

to improved grammar test scores for the experimental group. However, the study had limitations such as a relatively small sample size and a single assessment point after the intervention, which makes it difficult to determine if FC-exposed students learned more during the learning period.

Another investigation conducted by Ishikawa et al. (2019) investigated methods to enhance the degree of participation of Japanese learners in carrying out e-learning activities on the TOEIC, which has a minimum scale score of 10 and a maximum scale score of 250. The increase of the scores in the experimental group was 151.38 (M = 345.97 to 497.35), and this level of improvement was much larger compared to the control group which was 54.04 (M = 361.03 to 415.07). An independent sample t-test revealed that the mean score on the post test for the experimental group was much higher than that of the control group ($t[444] = 8.05$, $p < .001$; $d=.56$). The findings revealed a more significant level of improvement in English reading/listening in the experimental group. The findings of this quasi-experimental research, along with previous studies reviewed thus far, indicate that the implementation of the flipped learning approach could potentially enhance students' grammatical skills.

Various quasi-experimental and experimental research studies have concluded that the flipped learning approach has a favorable impact on the level of involvement and motivation of intermediate students in learning English grammar (Afzali & Izadpanah, 2011; Al-Harbi & Alshumaimeri, 2016; Al-Naabi, 2020). These findings provide evidence of students' generally favorable attitudes towards the instructional strategies employed in the flipped classroom model. In these studies, students responded that flipped classes made learning more productive and engaging. Singay's (2020) study discovered several topics through semi-structured interviews, including the creation of an amiable learning environment, the eagerness to incorporate more technological tools, better teacher-student relationships, and

increased collaboration with peers while employing a flipped learning approach. However, hitherto, such empirically-based studies have not been undertaken in Kazakhstan, so little is known about student perception of FC in this context.

Bishop and Verleger's (2013) research provides evidence to support the notion that students hold favorable views toward the flipped approach. Numerous research studies have investigated students' perceptions of the flipped classroom approach, and the findings suggest that it has a favorable impact on their motivation, autonomy, and collaboration. This is supported by a variety of studies conducted by Erbil (2020), Al-Naabi (2020), Ahmad et al. (2020), Bishop and Verleger (2013), and Xu and Shi (2018). These studies highlight that students' engagement and learning outcomes can be significantly enhanced through flipped classroom instruction, which involves students preparing for class by watching pre-recorded lectures or videos at home and then using class time for interactive activities and discussions. The flipped classroom approach allows students to take ownership of their learning, work collaboratively with peers, and develop critical thinking skills while the teacher serves as a facilitator and guide in the learning process.

These studies' results suggest that students exhibit a strong desire to engage with their peers in a classroom setting and appreciate the opportunity to explore the learning material at their own pace. According to Maciejewski (2016), the flipped approach provides additional time for classroom-based interactive activities. This extra time can be used by students to engage in real-time practice and interaction with each other or with the group, if it is well-organized.

According to Al-Harbi and Alshumaimeri's (2016) study, the implementation of the flipped classroom model had a beneficial impact on both the academic outcomes and attitudes of Saudi Arabian secondary school students. To facilitate communication and the

provision of learning materials, the Edmodo platform (Borg et al., 2008) was utilized. They used the Edmodo platform (Borg et al., 2008) to provide materials and remain connected to students. The study used a non-equivalent group quasi-experimental posttest only research design. The students in the flipped group (n = 20) completed collaborative tasks in pairs and groups in class, while the control group performed regular practices (n = 23). The present study employed the independent samples t-test to compare the posttest results of the experimental and control groups. The statistical analysis revealed that there was no significant difference in the post-test scores between the two groups, as indicated by the mean score of 33.30 (SD = 6.85) for the experimental group and 30.78 (SD = 8.19) for the control group, $t(41) = -1.08$, $p = 0.285$. Although the findings did not support the presence of statistically significant differences, a qualitative analysis of the students' open-ended responses indicated that they believed collaborative activities and more engaging videos would be beneficial for further classroom practice.

As part of the article, the scholars describe how a flipped classroom might be implemented for grammar exercises and tests, online platforms, and alternate teaching techniques. The proposed methodologies outlined in the paper offer educators a framework for executing and supervising the impact of instructional modifications in contemporary classrooms. Nevertheless, the majority of the previously summarized investigations in this area were conducted in Western settings and predominantly employed quantitative techniques. To the best of this author’s knowledge, the use of more comprehensive pretest-posttest quasi-experimental research designs focused on examining student development of English grammatical competence is yet to be explored both internationally and in Central Asia.

The summarized studies highlight that the flipped teaching strategy may facilitate students’ general and autonomous capacity to learning at home and during more practical in-

class activities (Li, 2018; Santos & Serpa, 2020). According to Lofnetz (2016), the flipped classroom's efficacy is postulated to stem from students assuming accountability for their self-directed learning by viewing instructional videos before attending class. Moreover, it is hypothesized that students' participation in self-governing learning could lead to a heightened awareness of their strengths and limitations, as well as potential insights into how to address these inadequacies through in-class activities at school. Jacobs (2013) states that autonomy plays a significant role for the learner as the teacher does not carry the entire responsibility of teaching in the classroom. The following subsection explores what research has been undertaken on student learning of English grammar in Kazakhstan.

2.4 The Kazakhstani Typical Curricula

The Kazakhstani Typical Curricula (2022) aims to achieve a level of language proficiency based on the competencies associated with the Common European Framework of Reference (CEFR). Achieving this level of proficiency typically requires engaging in various exercises and utilizing diverse oral and written materials. To be more specific, it is anticipated that students in Kazakhstan who have completed 8th grade should attain a B1 intermediate level of proficiency, as indicated in Table 1. Achieving the mid-B1 level of proficiency in the Kazakhstani education system requires a diverse set of exercises and materials for both oral and written communication. The 8th-grade students in Kazakhstan are expected to attain this level according to Table 1. The Kazakhstani Curricula focuses on enhancing all four language skills: writing, speaking, reading, and listening, while gradually introducing more complex grammatical and lexical structures in a step-by-step manner. This approach is based on the principle of simplicity to complexity as outlined in the MoES (2022) learning program.

The teacher’s job becomes more challenging as students are expected to combine all four language skills in one lesson, with grammar skillfully integrated, teachers are expected

to provide students of all abilities the opportunity to communicate. With these expectations in mind, implementing the flipped approach may be beneficial for helping students improve their language proficiency (Witten, 2013). Levels of CEFR Proficiency in English for Grades in Kazakhstan.

Table 2

Levels of CEFR Proficiency in English for Grades in Kazakhstan

Grade	CEFR Level
1	A1 low
2	A1 low
3	A1 mid
4	A1 high
5	low-mid A2
6	mid-high A2
7	low B1
8	mid B1
9	***high B1***
10	B2 low-mid
11	B2

Note. Grade 9 levels, relevant to the study at hand, underlined; reprinted from MoES (Ministry of Education and Science), Instructive Methodological Letter, 2022.

According to Karimova (2018), there is a widespread belief in Kazakhstan that students have a preference for traditional methods of learning, whereby they adopt a passive role and wait for the teacher to impart knowledge to them. Bergman and Sams (2012) note that the conventional approach to teaching is characterized by a prevalent "wait and receive" attitude, which is familiar and convenient for students and typical of the classroom environment. Karimova (2018) argues that students can enhance their cognitive and creative abilities by integrating interactive methodologies, self-directed learning, and collaborative tasks. The application of the flipped learning method could serve as an effective mechanism to enhance the level of participation and autonomy among students from Kazakhstan who

tend to be less involved in the process of learning. Developing students' independent learning and other self-regulated skills with modern information technologies may contribute to meeting one of the goals of the Kazakhstani Curriculum Program (MoES, 2022). Understanding how students perceive the FC approach may inform policy and practice in Kazakhstan.

2.5 Studies on Student Learning and the Flipped Approach in Kazakhstan

The research on implementing the flipped model in secondary education in Kazakhstan appears to be limited. As of the writing of this thesis, only two studies have been identified by the author in Kazakhstan that address this topic: Koshegulova & Mindetbay's (2020) and Yudintseva's (2016) investigations.

Koshegulova and Mindetbay (2020) conducted an analysis to determine the effects of flipped learning on the academic performance of students in Science at Bilim Innovation Lyceums (BIL) located in Kazakhstan. To be precise, student achievement in the subjects of Biology (8th grade), Computer Science (9th grade) and Algebra (10th grade) was analyzed under the two different pedagogical conditions. The research applied a pretest-posttest quasi-experimental design on 168 students divided into two groups; the experimental group was comprised of 84 students who participated in flipped learning classes for seven weeks and the control group consisted of 84 students who experienced the conventional method of classroom teaching. A pre-test and final placement test was utilized before and after the intervention of flipped classroom approach. The study's findings demonstrated a significant difference in results between the pre-test and post-test scores after implementing the flipped classroom ($t = -8.416$, $p < 0.05$). The research findings showed that there was a noticeable contrast in the scores of the experimental and control groups in the post-test ($t=3.151$, $p<.005$). Therefore, the experts suggested that Science instructors employ effective teaching techniques such as flipped learning to ensure that learning is continued successfully.

However, the study only made use of male students (it was a single-sex school), presented no evidence of pre- and post-test reliability for the three subjects, appeared to make use of an aggregate score (with max score just 10) for the three subjects of interest (without an examination of discriminant validity), and made use of post-test raw scores that appeared to demonstrate large ceiling effects. Therefore, more comprehensive research is needed to ensure the utility of the flipped approach in specific subject areas.

Yudintseva (2016) conducted a study that examined how instructional videos affect the motivation of intermediate undergraduate students from Kazakhstan in flipped learning environments. Yudintseva asserts that the effective use of video content can aid in the acquisition of listening skills, vocabulary, and grammar. Yudintseva remarks that students spent less time on preparation for class in comparison with the traditional method of learning. After conducting her study, Yudintseva recommended that teachers should provide instructional videos that feature a variety of exercises and realistic examples. Furthermore, she advised that music should not be included in these videos, as it tends to be distracting to students.

The aforementioned research indicates that several schools and universities in Kazakhstan have started utilizing the flipped approach in different subject areas (Yudintseva, 2016; Rakhimzhanova, 2016; Rybinski & Sootla, 2016; Koshegulova & Mindetbay, 2020). Nevertheless, there is a dearth of comprehensive empirical literature concerning the efficacy of this approach in conventional schools, particularly in terms of enhancing students' English grammar learning. The extent of research on flipped learning within the scope of school education is limited, with only a few publications available in Kazakhstan. Therefore, it is necessary to conduct further studies in this area. The present study reviews previous research on the flipped learning approach and student learning in Kazakhstan, with a particular focus on the effectiveness of a specific app, namely, WhatsApp, used to support student learning.

2.6 Use of WhatsApp for Student Learning

Arifani et al. (2020) note that WhatsApp has emerged as a widely used mobile-based social media platform, offering various features. Kazakhstani students frequently use this social media application for both personal and academic purposes. It has become commonplace for teachers and students to use WhatsApp as a means of obtaining instructional materials and receiving feedback from teachers and classmates. The app's popularity may be explained by the fact that classes in Kazakhstan a commonly large (above 30 students), and copying additional materials for thirty students is a burden for teachers.

Ahmad et al. (2020) conducted a quantitative study utilizing the flipped approach and WhatsApp application to support students' learning of conditional sentences. Additionally, Noroozi et al. (2020) reported that the utilization of WhatsApp by learners increased their motivation and facilitated access to instructional materials, resulting in enhanced learning outcomes compared to traditional teaching methods. While the authors used a pretest-posttest quasi-experimental design and the rate of improvement of the experimental group statistically significantly exceeded that of the control group, the pre- and post-tests themselves were not equivalent. The question items in the post-test were simply "similar" to those in the pre-test. Therefore, the estimates of improvement were not empirically based.

2.7 Students' Perceptions and Teacher's Perceptions

Research has assessed the impact of the flipped classroom for enhancing students' motivation (Singay, 2020; Hsieh et al., 2017; Afzali & Izadpanah, 2001; Noroozi , 2022; Xiu & Thompson, 2020). Their findings strongly suggest that students' attitudes toward the flipped learning approach were positive. The learners became more active and engaged in class discussions and group presentations. However, the researchers Santos & Serpa (2020) highlight the role of teachers in the flipped learning model for building students' attitudes. They state that if the flipped lesson is not carefully planned and explained, the students will

generate anxiety about and resistance to the new approach. Another study emphasized that teachers should carefully implement a proper combination of online and face-to-face practice. Otherwise, technological innovation can become an obstacle for students (Strayer, 2012). Xiu & Thompson (2020) also pointed out that many online materials can cause fatigue and resistance in students to study in the flipped learning mode. Regarding accessibility to technology, the researchers Gough et al. (2017) stated that the nine graders demonstrated no sense of responsibility while studying under the flipped method. The same researchers concluded that flipped classroom model presented difficulties for some students as they could not ask questions directly to the teacher while viewing an English video at home.

At the same time, teachers' perceptions of the potential benefits for students in the flipped classroom are considered as potential benefits for students. Gough et al. (2017) administered a survey to 44 teachers and asked them how effective they thought that the flipped approach was for different aspects of teaching and learning. The survey used Likert response options with the following anchors: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

Overall, teachers agreed most strongly with the flipped classroom benefitting absent students (M = 4.02, SD = 0.76). The mean perceptions associated with learning included the areas of English Language Learners (M = 3.11, SD = 0.78), passive education (M = 3.39, SD = 1.10), and student learning (M = 3.18, SD = 1.06). However, Gough et al. (2017) confirm that the flipped classroom model creates favorable conditions for active learning and student-to-teacher productive interactions. They also reveal that the flipped classroom model's increased time afforded to the classroom could be used for more detailed practice and communicative activities (Gough et al., 2017). With a review of the perceptions of the flipped approach completed, we now turn to the educational theories underpinning the current thesis.

2.8 Educational Theories and the Flipped Model

2.8.1 Constructivist Learning Theory

Xu and Shi (2018) suggest that the constructivist learning theory is highly relevant to the flipped learning model. This theory is centered around the learner and is guided by teachers in creating an environment that promotes learning. The essential components of the constructivist approach include the learning environment, discourse, collaboration, and instruction focused on meaning. These components serve as learning tools to encourage students to be enthusiastic and take initiative in their learning. Kim and Bonk (2006) propose that the flipped learning model, based on constructivist principles, promotes student engagement through interactive and collaborative activities during the acquisition of knowledge. Teachers, according to Martin (2012), utilize digital content or online resources that students can review and analyze at home, allowing for more interactive and problem-solving activities to take place in the subsequent class, fostering creativity among students. During this process, teachers assume the role of facilitators or supervisors, while students are at the center of the learning process. The constructivist theory accentuates the opinion of students and considers them the central bodies of cognition and the active participants of the learning process (Xu & Shi, 2018).

Li et al. (2017) conducted research based on constructivist theory. The teachers involved in the study designed substantial content for both pre-class and in-class activities. Similar to the flipped classroom approach, students gained fundamental knowledge during the pre-class phase, which facilitated engaging and interactive activities during class time. During in-class time, students became active participants in the acquisition of grammatical content, interacting with their classmates and the teacher rather than remaining passive recipients of knowledge.The focal area of grammatical content covered was the attributive clauses concept. According to the study's results, which were based on well-organized teacher

supervision, interactive exercises, and feedback from the teacher, students were able to effectively absorb and internalize knowledge related to grammar. Therefore, in accordance with the constructivist learning theory, the teacher's role is to provide students with the necessary information and resources to develop their perspectives and draw conclusions (Ozer, 2004).

In summary, the flipped classroom is tightly interrelated with the constructivist learning environment. The students create their own understanding by watching, listening to, or studying subject-specific material on their own (at home). The next day, when they come to class, the teacher provides facilitated learning activities that enable students to engage with their classmates and analyze the material more deeply, drawing on the knowledge they gained at home. The teacher is a supervisor to guide students through class time, correcting and assisting their work.

2.8.2 Bloom's Taxonomy

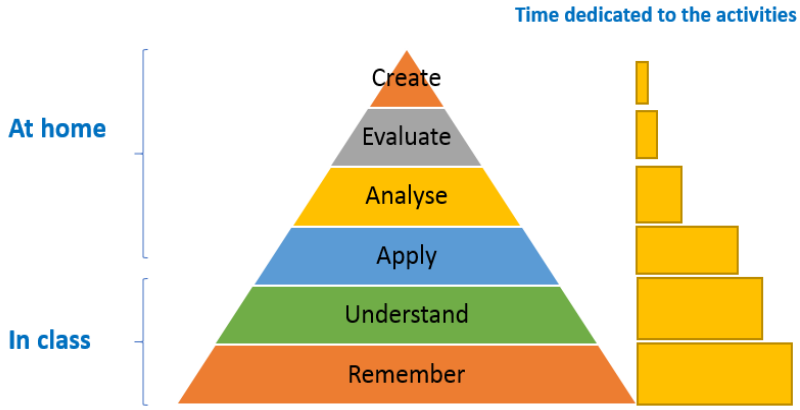
In 1978, Benjamin Bloom identified multiple domains of learning, ranging from the basic retention of material to the application of knowledge. However, he emphasized the importance of concentrating on higher-level learning objectives instead of basic skills. He argued that problem-solving, material application, and the cultivation of students' creative abilities are crucial.

According to Bergman and Sams (2014), teachers tend to focus primarily on the cognitive domains of remembering, understanding, and applying during classroom instruction. Conversely, they often neglect the higher-order thinking skills of analyzing, evaluating, and creating. Given the time constraints inherent in classroom instruction, teachers commonly assign these latter skills as homework.

Figure 1 illustrates the distribution of time in the traditional classroom settings vis-a-vis about Bloom's Taxonomy. On the other hand, Figure 2 illustrates the time allocation in Flipped Classrooms according to Bergman and Sams' (2014) approach. Ouda and Ahmed (2016) note that Bloom's revised taxonomy of flipped learning, depicted in Figure 3, highlights the students' responsibility for lower-level tasks, such as remembering and understanding, outside of the classroom. This approach frees up more in-class time for higher-order activities such as applying, analyzing, evaluating, and creating.

Figure 1

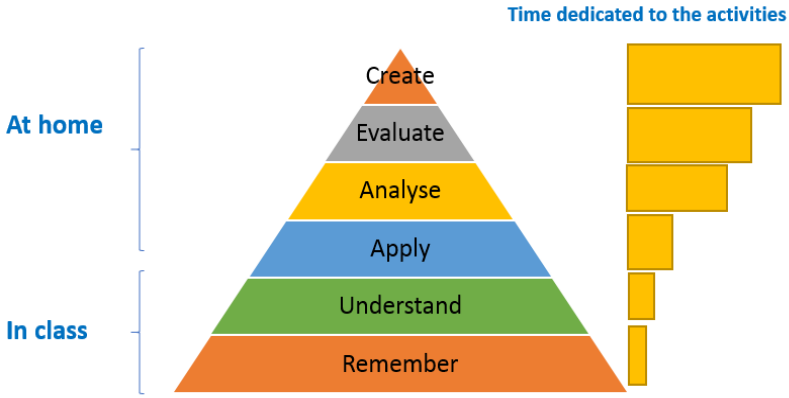
Distribution of Time Devoted to the Activities in the Traditional Class



Note. Reprinted from "Flipped Learning As A New Educational Paradigm: An Analytical Critical Study," by H. Ouda, K. Ahmed. (2016). *European Scientific Journal*, *12*(10).

Figure 2

Distribution of Time Devoted to the Activities in the Flipped Classroom

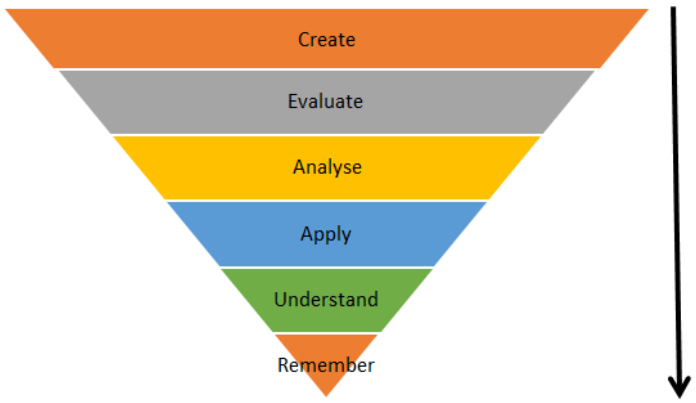


Note. Reprinted from "Flipped Learning As A New Educational Paradigm: An Analytical Critical Study," by H. Ouda, K. Ahmed. (2016). European Scientific Journal, *12*(10).

The flipped learning model enables students to grasp the fundamental aspects of a topic before class, freeing up in-class time to focus on the development of higher-level skills through various consolidation activities with the guidance of teachers. In contrast, traditional approaches typically involve basic skills such as remembering and understanding being taught during class time, with higher-level activities assigned for independent work at home.

Figure 3

Bloom's Taxonomy Revised and Inverted



Note. Reprinted from "Flip Your Classroom: Reach Every Student in Every Class Every Day," by J. Bergmann, A. Sams. (2014). *International Society for Technology in Education.*

Wright (2013) proposed a taxonomy-based flipped learning approach to teach English grammar. Initially, he found it challenging to use the revised Bloom's Taxonomy to teach grammar. However, he realized that flipping Bloom's taxonomy could simplify his teaching. He assigned a paragraph writing task to his students in response to a prompt. The students worked collaboratively in pairs or groups and analyzed the language structures used in their writing. They compared their writing with each text, analyzed similarities and differences, and grouped them. Wright (2013) proposed a taxonomy-based approach to flipped learning. He initially struggled with teaching English grammar using Bloom's revised taxonomy but found that flipping the model made it easier. His students wrote a paragraph in response to a prompt, worked in pairs or groups to evaluate the language structures, and finally applied what they learned by revising their writing. They listened to a podcast to aid their understanding and created a graphic organizer or screencast of the language rules they learned.

Bergman and Sams (2014) support this approach and suggest that the inverted Bloom's model, starting with a project-based approach (create) before moving to lower-level objectives (remember), is better aligned with students' interests and values. This method allows for discovery-based learning, where students are presented with a problem to solve or explore, leading to further development of their understanding during classroom activities.

2.8.3 Sociocultural Theory

The study's framework includes a sociocultural approach since flipped learning involves interacting with digital resources created by humans. The sociocultural theory perceives mental processes as mediated and shaped by cultural artifacts, concepts, and activities (Lantolf, 2000). It assumes that cultural tools enable people to regulate and transform their biological and behavioral functions. In this context, language is considered as the primary tool for mediation (Fahim & Haghani, 2012).

The sociocultural theory is rooted in the work of Lev Vygotsky (1978), a Russian psychologist who emphasizes the crucial role of social interactions in the advancement of human cognitive abilities. Additionally, Vygotsky proposed that cognitive development is restricted to a “zone of proximal development” (ZPD), which refers to the gap between a learner's current level of knowledge and their potential level of knowledge that can be reached through guidance from adults or more skilled peers in collaborative problem-solving (Vygotsky, 1978, p. 86). Learners study better when working with more experienced peers during mutual collaboration. By collaborating with more experienced individuals, learners acquire new concepts, skills, and psychological tools. This process is known as “scaffolding,” where a teacher or a more capable peer provides support to help the learner grasp the subject matter or acquire advanced skills. To sum, collaborative learning, communication, and scaffolding are strategies for supporting learners’ intellectual knowledge and skills and enhancing intentional learning.

2.9 Limitations of the Flipped Approach for Learning Grammar

Stone (2012) highlighted that teachers must be cautious of the potential negative consequences that may arise from implementing the flipped classroom model. One of these risks is related to the teacher's limited control over students' motivation and dedication to complete the pre-class activities. The teacher presents the instructional materials in the form of videos, so it is up to the students to ensure that they complete the assigned tasks before coming to class. Additionally, there is a concern regarding whether students have effectively completed the pre-class activities even if they have attempted all the necessary readings (Acedo, 2019).

As a teacher, I share the concern that not all students may possess the same level of self-motivation when working independently. Agarwal et al. (2019) suggest that the most effective approach to ensure students' readiness for flipped learning is to assess their understanding through quizzes or tests at the end of the pre-class activity. This enables instructors to address the issue of poor participation and lack of motivation during in-class activities resulting from being unprepared. These assessments can be in various formats, such as written, verbal, or online. According to Agarwal et al. (2019), the instructor in their study found quizzes or tests to be effective in identifying areas where students struggled to understand. They designed the assessments based on the learning outcomes they needed to achieve. Tests included short answer, easy-type, open-ended, and multiple-choice questions. The tests/quizzes indicated the readiness of students to participate in the flipped classroom. As a result, this practice was effective and helped students gradually prepare for the assessments. This approach was used in the current study.

Cuban (2001) has raised a second concern, contending that technological resources are insufficient in themselves to enhance knowledge delivery. He argues that "a new computer cannot make a teacher better; nor can it provide a magic formula to improve

learning; a new pencil cannot make a child better at writing essays" (p. 10). Therefore, it is the responsibility of the instructor to select and modify teaching aids, resources, and interactive video content based on the learners' needs and the goals of the curriculum.

2.10 Summary

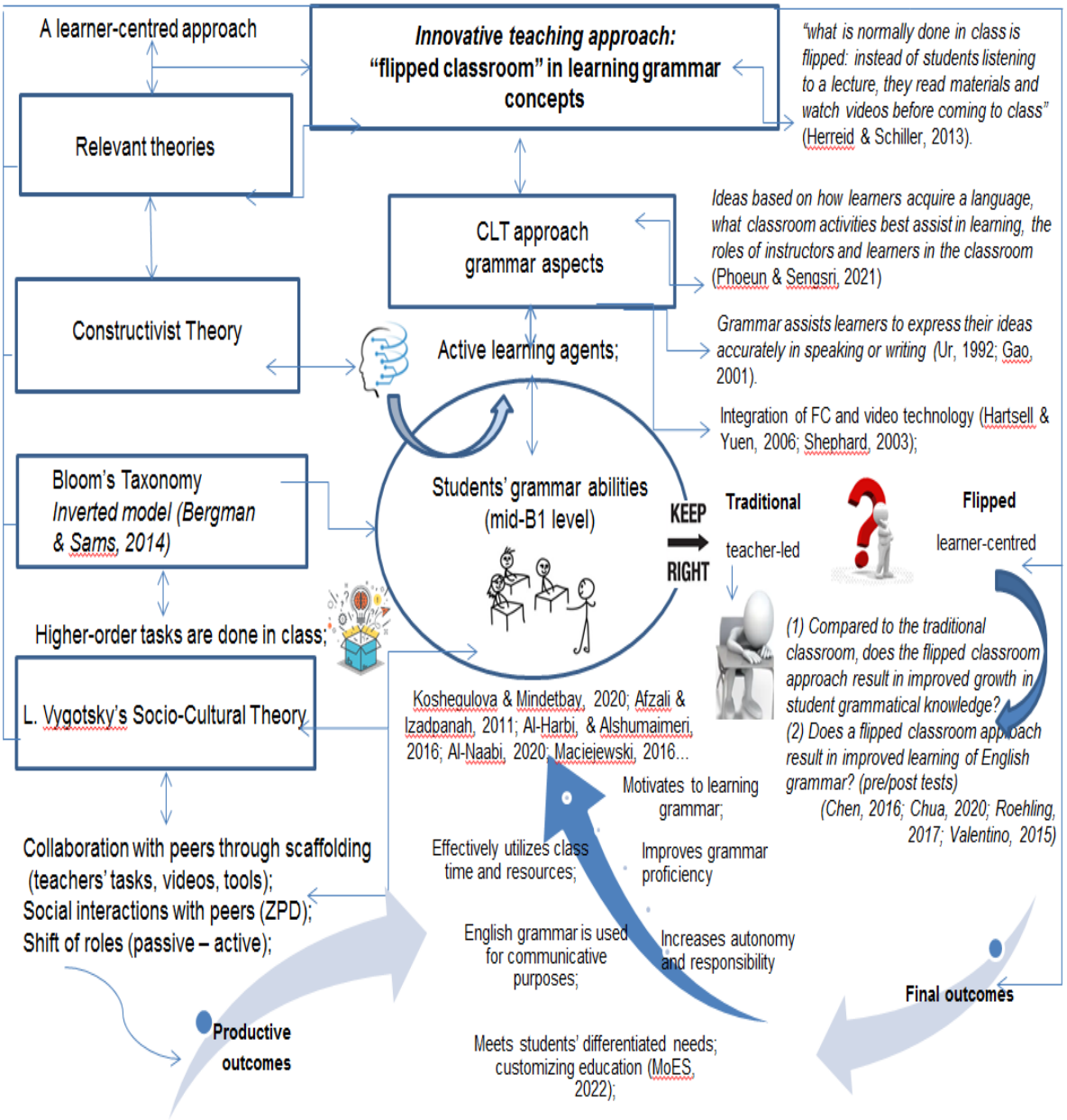
To conclude this literature review, we have seen that the flipped classroom model has provided largely positive results for improving the motivation of students and for enhancing the learning of grammar. In addition, flipped learning can provide the additional time needed to increase the number of opportunities to learn grammatical concepts communicatively and in an engaging way. Much of the literature was based on comparing traditional classrooms with flipped classrooms focusing on the positive effects of flipped learning on students' performance. Nevertheless, the role of the teacher in implementing the flipped classroom should be taken into thorough consideration. The teacher plays a vital role in carefully and effectively organizing the flipped lessons. While many studies point to the potential of the flipped approach for learning grammar, they have either not strictly assessed the learning of grammar itself or applied a research design that does not provide a comprehensive pretest-posttest examination of the comparative enhancement of learning due to the flipped approach. Therefore, the purpose of the study at hand is to fill this gap in the literature.

2.11 Conceptual Framework

The conceptual framework, represented visually in Figure 4, starts with the definition of the flipped classroom approach and how it can be applied in learning grammar. According to Herreid and Schiller (2013), the flipped approach is characterized as the process of acquiring grammar content at home while watching instructive videos and then having this material internalized during in-class sessions (2013).

Figure 4

Conceptual Representation of the Flipped Classroom Approach in Learning Grammar



Note. The concepts compiled by author throughout the thesis process.

The framework emphasizes the idea to study grammar concepts based on the communicative based approach (see communicative language teaching, CLT, Hummel, 2004) as it is the one that ensures students experience the language authentically. It is

conceptualized that the effective combination of communicative strategies (Phoeun & Sengsri, 2021) and the flipped classroom approach (Herreid & Schiller, 2013) will develop students' abilities to apply grammar effectively.

Hitherto, the literature review has presented empirical evidence suggesting that the flipped classroom approach has a positive impact on students' enhancement of grammatical knowledge. This mode of learning is student-centered developing such skills as autonomy and responsibilities for learning (MoES, 2022). Furthermore, the advantage of this approach is thought to be connected to students having more time to learn the content at their own pace and comfort watching videos outside the classroom. In case the activities are effectively organized by the teacher, the FC can account for students' needs and preferences and provide them more time for active grammar practices during in-class lessons.

The flipped classroom approach is underpinned by several theories that support student learning. Based on constructivist theory (Vygotsky, 1978), students interrelate their past knowledge with existing information to build their comprehension of new material. According to Vygotsky (1978), students better acquire knowledge when they are engaged in interactive and collaborative problem-solving activities. Furthermore, Bloom's (Bloom et al., 1956) theory is tightly connected with the application of the flipped learning pedagogy. In contrast to the traditional approach, where a great deal of class time is spent on remembering and understanding the material, the flipped approach enables students to devote more time to the lower order skills outside the classroom and devote more time to applying, analyzing, evaluating, and creating higher-order tasks during class time. The general conceptual framework, presented in Figure 4, also presents a new paradigm of Bloom's taxonomy in the interpretation of Bergman and Sams (2014) confirming the re-allocation of tasks.

The socio-cultural theory presented by Vygotsky states that a child's cognitive development occurs within the zone of proximal development (ZPD) when he/she learns alongside more experienced peers. Based on this theory, students acquire knowledge better if they are given proper scaffolding and are engaged in collaboration with peers to encounter more significant levels of problem-solving tasks. The aforementioned concepts and theories function together in the conceptual framework presented in Figure 4.

3. Methodology

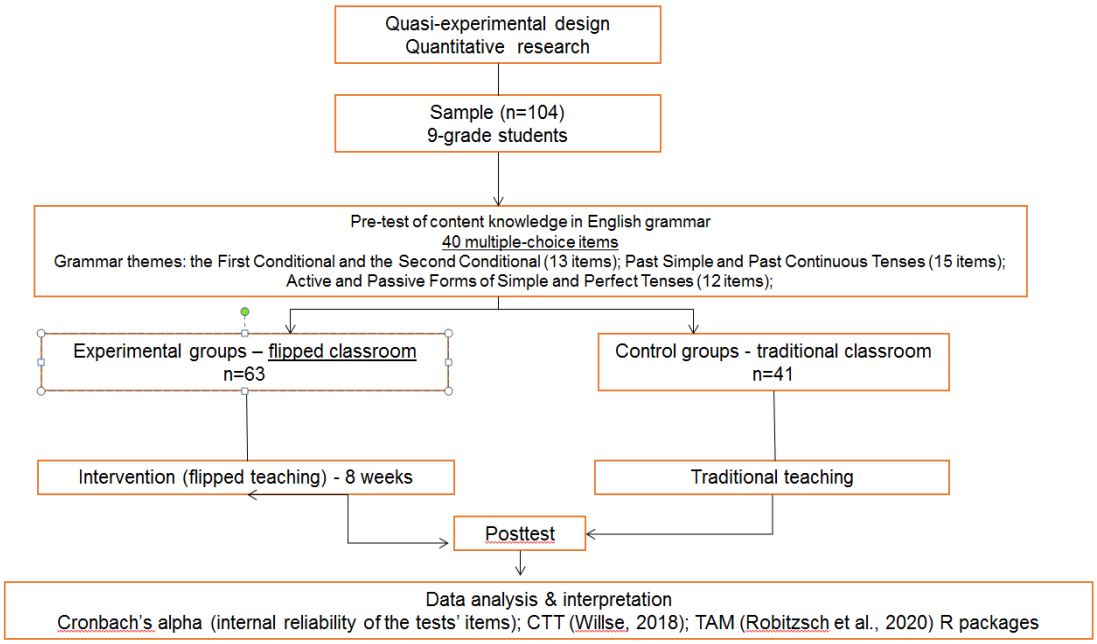
Creswell (2012) distinguishes three primary categories of designs in quantitative research: experimental, correlational, and survey. The current study utilized a quasi-experimental approach. As part of regular school non-streamed class allocation practices, participating students were divided into seven distinct classes (four for flipped, three for traditional). Given that the allocation of students to each class was not done purely at random the current study was considered quasi-experimental (Gribbons & Herman, 1997). It may have been the case that other socio-cultural factors may have influenced the allocation of some students to their respective classes Therefore, the study uses a convenience sample of two assumed-to-be equivalent classrooms. Mackay and Gass (2005) write that a convenience sample enables researchers to save time and initiate data collection procedures appropriately. As stated, four experimental groups (n = 63) studied grammar concepts using the flipped classroom strategy. The other four control groups (n = 41) learned English grammar using the traditional teaching approach. A pre-test was administered to experimental and control groups before the intervention occurred. A post-test was then conducted one week after the interventions were completed.

The design of the quasi-experimental study has potential issues with internal validity that pertain to the participants and need to be addressed. As described, since the participants were not randomly allocated to groups, there are potential threats to validity from “history” and “selection” factors (Creswell, 2008, p. 304). Since the participants come from various backgrounds, including socio-economic and cognitive abilities, and have varying levels of language proficiency, these factors need to be considered. All these factors can influence the groups’ average performance and the study results. Therefore, insofar as possible, careful statistical comparisons (e.g., two-by-two χ^2 tests) between the groups’ demographic makeup were conducted to check for this threat. The “resentful demoralization” threat might occur

when the control group identifies as receiving less desirable conditions than the treatment group (Creswell, 2012, p. 305). The remedy for this threat is planned as the respective teachers will swap classes for the forthcoming unit of work providing opportunities for novel and traditional approaches for all children. Another danger of repeated standardized testing procedures occurs when participants become familiar with the questions themselves and remember answers for later testing (Creswell, 2012, p. 305). To provide a solution to this threat, the current study only repeats a smaller subset of question items (link items) in the posttest (link items response options are also scrambled so as ensure less familiarization with test items). Such an approach is also advantageous given that the follow up test can be made more difficult overall limiting the potential for ceiling effects.

Figure 5

Flowchart of Research in the Current Study



Note. Data compiled by the author.

3.1 Research Site

The study was carried out on students enrolled in a gymnasium, a type of public school, located in the Central region of Kazakhstan. This school is one of the top mainstream schools in Karaganda city, and it was founded in 1972. It was granted gymnasium status in 1996 and Russian is the language used for instruction in this school. At the time of research, 1,202 students studied in the school and there were four 9th Grade classes with a total of 104 pupils.

3.2 Participants

A total 63 students comprised the experimental (flipped) group (four separate classes) and a total 41 students made up the control (traditional) group (three separate classes). The participants were aged between 15 to 16 years old. The students had been learning English since the 1st grade, and most had reached the mid-B1 level of English proficiency at the end of the 8th grade (Table 1). I decided to conduct my study at this Gymnasium as (1) I am a practicing teacher of this school for 18 years and it is relevant and accessible to me, and (2) taking pre-and post-unit grammar tests by the 9th grades has become a regular practice (part of the regular testing regime) and (3) the current study may provide an important timely contribution to the research area.

3.3 Data Collection Instruments

The study uses a quantitative research design. It will employ a quasi-experimental pretest-posttest design. During the study, four experimental sub-groups (n = 63) studied grammatical concepts using the flipped classroom strategy. The other four control sub-groups (n = 41), taught by another teacher, learnt the same grammatical content using the traditional teaching approach.

Before the intervention, both experimental and control groups were given the same pretest to assess their proficiency levels. After the eight-week intervention period, the same

students were given a posttest that included link items, which are a subset of common items across both test instruments, to compare the results.

Even if the pre-test reveals that the ability levels in the control and experimental groups had not been equivalent (i.e., had exhibit statistically significant differences), the focus of the study is on whether the flipped class-room approach results in improved "growth" in student grammatical ability. Therefore, such an instance would not have been completely detrimental to the study findings.

3.3.1. Pre-and Post-Test Assessments of Student Grammatical Ability

The study went on for a total of nine weeks, with eight of those weeks designated for the intervention or non-intervention, and one week set aside for both pre- and post-tests. The participants were evaluated on their comprehension of grammatical concepts in both the pre- and post-tests. The test focused on three different areas, including the ability to differentiate between the First and Second Conditionals, the Past Simple and Past Continuous tenses, and the Active and Passive Forms of Simple and Perfect Tenses. There were a total of 40 items on the test, all of which were either right or wrong. The pretest and posttest were conducted during the first and last lessons, respectively, which took place during weeks one and nine. Courtney et al. (2021) aimed to furnish stakeholders with feedback on students' progress during a specific timeframe. To measure students' proficiency in English grammar throughout the study, two test versions were created: a pre-test and a post-test. The researcher administered a grammar pre-test to evaluate the students' initial comprehension of the aforementioned grammar concepts. They validated the tests using classical test theory and Rasch modeling, according to Wu, Tam, and Jen (2016). The experimental groups received 15 flipped grammar lessons through WhatsApp, with the teacher directing students' attention to the provided grammar tasks.

The content of grammar that will be taught using the flipped approach is closely connected with the CEFR Program, and includes topics like the First and Second Conditional, Past Simple and Past Continuous Tenses, and Passive Voice (MoES, 2022). The textbook used for teaching, English Plus, Kazakhstan, Grade 9 (Pye & Wetz, 2018), is designed to match the motivating themes of the grammar concepts to be learned. The key to effective grammar instruction is to teach the concepts accurately and appropriately while also incorporating interesting and engaging materials that capture students' attention and motivate them to learn. The primary goal for students is to apply their understanding of grammar rules during interactive classroom practice and show improvement in their grammar knowledge and skills during the post-test phase. Noroozi (2010) suggests that teaching grammar is more effective and authentic when items that are used together in communication or a text are presented in context.

The researcher chose pre- and post-tests from well-known sources that covered the same topics as the course objectives and standards. These tests were designed with multiple-choice questions, which offer several advantages for learners. As Van Blerkom (2009) suggested, multiple-choice tests can evaluate not only lower-level cognitive skills but also higher-level learning, and they allow students to answer more questions in the same amount of time compared to open-ended questions in an exam.

Students’ pre- and post-test scores were reported as raw scores, which are described in this study. Though, student ability estimates (θ) based on Rasch modelling were ultimately specified as the dependent variables in the current study.

3.4 Data Collection Procedures

The research adhered to ethical guidelines and protocols established by Nazarbayev University. The study received approval from the NU IREC (Nazarbayev University

Institutional Research Ethics Committee), and consent was obtained from the school administrators and parents of the students involved in the research, as per Creswell (2012, p. 147). All parties were informed about the purpose of the study, parental consent was provided to parents, and an assent script was handed to all student participants. The participants were informed about the study's purpose and its specific character. The consent form outlined participants' roles and responsibilities throughout the research process.

In week 1, the students of experimental and control groups had a pre-test containing 40 items testing the aforementioned grammatical concepts. The students had some prior knowledge of some of these grammatical themes from the previous classes as they are part of the school curriculum introduced gradually in the senior school curriculum. The pre-test was used to gauge all participating students' capacity in English grammar before undertaking the intended treatment.

In this study, the experimental and control groups covered the same grammatical concepts, which were derived from the curriculum, the school Course Plan for the 9th grade, and the textbook English Plus, 9th edition (The Typical Curricula, 2022). The experimental groups used the following approach: the teacher chose or created video content on the same topics as the grammar material. The teacher created videos that aligned perfectly with the goals of the curriculum and shared them with the students via their WhatsApp groups a day or two in advance of the scheduled class. In the experimental group, the teacher instructed students to utilize WhatsApp to communicate with the teacher if needed. The experimental group received pre-class materials and instructions before each lesson, which included watching the videos attentively, completing assignments, and sharing comments or questions through the chat. Students were also encouraged to collaborate with their peers and teacher to address any issues or uncertainties. The teacher motivated the students to get ready for the class by completing the tasks and informed them that a short quiz would be given at the start

of the next session to evaluate their readiness level. At the beginning of each class, the teacher administered a quiz or set of questions to assess the students' comprehension and preparedness level to determine their familiarity with the material. To ensure students were prepared for the upcoming class activities, a brief five-minute quiz was administered at the start of the lesson to evaluate their understanding of the pre-class material. The purpose of the quiz was to assess the extent to which most students had engaged with the content.

During the classroom session, the teacher drew the students' attention to the WhatsApp activities to initiate instruction on interactional grammar. Following this, the teacher facilitated the students' practice of related grammatical concepts, encouraged interactive discussions, and facilitated group activities. The students were given the choice to either use the supplementary materials provided by the teacher or complete grammar tasks in their textbooks and activity books. Various communicative activities were then introduced to help students apply their knowledge of grammar in real-life scenarios. An array of activities were implemented, such as Jigsaw, Venn diagrams, pair work dictations, debates, guessing games, and board games, to promote the development of students' communicative competence and encourage the improvement of their grammatical skills.

In the classroom phase of the flipped instruction, the teacher encouraged student independence, giving them the freedom to determine the most effective use of their time during class. Students worked on relevant assignments and engaged in interactive activities, with the teacher taking on a supportive role in the classroom. During the task completion, the teacher observed and assisted the students by moving around the classroom and answering their inquiries. In contrast, the control groups received traditional grammar instruction from the teacher without any technological support. The grammar exercises were completed in class without much focus on interactive learning, and some of them were assigned as homework due to time constraints in class.

After 15 lessons of (1) flipped grammar instruction supported by WhatsApp, and (2) the traditional classroom learning setting, all student participants took the standardized post-test of English grammar proficiency. The test was administered to determine the level of improvement of students in both experimental and control groups.

3.5 Flipped Classroom Videos

The teacher created ten videos that were in accordance with the Course Plan and the Curriculum (MoES, 2022). They reviewed and chose suitable YouTube videos based on their quality and relevance. When the appropriate video could not be found, the teacher created videos that met the needs and interests of the students. The teacher utilized PowerPoint to present the material in a visual format and recorded the videos using the Zoom platform. The teacher's presence in the tutorial videos was aimed at encouraging and motivating the students. One of the benefits of instructor-created videos is that they can be organized as a more seamlessly integrate dpart of the lesson. Specifically, the video content was limited, narrowed, and accompanied by the teacher’s assigned exercises. Table 3 illustrates the list of grammar topics and the length of the videos.

Table 3

Video Topics and Length

Video	Topic	Length
Video 1	First Conditional	4:30
Video 2	Second Conditional	3:00
Video 3	First Conditional & Second Conditional (in comparison)	3:50
Video 4	Past Simple Tense (Active Voice)	3:05
Video 5	Past Progressive Tense (Active Voice)	3:00
Video 6	Past Simple Tense & Past Progressive Tense (in comparison)	2:30
Video 7	Present Simple Tense & Past Simple Tense (Passive Voice)	3:06
Video 8	Future Simple Passive	3:02
Video 9	Present & Past Progressive (Passive Voice)	2:50
Video 10	Transformation Active Forms into Passive (Revision)	3:10

3.6 Data Analysis

The method of data analysis was dependent upon the research question of interest. The process of data analysis for each of the research questions is now described. It should be noted that all electronic data was kept on a password-protected personal laptop of the master's student and the thesis advisor with student names anonymized.

3.6.1 RQ1: Validity and Reliability of Pre- and Post-Tests

The study used subject matter experts to ensure that the question items exhibited face validity and classical test theory (CTT) to ensure that the pre-and post-tests were reliable (Rasch, 1960).

For face validity, all items were reviewed by a single subject matter expert prior to administration. The review itself helped ensure that each item, and the skills assessed by the item, were well aligned with the goals of the national Kazakhstani curriculum (see Appendix A for pre- and post-tests).

To check for test reliability, the study made use of the following: for CTT, the item-rest correlations, the alpha-if-deleted coefficients, Cronbach's alpha reliability, and standard error of the mean. All analysis was carried out with the R CTT (Willse, 2018) and TAM (Robitzsch et al., 2020) packages. Based upon the analysis of the flipped and traditional combined item-response matrices, poorly functioning items (i.e., negative item-rest correlation coefficients) were removed to ensure that students received the most valid and reliable ability estimates for the study (see Appendix B, R Code for details).

3.6.2 RQ2(a): Pre-Test Grammatical Ability of the Exp. and Control Groups

Analysis of the data here included students' percentage correct scores and student ability ("theta", from the Rasch analysis). Student ability estimates, theta (θ) and item difficulty estimates (δ) were generated using marginal maximum likelihood (MML)

estimation as some level of generalization to the population from which the sample was derived was an objective. To compare ability, an independent samples *t*-test (or a non-parametric equivalent) was used to examine the statistical significance of the difference (critical alpha set at .05), and the Cohen's *d* effect size was used to examine the practical significance of the difference between the pre-test performance of both groups. An examination of the degree to which the variance in student ability could be attributable to classes (seven total) was also undertaken with the assistance of the `misty::multilevel.icc` function. Where ICCs and associated design effects ($de = 1 + (ICC \cdot [avg\ cluster\ size - 1])$ are greater than .10 and 2.00, respectively, adjustments to the study (i.e., group-by-group analyses) may be necessary (Lai & Kwok, 2014).

3.6.3 RQ2(b): Post-test Grammatical Ability of the Exp. and Control Groups

The researchers used a method called common-item equating to assess how much the students' abilities in grammar improved from the beginning to the end of the study. This involved using a subset of test items that were the same in both the pre-test and post-test. There were ten of these "link items," which covered different topics and were of varying difficulty. The researchers used the `TAM` package's `tam.mml` function to perform two separate scaling procedures with the item-response matrices from both tests. Thereafter, the stability of item difficulty estimates (equating error) was examined for both tests and the standard error of equaitng was estimated in accordance with the following formula:

$equating\ error = \frac{standard\ deviation\ of\ (\delta_i - \acute{\delta}_i)}{\sqrt{L}}$, where L is the number of link items, δ_i is the item difficulty estimte for item *i* in the pre-test, $\acute{\delta}_i$ is the item difficulty estimate for item *i* in the post-test. Note that the average item difficulty estimates for items in both tests are equal such that, $\sum_{i=1}^{L}(\delta_i - \acute{\delta}_i) = 0$. Consequently, poorly functioning link items, those for which their ommision would result in substantively lower standard errors of equating, would be

removed from the fixed item equating procedure (if deemed necessary). Thereafter, common item test equating was carried out with the assistance of the `TAM` package's `tam.mml` function's `theta.fixed` argument. This resulted in the post-test ability estimates for the sample cohort. The practical and statistical significnace of the differences between the two groups at the post-test (θ_2) was examined in the same way as at pre-test (i.e., *t*-test or equivalent and Cohens *d*).

3.6.4 RQ2(c): The FC Approach and Growth in Student Grammatical Ability

To estimate student growth, pre-and post-test ability estimates were used by subtracting the pre-test estimate from the post-test estimate. This process provided an estimate of growth (θ_g) for each student who participated. To determine the statistical significance of the growth difference between the two groups, an independent sample t-test (or non-parametric equivalent) was used with alpha set to .05. This was done using the t.test function from the stats package, R Core Team, 2022. In addition, to determine the practical significance of the difference in growth between the two groups, Cohen's d effect size whereas used (with the assistance of the effsize package's cohen.d function) with interpretation as follows: under 0.20 = negligible, 0.20 or above = small, 0.40 or above = medium, and 0.60 or above = large (Hattie, 2008). Note that an exposition of the mathematics of the Rasch analysis approach adopted in the current study is provided in Appendix C. It should be noted that, with (1) both pre- and post-test instruments, (2), all anonymized original data[i], and (3) all R code (Appendix B) made publicly available, the entire research project could conceivably be replicated in another research context.

[i]Pre-test: https://docs.google.com/spreadsheets/d/1kQSZ__xeQu3omh9nMXMWY5NtGVh6FhL3BdMB-6RaVxI/edit?usp=sharing Post-test: https://docs.google.com/spreadsheets/d/1-kh2kh_B-vcLT-te_VFG82x8cgOIG9ALoUHKX9A8XzQ/edit#gid=236521054

3.7 Ethical Issues

The research project was conducted at Nazarbayev University in accordance with ethical principles. The researcher provided information to the participants about the research's nature, purpose, and their involvement in the process. Participation in the study was optional. The matter of data collection was addressed with the School's Principal, who gave permission for the research and offered assistance if necessary.

The researcher spoke at the teacher-parental meeting and gave a detailed explanation of what the “flipped approach” is and how it will be conducted. Parental consent forms were handed to parents, in which they were informed about all the features of the research. The researcher clarified all parents’ questions and misunderstandings. The parental consent forms assured parents that measures would be taken to avoid students feeling coerced to participate in either classroom setting. It was mentioned that the test regime was no different from what would usually be administered for that grade. The instructor clarified that the videos provided by the teacher would be matched to the participant’s level of knowledge and accompanied by the appropriate amount of detailed exercises based on the curriculum requirements.

Assent scripts were distributed to students, which clarified their agreement to participate. Given the anonymous nature of the demographic questions and associated test, it was not possible for respondents to withdraw their contributions up to eight weeks after agreeing to contribute to the study, as the analysis of these results has been written up in the thesis.

The research presented a low level of risk for the participants. It is associated with this study as the potential exposure of the participant's identity. To reduce the risk associated with the study, the participant's identity was not disclosed in any reports (written or presented) related to this thesis. Participants’ information was also anonymized as discussed previously. Due to the new method, there was a risk that participants might cause slight stress

by doing extra homework, and the amount of time available for other subjects could be reduced.

3.8 Conclusion

This chapter provides a comprehensive account of the methodology employed in the study, including the rationale behind selecting the research site, the research design, the sampling procedures, the data collection methods, the data analysis techniques, and ethical considerations. The study used a quantitative approach, with pre- and post-tests administered to measure growth in student grammatical performance under both control and treatment conditions. In order to assess growth over time, Rasch modeling and common-item equating were employed, and ethical considerations were taken into account by addressing participants' rights and concerns prior to the study. The subsequent chapter will present noteworthy results derived from the study.

4. Findings

Chapter 4 presents the results of the analysis for each of the research questions. The chapter begins by providing basic descriptive statistics for student performance in the pre- and post-tests alongside evidence that the tests were reliable and valid. After this, the chapter provides information about the fixed equating procedure used to generate the post-test results enabling a comparison of the post-test grammatical ability of flipped and traditional groups. Finally, the chapter provides a comparison of the degree to which each group improved in the grammatical ability for the study period.

4.1 RQ1: Validity and Reliability of Pre- and Post-Tests

The subject matter experts reviewed the items and deemed them to be well-aligned with the Kazakhstani curriculum and its goals, therefore meeting the requirement of face validity. Having received the endorsement of the subject matter experts and after administering the pre- and post-tests to students, CTT was applied to resultant item-response data to ensure that all of the items functioned well. The reliability coefficients for pre- and post-tests are presented in Table 4.

Table 4

Descriptive and Reliability Estimates for Pre- and Post- Tests of English Grammar

Condition	*N* of items	*M*(*SD*)	Cronbach's Alpha	Rasch Reliability
		Pre-Test		
Flipped	40	22.94(9.07)	.909	.901
Traditional	40	24.66(6.50)	.813	.823
Total	40	23.62(8.16)	.885	.880
		Post-Test		
Flipped	40	24.37(7.77)	.875	.878
Traditional	40	19.46(7.43)	.846	.839
Total	40	22.43(7.97)	.873	.874

Note. Data collected by author.

In addition, all item-rest correlations for the pre-test (both groups: r = .04 to .62) and the post-test (both groups: r = .14 to .51) were all positive suggesting that each item

contributed positively to the estimation of student performance in grammar. In addition, all item-if-deleted coefficients were lower than the respective standard alpha for each of the pre- and post-test item-response matrices also suggestive of adequate reliability. Having demonstrated an adequate level of test reliability for both tests, the mean ability of students in the flipped and traditional settings at the pre-test was undertaken.

4.2. RQ2(a): Pre-Test Grammatical Ability of the Experimental and Control Groups

After running the Rasch analysis, the pre-test ability for the students in the flipped and traditional classroom conditions is presented in Table 5.

Table 5

Descriptive Statistics for the Pre-Test English Grammar Ability

Test	***M***	***SD***	**Skew**	***d*** ($M_{flipped} - M_{trad.}$)
Pre-test (flipped)	-0.06	1.07	0.21	-.18
Pre-test (trad)	0.11	0.78	0.69	–
Overall	0.01	0.97	0.24	–

Note. Data collected by author

Prior to comparing means at the pre-test, a homogeneity of variance (Levene's Test) test and a normality (Shapiro-Wilk) test was conducted on the outcome of interest, student ability (θ). While the normality test was not violated ($W = 0.99$, $p = .358$), the homogeneity of variance test was violated ($F[1, 102] = 5.813$, $p = .018$). Therefore, the alternate, Welch two sample t-test was deemed appropriate. The results suggested that there were no statistically or practically significant differences in the means of the two groups: $t(100.45) = -0.931$, $p = .354$, Cohen's $d = -.18$ (small). Having demonstrated an equivalent level of student ability for the two groups at the pre-test, the current study estimates the ability of the student sample at the post-test, and, thereafter, compares student ability at the pre- and post-test stages.

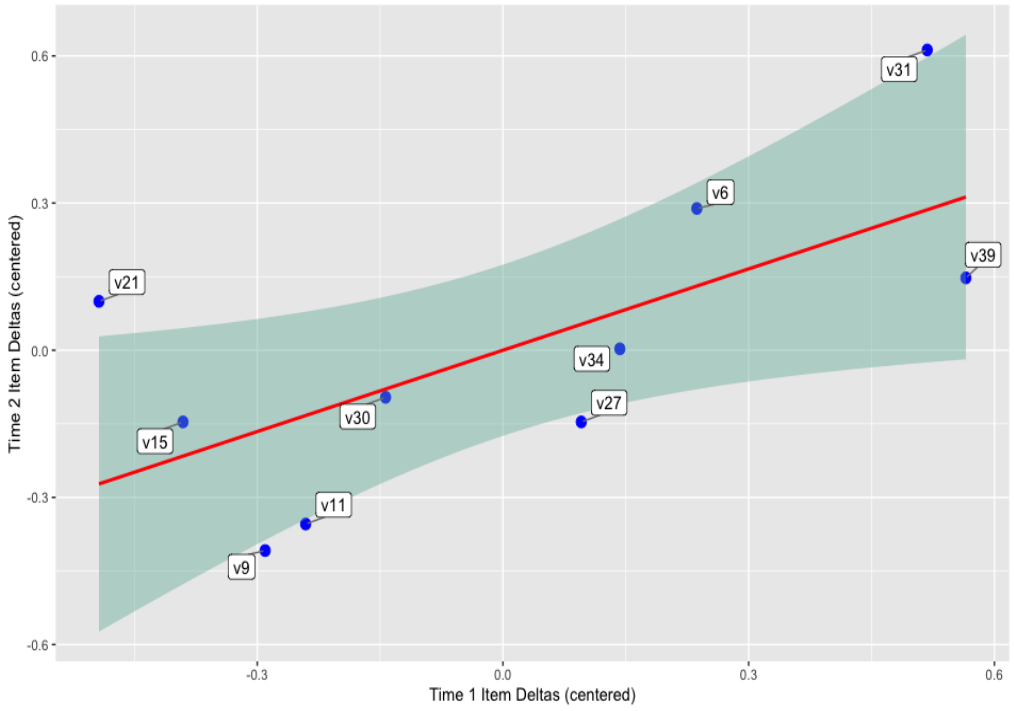
As regards to the gender aspect, there were 28 females and 35 males in the flipped group and 26 females and 15 males in the traditional group. However, the proportion was not deemed statistically significantly different ($\chi^2[1] = 2.86$, $p = .09$; Yates' continuity correction applied). Therefore, the gender aspect had no statistically significant impact on learning outcomes. In addition, the ICC statistic representing the proportion of variance in theta attributable to classes was slighty under .10 (*de* = 2.26). This suggested that student grammatical ability at the pre-test stage did not vary substantially by the seven classes.

4.3. RQ2(b): Post-Test Grammatical Ability of the Exp. and Control Groups

In order to estimate the grammatical ability of students at the post-test stage, a fixed equating procedure was carried out using the link items. Prior to performing the linked equating procedure, it was necessary to check that the link items functioned in a similar way at both time points. This was done by running separate Rasch model on the item-response matrix at pre-test (both groups) and the item-response matrix at post-test (both groups). After this procedure was carried out, each set of link item difficulty estimates (δ) were centered on zero and first compared visually (Figure 6).

Figure 6

Comparison of Link Item Difficulty Estimates for Pre- and Post-Tests



Results suggest that the link items were of a similar order of difficulty for both test administrations (note the general positive relationship in the graph). In addition, the standard error of equating was small (compared to the distribution of theta and delta) at 0.088 suggesting that the ten link items would be useful for generating ability estimates at the post-test.

After running the Rasch analysis with the fixed equating procedure (i.e., fixing the post-test link item difficulty estimates to the pre-test estimates, see Appendix B, R Code), the post-test ability for sample students is presented in Table 6.

Table 6

Descriptive Statistics for the Post-Test English Grammar Ability

Test	***M***	***SD***	**Skew**	***d* ($M_{flipped} - M_{trad.}$)**
Post-test (flipped)	0.570	0.914	0.607	.65
Post-test (trad)	0.010	0.782	0.441	–
Overall	0.01	0.97	0.24	–

Note. Data collected by author.

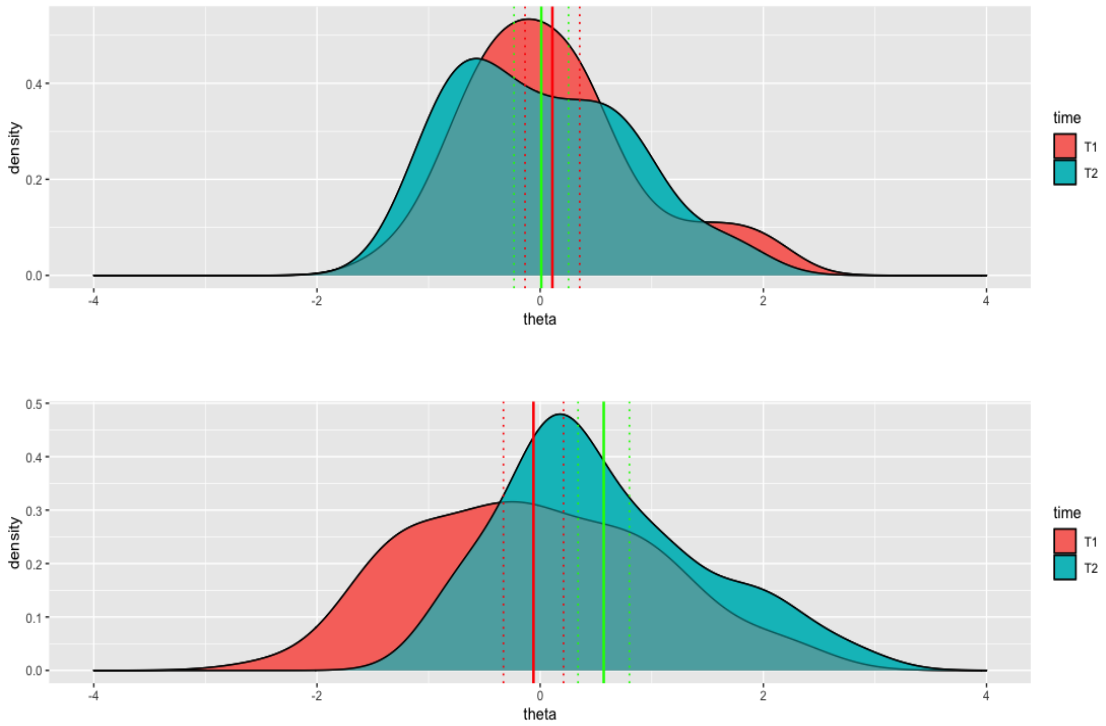
Also, to note is that the ICC statistic was only .11 (*de* = 2.44). This suggested that student grammatical ability at the post-test stage also did not vary substantially by the seven classes.

Prior to comparing means at the post-test, a homogeneity of variance (Levene's Test) test and a normality (Shapiro-Wilk) test was conducted on the outcome of interest, student ability (theta) at the post-test. While the homogeneity of variance test was not violated (F[1, 102] = 0.321, p = .573), the normality test was violated (W = 0.965, p = .008). Therefore, the alternate, Wilcoxon-Rank Sum Test (also known at the Mann-Whitney U Test) was applied. The results suggested that there was a statistically significant difference in the means of the two groups: W = 859.5, p = .004.

Figure 7 provides a visual illustration of the shift in grammatical ability for each of the two pedagogical conditions.

Figure 7

Comparative Change in Distribution of Student Grammatical Ability for Traditional (top) and Flipped (bottom) Pedagogical Conditions



Note. Red thick line = mean ability at the pre-test; red dotted lines = +/- 2 standard errors of the mean (`SD/sqrt(N)`); green thick line = mean ability at the post-test; green dotted lines = +/- 2 standard errors of the mean (`SD/sqrt(N)`).

Having demonstrated that students in the flipped condition performed better at T2, a final analysis of comparative "growth" in ability was undertaken.

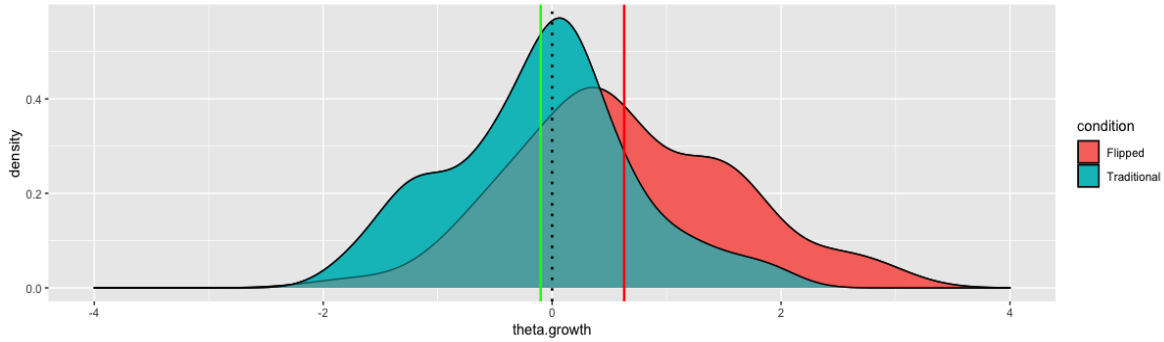
4.4. RQ2(c): Comparative Growth in Student Grammatical Ability

An estimate for the growth in student grammatical ability (θ_g) was computed by subtracting the post performance theta estimates ($\theta_2 - \theta_1 = \theta_g$) to generate an estimate for student growth in ability for both cohorts. Prior to comparing mean growth for each condition, a homogeneity of variance (Levene's Test) test and a normality (Shapiro-Wilk) test was conducted on the outcome of interest, growth in student ability (θ_g). The

homogeneity of variance test was not violated (F[1, 102] = 1.020, p = .315), and the normality test was also violated (W = 0.985, p = .299). Therefore, the standard independent sample *t*-test was applied to the data. The results suggested that there was a statistically significant difference in the mean level of growth of the two groups: t(1, 102) = 4.016, p < .001. The mean growth for the flipped group was 0.63 and the mean growth for the traditional group was -0.10 with an associated Cohen's *d* of 0.81 (large). Figure 8 provides a visual illustration of the comparative growth in grammatical ability of the two independent groups.

Figure 8

Comparative Growth in Student Grammatical Ability for Tradtional and Flipped Groups



Note. Red thick line = mean growth in ability for the flipped group ($\bar{\theta}_g$ = 0.63); green thick line = mean growth in ability for the traditional group ($\bar{\theta}_g$ = -0.10); black dotted line represents instances of zero growth in ability.

4.5. Summary of the Findings

Analysis revealed that the flipped grammar approach outperformed the traditional lecture-based learning. The results of the study suggest that the flipped learning can be an effective instructional approach specifically in the learning of English grammar. The results are consistent with empirical studies in similar contexts stated previously (Singay, 2020; Noroozi, 2022; Al-Harbi & Alshumaimeri, 2016; Pudin, 2017; Meléndez & Iza, 2017; Afzali & Izadpanah, 2011; Al-Naabi, 2020). In the following section, the findings are briefly summarized in accordance with the research questions.

The objective of this research was to investigate the impact of implementing the flipped classroom methodology on the acquisition of English grammar concepts. Each of the research findings are now briefly summarized. RQ1 asked whether the instruments were valid and reliable. Based on the assessment of the subject matter experts and the results of the pscyhometric analysis, this was deemed to be the case. RQ2 explored the equivalency of student abilty between the two group for the pretest. In additional to being generally equivalent in terms of gender, findings suggested that the students exhibited equivalent baseline levels of grammatical ability. RQ3 examined the difference in student ability at the post-test. Here, the results suggested that the flipped students' grammatical ability far exceeded that of the students in the traditional group and this was both practically and statistically significant. RQ4 compared the level of growth in students' grammatical ability between the two groups. Findings revealed that the students in the flipped group improved more that the students in the traditoinal group and this difference was both practically and statistically significant.

Overall, it can be understood from the data that the flipped classroom approach may be more effective for learning grammar compared to the conventional approach.

5. Discussion

The primary objective of the research was to assess the influence of flipped learning on the grammatical aptitude of learners by contrasting the progress of learning outcomes between the traditional teaching approach and the flipped classroom model. The results of the study indicate that the flipped approach was found to have a practically and statistically significant impact on students' rate of improvement in English grammatical ability. It is assumed that this effect may have been the result of students having more time to interact with peers, embedding and reinforcing what they had reviewed at home, engaging in problem-solving tasks, and concentrating on higher-level cognitive activities during lessons (Mahboob & Rahman, 2016; Ouda & Ahmed (2016). These results appear to support Bloom's (2001) revised taxonomy in which the tasks dedicated to developing higher-order skills are primarily developed during the in-class time, whereas the first-order abilities could be acquired at home (Bergman & Sams, 2014).

RQ1 was concerned with gauging the reliability and validity of the pre- and post-tests. Some of the research dedicated to examining the role of the flipped classroom on student learning lacks evidence for test reliability and validity. For example, the Koshegulova and Mindetbay (2020) study on the role of the flipped classroom focusing on Kazakhstani student learning presents no evidence for test reliability or validity. This calls to question the findings of the study and the capacity to generalize to the broader population in Kazakhstan. The instruments developed in the current study (Appendix A) were deemed to be aligned with the curriculum and exhibited face validity, according to subject matter experts. In addition, both tests exhibited excellent levels of reliability. Therefore, fundamentally, this suggested that the pre- and post-tests reliably discriminated between students with higher and lower grammatical ability. Future research on the utility of the flipped classroom, and other pedagogical innovations, for learning outcomes in Kazakhstan should be based on careful

instrument development and open exposition of test psychometric properties. Moreover, future research that makes use of examinations of student learning should also be informed by present day international standards and best practice in educational measurement and testing (AERA et al., 2014).

RQ2(a) focused on testing the equivalence of students' grammatical ability in the flipped and traditional groups. Findings suggested that they were no statistically of practically significant differences between the grammatical ability of the two groups at the start of the study. This was important as the subsequent tests of differences of the growth in academic achievement for the pre- and post-test periods involved the use of simple independent sample t-tests. However, it is important to note that equivalency of ability at the initial period of quasi-experimental research is not completely necessary. For example, Courtney et al. (2022) examined the initial status (literacy at the start of school) and rate of improvement in the first four years of school for children in updated and traditional curricula conditions. While students, on average, in the traditional curriculum happened to start school at a higher level than their counterparts in the updated curricula, the students in the updated curricula improved at a much faster rate over the following four years. This means that the equivalency of performance between quasi-experimental groups at the pre-test stage is not a necessary condition for evidence of the utility of any specific pedagogical intervention.

The key outcome of the current study (RQ2[b]) was that the grammatical ability of students taught under the flipped learning method was substantively higher than that taught under the traditional method. The posttest results suggest that flipped learning approach may enhance students' grammatical competence by activating learning motivation, learner autonomy, the efficient use of technology, and by providing more opportunities for more intense face-to-face class interaction. This discovery aligns with previous research studies

(Noroozi, 2022; Al-Harbi & Alshumaimeri, 2016; Hung, 2015) that have observed marked progress in learners' post-assessment scores following flipped classroom interventions.

Supplementing the results for RQ2(b), the results for RQ2(c) provided an analysis f the comparative improvement in grammatical ability for the students in the flipped and traditional classrooms. As expected, results suggested that students improved substantively more under the flipped learning pedagogical condition. The findings of the study are consistent with several studies reporting the positive impact of flipped instruction on students' grammatical skills in secondary schools (Afzali & Izadpanah, 2001; Noroozi, 2022; Al-Naabi, 2020). A more thorough discussion of the specific processes for which these improved learning outcomes may have been realized is now provided.

The findings of the study strongly suggest that grammar may be best learned through communicative language learning (Afzali & Izadpanah, 2011; Al-Harbi, & Alshumaimeri, 2016; Al-Naabi, 2020; Maciejewski, 2016). The learners taught in the flipped classroom condition demonstrated motivation to engage in different learning activities and willingly collaborate with their peers (Bishop and Verleger, 2013; Singay, 2020). During the intervention, participants had sufficient time for meaningful communication with scaffolding arranged by the teacher, which was aligned with the Socio-Cultural Vygotsky's theory as a Zone of Proximal Development (Vygotsky, 1978).

It may be that the improved level of learning of students in the flipped condition may have been explained by the combination of student-centered preparatory and in-class activities organized by the teacher. Though speculative, this supports the Constructivist Theory whereby the teacher played the role of a facilitator providing learners with student-centered activities ensuring that they were active participants in the language learning environment (Kim & Bonk, 2006; Li et al., 2017, Xu & Shi, 2018).

Another vital factor that affected the productiveness of lessons and the final outcomes is the quality of the video content and teaching materials prepared by the teacher for the flipped lessons. As mentioned before, not only is it essential to have a proper balance of online and face-to-face materials for the learners but to draw special attention to the quality and the length of the instructional videos (Santos & Serpa, 2020; Strayer, 2012).

In order to mitigate the possibility of students attending class without having adequately prepared, the researcher administered brief quizzes at the start of each session with the goal of encouraging students to take personal responsibility for their own readiness (Acedo, 2019).This procedure guaranteed productive lessons and ensured strong rapport with each student via WhatsApp if any questions arose.

Utilizing both videos created by teachers and those found on YouTube, along with the WhatsApp software, enabled learners to engage with peers and experience innovative forms of instruction. As a result, the implementation of flipped learning instruction is highly recommended for English classes.

The current study revealed that flipped grammar model had a productive capacity as an effective strategy in teaching and learning students of higher grades to study grammar concepts and engage them in interactive and collaborative activities by providing time for in-class practices. The study also hopes to assist officials and teachers to establish a more practically applicable approach to learning using flipped instruction.

5.1 Limitations

While this research effectively investigated how the flipped classroom model could enhance the grammatical skills of 9th grade students, there were some constraints and opportunities for further exploration in future studies.

Firstly, the study is limited in scope as it considered a limited number of grammatical aspects, and the intervention lasted only eight weeks. It would be practical to comprise more grammatical items and a more extended period for further research.

Secondly, it would also be viable to include qualitative data to have a more in-depth understanding of students' perceptions of learning grammar using a flipped design.

Lastly, the data collected from English grammar may not apply to similar interventions in different subjects. Therefore, more research is needed to confirm the current results.

5.2 Implications and Recommendations for Further Practice

The findings of this research have important consequences for how the flipped classroom model is implemented in the education system of Kazakhstan, specifically in the teaching of English grammar. The study supports the idea that educators should consider moving away from traditional teaching methods and instead adopt more practical and efficient techniques for teaching English grammar, using the flipped classroom approach.

A common problem for teachers is the absence of instructional time when introducing new language aspects. It should be considered that not all aspects of studying a language can be taught by applying a flipped classroom model. The teacher should thoroughly analyze and select the material appropriate for online teaching and flipped instruction.

The flipped classroom model makes educational improvement feasible since it frees up teacher instructional time by incorporating such strategies as differentiation, peer collaboration, scaffolding, and problem-based learning. Moreover, it may be that the interactive in-class activities conducted by the teacher can elevate the effectiveness of flipped lessons. The flipped teacher plays the role of a facilitator guiding students' interactions. Compared to traditional classes, the flipped classroom design provides more opportunities for

group activities when the facilitating teacher's role becomes vital. As a result, learning grammar concepts using in the flipped classroom can be engaging and productive, as the study's results suggest.

It is important that instructors are thoroughly prepared for face-to-face class time with proper activities and exercises. Otherwise, the outcomes may not result in higher student achievement. The teacher should not consider herself/himself to be an expert who transmits information but a master in classroom and facilitation management. Flipped teachers are the ones who use face-to-face class time adequately to provide active and cooperative learning opportunities for their students.

Students are also required to complete the online homework assignments. One of the recommendations for educators is to make a task that checks and motivates students to watch the videos and digest their content (Broman & Johnels, 2019). According to Burke & Fedorek (2017), the flipped model works effectively if students are well prepared. If students are not ready, the teacher will have difficulties conducting the in-class activities. To check students' preparedness, the teacher should provide quizzes at the beginning of each lesson. The completion of such mandatory pre-class activities could be incorporated into student grades to encourage student effort.

Watching instructional videos allows students to find their own time and pace to learn the material. However, the video episode should not be longer than five minutes as longer videos may result in student inattention. In addition, the online section of a flipped classroom should integrate with the face-to-face activities to ensure content coherence and relevant scaffolding. The students should not be overwhelmed with excessive pre-online materials and exercises. Therefore, the instructors are recommended to present only the most essential and relevant (grammar) material with tasks suitable to organize fruitful activities during the

lesson. Otherwise, inappropriate pre-task activities may result in lower academic achievement and loss of motivation among students (Burke & Fedorek, 2017).

The flipped classroom model presented in this research is just one example of how English grammar can be taught. The flipped model requires watching the video content at home, understanding it and doing various follow-up activities in the classroom. But it does not mean that every flipped lesson should be implemented in such a way. Educators may attempt flipped strategies in teaching various language aspects to meet their curricular needs.

6. Conclusions

The objective of this study was to investigate how using the flipped classroom model affected the acquisition of grammatical concepts among high school students in a specialized gymnasium located in Karaganda city, Central Kazakhstan. According to the results obtained, the flipped classroom method enabled the majority of students to learn at a comparatively faster pace compared to the conventional classroom approach. The flipped learning approach was more effective than a conventional method of teaching as it taught students to be responsible for their learning in and outside class. The flipped classroom design freed time for in-class practices concentrating on developing the fundamental language skills of students required for effective acquisition of English grammar Therefore, the shift from conventional teaching to a flipped mode helped optimize the time outside and inside the classroom boosting grammatical performance and raising students' motivation to learn grammar.

Incidentally, it was observed that students developed complementary skills related to interaction, peer collaboration, scaffolding, and autonomous learning, and meta-cognition. It was observed that students' attitude and position toward learning grammar progressed from generally passive recipients of knowledge to more active participants in the learning process. As a result, findings from this study strongly suggest that the interactive activities during in-class enabled students to overcome such challenges as language barriers and demotivation for studying grammatical tasks.

Furthermore, the flipped classroom inspired students' interest in multimedia technology. Students had access to videos provided by the teachers and instructors using the WhatsApp platform. Participants could learn the video content at their own pace and time.

In summary, the recent research indicated that implementing the flipped classroom technique is an effective teaching method that allows teachers to enhance students' grammatical skills through interesting videos and suitable in-class exercises. This study adds

to the existing literature on the applicability of the flipped classroom model in Kazakhstani high schools, especially regarding the advancement of literacy competencies among teenagers.

The students were empowered to regulate and devise their own learning, which fostered their aptitude for creativity and critical thinking. The adoption of the flipped classroom approach was favored over the conventional classroom setting as it allowed for a self-paced learning style. Furthermore, the implementation of flipped learning facilitated the cultivation of collaborative learning among peers. Students relished the opportunity to engage in interactive tasks while consolidating their grasp of grammatical concepts. In line with Vygotsky's sociocultural theory (1978), collaborative activities have the potential to enhance students' interactivity and positive disposition towards learning grammar.

The results of the present study substantiate the notion that the flipped classroom model can be employed proficiently to augment students' comprehension of grammatical elements of the English language, while simultaneously intensifying their self-motivational and independent learning capabilities. Additionally, with careful implementation, the flipped classroom method affords a personalized approach to education for each student and fosters interactive relationships between teachers and students, which, in turn, leads to a more effective learning experience.

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Appendices

Appendix A. Pre- and Post-Tests

Part 1 First and Second Conditional, wish subjuntives
Choose the correct form to complete the first or the second conditional sentences

1. If you don't leave now, you …. the train
   a) miss b) will miss c) missed d) misses
2. If it …. tomorrow, we … to the cinema.
   a) rains/go b) rains/won't go c) will rain/will go d) rains/will go
3. If the class … full, we … another one.
   a) is/will find b) will be full/find c) is/won't find d) will be full/will find
4. What … we … if the taxi ….?
   a) will do/come b) will do/will come c) do/won't come d) will do/doesn't come
5. We won't find peace until we … who did this.
   a) find b) will find c) should find d) finds
6. A lot of health problems could be prevented if people … better.
   a) eat b) ate c) would eat d) eated
7. You wouldn't have so many accidents, if you … more carefully.
   a) would drive b) will drive c) drove d) drive
8. If you were more responsible, maybe your parents … you to do more things.
   a) allowed b) would allow c) allow d) should allow
9. I am sorry, I can't go out. I'd go out if I … this terrible headache.
   a) didn't have b) don't have c) would not have d) will not have
10. If he … a nice person, he … people so badly.
    a) is/won't treat b) were/would treat c) was/will treat d) were/wouldn't treat
11. If we … late for the class, our teacher will be angry with us.
    a) is b) were c) will be d) are
12. If I … some fish, will you cook it for me?
    a) will catch b) catch c) caught d) am catching
13. Unless you … me alone, I'll call the police.
    a) leave b) will leave c) won't leave d) don't leave

Part 2 Past Simple and Past Continuous Tenses
Which is correct?

14. Jane had a book open in front of her, but she …it.
    a) didn't read b) wasn't reading c) read d) were reading
15. I wasn't very busy. I ... much to do.
    a) didn't have b)wasn't having c) had d) have
16. "What … when you … the accident?"
    a) did you do/were seeing b) did you do/was seeing c) were you doing/saw d) did you do/was seeing
17. I …. my finger while I ….
    a) was cutting/cooked b) cut/was cooking c) cut/cooked d) was cutting/was cooking
18. "How did you break your leg?" "I … the tree, while I …."
    a) hit/was skiing b) was hitting/was skiing c) hit/skied d) was hitting/skied
19. I … along the street when suddenly I … footsteps behind me. Somebody … me.
    a) was walking/heard/followed b) walked/heard/followed c) was walking/heard/was following d) walked/was hearing/followed
20. When I was young, I … to be a pilot.

a) wanted b) was wanting c) did want d) were wanting

21. Last night I … a plate when I … the washing-up.
    a) dropped/did b) was dropping/did c) dropped/was doing d) was dropping/was doing
22. I … you in the park yesterday. You ... on the grass and … a book.
    a) saw/were sitting/read b) was seeing/ was sitting/was reading c) saw/were sitting/were reading d) saw/sat/read
23. I … my back while I … in the garden.
    a) hurt/worked b) was hurting/was working c) hurt/was working d) hurted/was working
24. Last week a burglar broke into the house while we … television.
    a) watch b) have watched c) watched d) were watching
25. I found my lost pen while I … for my pencil sharpener.
    a) look b) looked c) was looking d) an looking
26. As he … the bank, a man in a mask … him onto the ground.
    a) passed/knocked b) was passing/knocked c) passed/was knocking d) was passing/was knocking
27. Why … me while they … in London?
    a) didn't they visit/stayed b) weren't they visiting/were staying c) weren't they visiting/stayed d) didn't they visit/were staying
28. What … when your computer …?
    a) were you writing/was crashing b) did you write/was crashing c) were you writing/crashed d) did you wrote/crashed

Part 3 Active and Passive Forms of Simple and Perfect Tenses (Present Simple and Active, Past Simple Active/Passive, Future Simple active/Passive, Present Perfect Active/Passive)

Choose the correct active or passive form

29. People … this road very often.
a) didn't use b) aren't used c) will be used d) don't use
30. All our money and passport … .
    a) are stolen b) stole c) were stolen d) steal
31. Hundreds of people … by the new factory this year.
    a) are employed b) were employed c) have been employed d) employ
32. I … to the city last Saturday.
    a) arrived b) have arrived c) was arrived d) will arrive
33. A lot of measures … to fix the economy.
    a) have been taken b) are taking c) has taken d) have taken
34. When do you think they … us the copy of the contract?
    a) will be sent b) will send c) are they being sent d) will have sent
35. Five people … after a car … into a bus last night.
    a) were injured/crashed b) injured/ was crashed c) injured/crashed d) were injured/was crashed
36. The university of Michigan is one of the best Universities in the United States and it … in Ann Arbor.
    a) located b) locates c) is located d) locate
37. This mansion … in 1750.
    a) was built b) built c) is built d) will be built
38. Many accidents … by dangerous driving.
    a) caused b) are caused c) have been caused d) were caused
39. The man … by the police yesterday, but he denies robbing the bank.

a) arrested b) has been arrested c) is arrested d) was arrested

40. It … in London this morning that the British Oil Corporation had discovered oil under the sea near the Welsh coast.

a) announced b) be announced c) was announced d) is announced

Total 40

Post-test (the items highlighted in black were taken from the pre-test)

Part 1 First and Second Conditional

Choose the correct form to complete the first or the second conditional sentences

1. If he …, we'll have a celebration.

a) passed b) will pass c) pass d) passes

2. If it …. now, we would go to the country.

a) is not raining b) doesn't rain c) didn't rain d) didn't rained

3. I don't know what … if you … this information.

a) happens/will forget b) will happen/forget c) happens/forget d) will happen/will forget

4. A lot of health problems could be prevented if people … better. (hard level)

a) eat b) ate c) would eat d) eated

5. If you … careful, you'll lose your money.

a) aren't b) are c) won't be d) will be

6. We're lost. If we … the map with us, we … where we are.

a) had/would know b) have/know c) will have/know d) have/will know

7. If I were in Scotland, I …. souvenirs for my friends and relatives.

a) bought b) buy c) would buy d) will buy

8. If you … water in the freezer, it … ice.

a) will put/becomes b) put/will become c) will put/will become d) put/becomes

9. I am sorry, I can't go out. I'd go out if I … this terrible headache. (easy)

a) didn't have b) don't have c) would not have d) will not have

10. You are a brilliant cook. If I ……as well as you, I … a restaurant.

a) can cook /will open b) could cook/would open c) am able to cook/would cook d) cooked/will open

11. Unless you … hard, you … the exam.

a) don't work/will fail b) work/fail c) will work/will fail d) work/will fail

12. If we … late for the class, our teacher will be angry with us. (medium)

a) is b) were c) will be d) are

13. If I … you, I … out in this weather.

a) was/go b) were/wouldn't go c) were/would go d) were/will go

Part 2 Past Simple and Past Continuous Tenses

Which is correct?

14. I wasn't very busy. I ... much to do.(medium)

a) didn't have b) wasn't having c) had d) have

15. She was talking on her mobile phone, while she… to work.

a) drove b) is driving c) was driving d) had driven

16. Last night I … a plate when I … the washing-up. (easy)

a) dropped/did b) was dropping/did c) dropped/was doing d) was dropping/was doing

17. "There was a power cut last night." "I know. I … some paperwork when the lights went out".

a) was doing b) had been doing c) had done d) did

18. Why didn't they visit me while they … in London?

a) stayed b) were staying c) had stayed d) had been staying

19. I … new glasses at the mall when I ... someone shoplifting.

a) bought/saw b) was buying/was seeing c) was buying/saw d) bought/was seeing

20. Why … me while they … in London? (hard)

a) didn't they visit/stayed b) weren't they visiting/were staying c) weren't they visiting/stayed d) didn't they visit/were staying

21. I don't know the answer to this question. I must confess that I … while the teacher … it to us.

a) wasn't listening/explained b) didn't listen/was explaining c) didn't listen/explained d) wasn't listening/was explaining

22. I … myself in a very difficult situation. I … what to do at that time.

a) found/didn't know b) was finding/didn't know c) found/knew d) found/wasn't knowing

23. I … a lot of delicious food while I … in Georgia last summer.

a) was tasting/was staying b) was tasting/stayed c) tasted/was staying d) tasted/stayed

24. They … to go shopping with me because they … their favourite film.

a) didn't wanted/were watching b) didn't want/ were watching c) didn't want/watched d) weren't wanting/were watching

25. Suddenly, I … some footsteps behind. Someone … me.

a) heard/followed b) was hearing/was following c) was hearing/followed d) heard/was following

26. They … to Canada when they … each other.

a) were travelling/were meeting b) were travelling/met c) travelled/met d) travelled/were meeting

27. A strange man … into the room. He … red trousers and a pink shirt.

a) was walking/wore b) walked/was wearing c) was walking/was wearing d) walked/wore

28. I tried to give him advice but he …. .

a) wasn't listening b) didn't listen c) didn't listened d) listened

Part 3 Active and Passive Forms of Simple and Perfect Tenses (Present Simple and Active, Past Simple Active/Passive, Future Simple Active/Passive, Present Perfect Active/Passive)

Choose the correct active or passive form

29. No information … to the new staff yet.

a) has been given b) was given c) hasn't been given d) hasn't given

30. All our money and passport …. (easy)

a) are stolen b) stole c) were stolen d) steal

31. Derby horse-races … since 1780.

a) are held b) have been held c) are hold d) have held

32. Hundreds of people … by the new factory this year. (hard)

a) are employed b) were employed c) have been employed d) employ

33. Robert Burns …a lot of wonderful poems.

a) writes b) has written c) wrote d) was written

34. When do you think they … us the copy of the contract? (medium)

a) will be sent b) will send c) are they being sent d) will have sent

35. The patients … after well in this hospital.

a) will look b) look c) have looked d) are looked

36. They … to watch this film tomorrow.

a) are allowed b) allow c) will be allowed d) will allow

37. Don't forget, all your words … down and … to the Headquarters.
    a) will write/send b) will be written/sent c) are written/sent d) will have been written/sent
38. A lot of people … by this company last year.
    a) were hired b) are hired c) hired d) was hired
39. Three men … after the incident, and five others … to hospital.
    a) arrested/took b) have been arrested/took c) were arrested/were taken d) are arrested/are taken
40. The man … by the police yesterday, but he denies robbing the bank. (advanced)
    a) arrested b) has been arrested c) is arrested d) was arrested

Appendix B: R Code

```
#################################################################################################
#                                        Tatyana R Code                                         #
#################################################################################################

# 1. Re-set everything in this software program
rm(list=ls())               # code removes everything from the Global Environment (saved data) ---->

# 2. Make a link with the data: 'Session' => 'Set Working Directory' => 'Choose Directory'
setwd("/Users/user/Desktop/Masters Students/Tatyana")    # for Matthew's computer
getwd()
# setwd("~/Desktop/Masters Students/Tatyana")
getwd()

# 3. To get the MS Excel files into R, we need to download special software packages:
# The first package is a software management package:
if (!require("pacman")) {
  install.packages("pacman", dependencies = TRUE)
  library(tidyverse)
  }

# 4. Install and load all necessary packages for the analysis in this script
pacman::p_load(psych, CTT, foreign, dplyr, readxl, TAM, car, ggplot2, misty)

# 5. Read in the .xlsx file
dir()
citation("readxl")                                                              # made in New Zealand
flip.t1 <- readxl::read_xlsx("spreadsheet pre test_done MC+.xlsx", sheet = "flip")
trad.t1 <- readxl::read_xlsx("spreadsheet pre test_done MC+.xlsx", sheet = "trad")
keys <- readxl::read_xlsx("spreadsheet pre test_done MC+.xlsx", sheet = "keys")

flipped.t1 <- flip.t1
tradition.t1<- trad.t1
######################################## Flipped ONLY ##############################################
# 6. Check the data
head(flip.t1)
head(trad.t1)
head(keys)

dim(flip.t1)    # 63 rows, 42 columns
dim(trad.t1)    # 41 rows, 42 columns
dim(keys)       # 1 row, 40 columns

str(flip.t1)    # Overall structure of the data is called a 'tibble' (special kind of spreadsheet that has colours, and shows some structure
etc.)
str(trad.t1)    # tibble
str(keys)       # tibble

flip.t1.names <- flip.t1$Name
flip.t1.classes <- flip.t1$Class

# 7. Change each tibble into a regular dataframe (regular spreadsheet of data)
```

```
flip.t1 <- as.data.frame(flip.t1)
trad.t1 <- as.data.frame(trad.t1)
keys <- as.data.frame(keys)

# 8. Check new structure
str(flip.t1)    # dataframe
str(trad.t1)    # dataframe
str(keys)       # dataframe

# 9. Score the results
flip.t1 <- flip.t1[ , 3:42]
flip.t1.scored <- CTT::score(flip.t1, keys, output.scored = TRUE)
print(flip.t1.scored)

# 10. Name the data efficiently
score.matrix <- as.data.frame(flip.t1.scored$scored)

# 11. Combine the data
options(max.print = 9999)
flipped.t1.full.results <- cbind.data.frame(flip.t1.names, flip.t1.classes, score.matrix, flip.t1.scored$score)
print(flipped.t1.full.results)

# 12. Change the names of columns
dim(flipped.t1.full.results)       # 63 rows, 43 columns
colnames(flipped.t1.full.results)[43] <- "Tot"
print(flipped.t1.full.results)

# 13. Order the students by total score
flipped.t1.full.results <- flipped.t1.full.results[order(flipped.t1.full.results$Tot, decreasing = T),]
print(flipped.t1.full.results)

# 14. Create Excel file with organized data
write.csv(flipped.t1.full.results, "flipped.t1.full.results.csv")

# 15. Reliability Analysis on the Test Data
CTT::reliability(score.matrix)    # .909

# 15.1 Total scores
mean(apply(score.matrix, 1, FUN = function(x)sum(x)))
sd(apply(score.matrix, 1, FUN = function(x)sum(x)))

# 16. Reliability analysis for each question
rel <- CTT::reliability(score.matrix)
rel$pBis     # this is the reliability for each question (in order) and it shoud be above 0.00 (i.e., no negative)
TAM::tam.mml(score.matrix)

# 17. Item difficulty
total.correct.each.q <- apply(score.matrix, 2, FUN = function(x)sum(x))
item.difficulty.rel.df <- rbind(score.matrix, total.correct.each.q, rel$pBis)
print(item.difficulty.rel.df)
dim(item.difficulty.rel.df)

# 18.identify difficulty of items
item.difficulty.rel.df.ordered <- item.difficulty.rel.df[, order(item.difficulty.rel.df[64,], decreasing = T)]
print(item.difficulty.rel.df.ordered)
```

```
# 19. Only get the difficulty and reliability
item.difficulties.plus.rel <- item.difficulty.rel.df.ordered[64:65,]
print(item.difficulties.plus.rel)

# 20. Choose 10 link items only from the last 75% of the difficult items (item 17 to item 10, 30 total questions)
names(item.difficulties.plus.rel)[11:40]
# "V17" "V9"  "V21" "V32" "V37" "V29" "V30" "V4"  "V12" "V2"  "V15" "V40" "V14" "V34" "V11" "V19" "V22" "V23" "V26" "V27" "V28" "V36" "V6"
"V13" "V31" "V35" "V33" "V39" "V38" "V10"

# Select 10 candidate link items for t2 test for January (high item reliability, from each of 3 aspect of grammar 3,3,4)

score.matrix.f <- score.matrix


######################################## Traditional ONLY ############################################
# 6. Check the data
dim(trad.t1)    # 41 students, 42 students
str(trad.t1)

trad.t1.names <- trad.t1$Name
trad.t1.classes <- trad.t1$Class

# 7. Change each tibble into a regular dataframe (regular spreadsheet of data)
# NA

# 8. Check new structure
str(trad.t1)    # dataframe
str(keys)       # dataframe

# 9. Score the results
trad.t1 <- trad.t1[ , 3:42]
trad.t1.scored <- CTT::score(trad.t1, keys, output.scored = TRUE)
print(trad.t1.scored)

# 10. Name the data efficiently
score.matrix <- as.data.frame(trad.t1.scored$scored)

# 11. Combine the data
options(max.print = 9999)
trad.t1.full.results <- cbind.data.frame(trad.t1.names, trad.t1.classes, score.matrix, trad.t1.scored$score)
print(trad.t1.full.results)

# 12. Change the names of columns
dim(trad.t1.full.results)       # 63 rows, 43 columns
colnames(trad.t1.full.results)[43] <- "Tot"
print(trad.t1.full.results)

# 13. Order the students by total score
trad.t1.full.results <- trad.t1.full.results[order(trad.t1.full.results$Tot, decreasing = T),]
print(trad.t1.full.results)

# 14. Create Excel file with organized data
write.csv(trad.t1.full.results, "trad.t1.full.results.csv")

# 15. Reliability Analysis on the Test Data
CTT::reliability(score.matrix)    # 0.813
```

```
# 15.1 Total scores
mean(apply(score.matrix, 1, FUN = function(x)sum(x)))
sd(apply(score.matrix, 1, FUN = function(x)sum(x)))

# 16. Reliability analysis for each question
rel <- CTT::reliability(score.matrix)
rel$pBis     # this is the reliability for each question (in order) and it shoud be above 0.00 (i.e., no negative)
# However, items 14 and 31 are negative, check in total matrix
TAM::tam.mml(score.matrix) # rel = .823

# 17. Item difficulty
total.correct.each.q <- apply(score.matrix, 2, FUN = function(x)sum(x))
item.difficulty.rel.df <- rbind(score.matrix, total.correct.each.q, rel$pBis)
print(item.difficulty.rel.df)
dim(item.difficulty.rel.df)

# 18.identify difficulty of items
item.difficulty.rel.df.ordered <- item.difficulty.rel.df[, order(item.difficulty.rel.df[42,], decreasing = T)]
print(item.difficulty.rel.df.ordered)

# 19. Only get the difficulty and reliability
item.difficulties.plus.rel <- item.difficulty.rel.df.ordered[42:43,]
print(item.difficulties.plus.rel)

# 20. Choose 10 link items only from the last 75% of the difficult items (item 17 to item 10, 30 total questions)
names(item.difficulties.plus.rel)[11:40]
# "V17" "V9"  "V21" "V32" "V37" "V29" "V30" "V4"  "V12" "V2"  "V15" "V40" "V14" "V34" "V11" "V19" "V22" "V23" "V26" "V27" "V28" "V36" "V6"
"V13" "V31" "V35" "V33" "V39" "V38" "V10"

# Select 10 candidate link items for t2 test for January (high item reliability, from each of 3 aspect of grammar 3,3,4)

############################################ Combined ############################################

t1.score.matrix <- rbind(score.matrix.f, score.matrix)
dim(t1.score.matrix)
colnames(t1.score.matrix)
rel.t1 <- CTT::reliability(t1.score.matrix)
rel.t1$alpha                    # 0.8846614
colnames(t1.score.matrix)
sort(rel.t1$pBis)
round(rel.t1$pBis, 2)           # All are positive so all items are fine

# 15.1 Total scores
mean(apply(t1.score.matrix, 1, FUN = function(x)sum(x)))
sd(apply(t1.score.matrix, 1, FUN = function(x)sum(x)))

# Order items by difficulty
total.correct <- apply(score.matrix.f, 2, FUN = function(x)sum(x))
score.matrix.f.totalitems <- rbind(score.matrix.f, total.correct)
score.matrix.f.totalitems <- score.matrix.f.totalitems[,order(score.matrix.f.totalitems[64,], decreasing = T)]

# Combine final information for review
df <- rbind(score.matrix.f.totalitems[64,], round(rel.t1$pBis, 2))
rownames(df) <- NULL
```

```
# Write it for review
write.csv(df, "full.item.results.csv")

# Choose 10 items of varied difficulty (1 easy, 1 medium, 1 hard, for example), all with high reliability (e.g., above .30 maybe), and cover the
three sub-domains (3-4 items per aspect)

# To identify the most ideal 10 link items from the pre-test, we selected 3 items from the conditional questions (I1-I13),
# 3 items from the past tense questions (I14-I26), and 4 items from the passive/active items (I27-I40).

# total               target   link # Easy    Medium  Hard    Advanced
# Conditional         13              3         v9       v11  v6
# past               13               3        v21       v15  v27
# passive                 14          4        v30       v34  v31           v39

# Link items were chosen based on exhibiting higher item-total correlations and various (e.g., easy, medium, hard, advanced)
# item difficulty.

# The ten link items are included in the follow up post-test:

#############################################################################################################

# Research question 2a: Ability of both groups at pre-test
dim(score.matrix.f)    # 63 students in flipped
dim(score.matrix)      # 41 students in traditional

# Generate a condition vector
condition.vector <- c(rep(2, 63), rep(1, 41))
t1.all <- cbind.data.frame(condition.vector, t1.score.matrix)

mod <- TAM::tam.mml(t1.all[,2:ncol(t1.all)])   # default is centering on students
mod$EAP.rel

mod$person$EAP
mean(mod$person$EAP)    # 0.006785481   # 0.01
sd(mod$person$EAP)      # 0.9658023     # 0.97
psych::skew(mod$person$EAP)             # 0.24 long tail to the right slightly

# group analysis
tapply(mod$person$EAP, t1.all$condition.vector, FUN = function(x)mean(x))
# Flipped mean = 0.11
# Traditional mean = -0.06

tapply(mod$person$EAP, t1.all$condition.vector, FUN = function(x)sd(x))
# Flipped sd = 0.78
# Traditional sd = 1.07

tapply(mod$person$EAP, t1.all$condition.vector, FUN = function(x)psych::skew(x))
# Flipped skew = 0.69
# Traditional skew = 0.21

# ICCs
length(mod$person$EAP)   # 104
nrow(flipped.t1)         # 63
nrow(tradition.t1)       # 41
unique(flipped.t1$Class)        # 4
unique(tradition.t1$Class)      # 3
```

```
class.v <- c(flipped.t1$Class, tradition.t1$Class)
icc.t1 <- misty::multilevel.icc(mod$person$EAP, class.v)   # 0.996
clus.size <- mean(table(tradition.t1$Class))
1+(icc.t1*(clus.size-1))  # 2.26

############################################## Cohen's d ##############################################
# Compare means
psych::cohen.d(mod$person$EAP, t1.all$condition.vector)
# lower   est.  upper 95
# -0.57  -0.18  0.22

############################################## significance ###########################################
options(scipen=999)

car::leveneTest(mod$person$EAP, t1.all$condition.vector)
# Levene's Test for Homogeneity of Variance (center = median)
#        Df F value Pr(>F)
# group   1  5.8127 0.0177 *
#       102

shapiro.test(mod$person$EAP)
# Shapiro-Wilk normality test
# data:  mod$person$EAP
# W = 0.9862, p-value = 0.3582

mean(mod$person$EAP[1:63])
sd(mod$person$EAP[1:63])
mean(mod$person$EAP[64:104])
sd(mod$person$EAP[64:104])

stats::t.test(mod$person$EAP[1:63], mod$person$EAP[64:104], var.equal = FALSE)

# Welch Two Sample t-test
#
# data:  mod$person$EAP[1:63] and mod$person$EAP[64:104]

# t = -0.93085, df = 100.45, p-value = 0.3542
# alternative hypothesis: true difference in means is not equal to 0
# 95 percent confidence interval:
#   -0.5304089  0.1916230
# sample estimates:
#   mean of x   mean of y
# -0.05999443  0.10939851

#############################################################################################################
# Perform linking between tests

# Check equivalency for student rows
dir()
flip.t1.test <- readxl::read_xlsx("spreadsheet pre test_done MC+.xlsx", sheet = "flip")
trad.t1.test <- readxl::read_xlsx("spreadsheet pre test_done MC+.xlsx", sheet = "trad")

flip.t2.test <- readxl::read_xlsx("spreadsheet post test _final data 2.xlsx", sheet = "flip")
trad.t2.test <- readxl::read_xlsx("spreadsheet post test _final data 2.xlsx", sheet = "trad")

flip.t1.test$Name == flip.t2.test$Students  # 2 small non-problematic anomalies
```

```
trad.t1.test$Name == trad.t2.test$Students  # 1 small non-problematic anomaly

################################ Score the test with the keys ####################################
# Get keys
keys <- readxl::read_xlsx("spreadsheet post test _final data 2.xlsx", sheet = "keys")
print(keys)
dim(keys)
keys <- as.vector(unname(unlist(as.vector(keys[2,]))[2:41]))
print(keys)
length(keys)

# Use keys to score the matrices
########## trad ###########3
trad.t2 <- trad.t2.test[, 3:42]
dim(trad.t2)
colnames(trad.t2)
trad.t2.scored <- CTT::score(trad.t2, keys, output.scored = TRUE)
print(trad.t2.scored)
trad.t2.scored <- trad.t2.scored$scored
# Overwrite NA as zero
trad.t2.scored[4,24] <- 0
dim(trad.t2.scored)
rel <- CTT::reliability(trad.t2.scored)
rel$pBis   # three items negative but let's check full data
TAM::tam.mml(trad.t2.scored)

# Totals
mean(apply(trad.t2.scored, 1, FUN = function(x)sum(x)))
sd(apply(trad.t2.scored, 1, FUN = function(x)sum(x)))

####### Flipped ########
flipped.t2 <- flip.t2.test[, 3:42]
dim(flipped.t2)
colnames(flipped.t2)
flipped.t2.scored <- CTT::score(flipped.t2, keys, output.scored = TRUE)
print(flipped.t2.scored)
flipped.t2.scored <- flipped.t2.scored$scored
rel <- CTT::reliability(flipped.t2.scored)
rel$pBis   # three items negative but let's check full data
TAM::tam.mml(flipped.t2.scored)

# Totals
mean(apply(flipped.t2.scored, 1, FUN = function(x)sum(x)))
sd(apply(flipped.t2.scored, 1, FUN = function(x)sum(x)))

# Merge both datasets
sum(colnames(flipped.t2.scored) == colnames(trad.t2.scored))  # 40 all true
dim(flipped.t2.scored)
dim(trad.t2.scored)
combined.t2 <- rbind(flipped.t2.scored, trad.t2.scored)
t2.all <- cbind.data.frame(c(rep(2, 63), rep(1, 41)), combined.t2)
colnames(t2.all)[1] <- "condition.vector"
print(t2.all)

rel <- CTT::reliability(t2.all[,2:41])
sort(rel$pBis)
```

```
TAM::tam.mml(t2.all[,2:41])

# Totals
mean(apply(t2.all[,2:41], 1, FUN = function(x)sum(x)))
sd(apply(t2.all[,2:41], 1, FUN = function(x)sum(x)))

# Note t1.all df included condition vector:
print(t1.all)

#############################################################################################
########################################## Equating Procedure ###############################
#############################################################################################

############################## Establish link item difficulty estimates for t1 ######################
colnames(t1.score.matrix)
mod$xsi
# link items are: v6 v9 v11 v15 v21 v27 v30 v31 v34 v39
link.items <- c("V6", "V9", "V11", "V15", "V21", "V27", "V30", "V31", "V34", "V39")
link.item.diff.t1 <- mod$xsi[colnames(t1.score.matrix) %in% link.items, ]

#            xsi    se.xsi
# V6  -0.1503250 0.2165530
# V9  -0.6773758 0.2228408
# V11 -0.6279417 0.2218468
# V15 -0.7776852 0.2251260
# V21 -0.8802445 0.2278423
# V27 -0.2914397 0.2173218
# V30 -0.5302921 0.2201351
# V31  0.1310131 0.2169549
# V34 -0.2442850 0.2169921
# V39  0.1781485 0.2172722

# total               target   link # Easy    Medium  Hard    Advanced
# Conditional         13              3         v9       v11  v6
# past               13               3         v21      v15  v27
# passive                 14          4         v30      v34  v31            v39

link.item.diff.t1.centr <- link.item.diff.t1$xsi - mean(link.item.diff.t1$xsi)

############################## Establish link item difficulty estimates for t2 ######################
rel.2 <- CTT::reliability(t2.all[,2:ncol(t2.all)])
rel.2$alpha # 0.8730712
round(rel.2$pBis, 2)
# [1] 0.48 0.48 0.34 0.26 0.35 0.26 0.46 0.51 0.49 0.44 0.28 0.30 0.31 0.30 0.21 0.37 0.39 0.41 0.31 0.40 0.36 0.29 0.43 0.28 0.46 0.48 0.42
0.35 0.22 0.32 0.20 0.32 0.14 0.39 0.40 0.40 0.44 0.43 0.39 0.26
# All positive

mod2 <- TAM::tam.mml(t2.all[,2:ncol(t2.all)])   # default is centering on students
mod2$xsi
link.items <- c("v6", "v9", "v11", "v15", "v21", "v27", "v30", "v31", "v34", "v39")
link.item.diff.t2 <- mod2$xsi[colnames(t2.all[,2:ncol(t2.all)]) %in% link.items, ]

link.item.diff.t2.centr <- link.item.diff.t2$xsi - mean(link.item.diff.t2$xsi)

############################## Graph item Difficulty Across Time ####################################
df.item.step.diff <- cbind.data.frame(link.items, link.item.diff.t1.centr, link.item.diff.t2.centr)
```

```
colnames(df.item.step.diff) <- c("Name", "T1", "T2")

ggplot2::ggplot(df.item.step.diff, aes(x = T1, y = T2)) +
  geom_point(color = "blue", size = 3) +
  xlab("Time 1 Item Deltas (centered)") +
  ylab("Time 2 Item Deltas (centered)") +
  geom_smooth(method = lm,
              color = "red",
              fill = "#69b3a2",
              se = TRUE) +
  ggrepel::geom_label_repel(aes(label = Name),
                            box.padding   = 0.4,
                            point.padding = 0.05,
                            segment.color = 'grey50')

# item difficulties not too distal: Proceed to equating after estimating standard error of equating
se.equating <- (sd(df.item.step.diff$T1 - df.item.step.diff$T2)) / sqrt(10)                          # see Wu, p. 241
print(se.equating)  # 0.08846857, it's so small, this is great!

############################ Perform Fixed Equating Procedure #######################################
describe(mod$person$EAP)

# Establish the names of the link items in t2 matrix (these are rownames of the link.df)
link.items

# Establish position of link items in the t2 matrix (this is column 1 in link.df: item)
item <- which(colnames(t2.all[,2:ncol(t2.all)]) %in% link.items)

# Establish item difficulty estimates to be imposed on the t2 matrix (this is column 2 in link.df: xsi.item)
xsi.item <- link.item.diff.t1$xsi

# Combine the values into a equating df
link.df <-cbind.data.frame(item, xsi.item)
rownames(link.df) <- link.items
print(link.df)    # this is the df to use as an argument in the "TAM::tam.mml" function's "xsi.fixed" argument.
str(link.df)
mod$xsi

# Perform equating procedure
mod.t2 <- TAM::tam.mml(t2.all[,2:ncol(t2.all)],
                       xsi.fixed = link.df)

# Compare performances t1 vs t2
mean(mod$person$EAP)        # 0.006785481
mean(mod.t2$person$EAP)     # 0.3489378

# Compare performances at : trad vs. flipped
mean(mod$person$EAP[1:63])                # -0.05999443

mean(mod.t2$person$EAP[1:63])             # 0.5696188
sd(mod.t2$person$EAP[1:63])               # 0.9138555
skew(mod.t2$person$EAP[1:63])

mean(mod$person$EAP[64:104])              # 0.1093985
mean(mod.t2$person$EAP[64:104])           # 0.00984261
sd(mod.t2$person$EAP[64:104])             # 0.7820131
```

```
skew(mod.t2$person$EAP[64:104])            # 0.4411179

# ICCs
length(mod.t2$person$EAP)   # 104
class.v <- c(flipped.t1$Class, tradition.t1$Class)
icc.t1 <- misty::multilevel.icc(mod.t2$person$EAP, class.v)   # 0.1133724
clus.size <- mean(table(tradition.t1$Class))
1+(icc.t1*(clus.size-1))  # 2.436051

################################ Cohen's d and t-test ###############################################
# Cohens d
psych::cohen.d(mod.t2$person$EAP, t1.all$condition.vector)

options(scipen=999)

car::leveneTest(mod.t2$person$EAP, t1.all$condition.vector)
# Levene's Test for Homogeneity of Variance (center = median)
#        Df F value Pr(>F)
# group   1  0.3206 0.5725
#       102

shapiro.test(mod.t2$person$EAP)
# Shapiro-Wilk normality test
# data:  mod.t2$person$EAP
# W = 0.96538, p-value = 0.008033

# Therefore, we perform the non-parametric alternative to the independent sample t-test
# The Wilcoxon Rank Sum Test

wilcox.test(mod.t2$person$EAP ~ t1.all$condition.vector)
# W = 859.5, p-value = 0.004097
# alternative hypothesis: true location shift is not equal to 0

mean(mod$person$EAP[1:63])
sd(mod$person$EAP[1:63])
mean(mod$person$EAP[64:104])
sd(mod$person$EAP[64:104])

stats::t.test(mod$person$EAP[1:63], mod$person$EAP[64:104], var.equal = FALSE)

# Welch Two Sample t-test
#
# data:  mod$person$EAP[1:63] and mod$person$EAP[64:104]

# t = -0.93085, df = 100.45, p-value = 0.3542
# alternative hypothesis: true difference in means is not equal to 0
# 95 percent confidence interval:
#   -0.5304089  0.1916230
# sample estimates:
#   mean of x   mean of y
# -0.05999443  0.10939851

#############################################################################################################
# Examining growth
growth.theta <- mod.t2$person$EAP - mod$person$EAP
t1.all$condition.vector
```

```
sum(growth.theta[1:63] > 0)  # 48 of 63 exhibited improvements
48/63*100   # 76.2%

sum(growth.theta[64:104] > 0)  # 19 of 41 exhibited improvements
19/41*100   # 46.3%

car::leveneTest(growth.theta, t1.all$condition.vector)
# Levene's Test for Homogeneity of Variance (center = median)
#        Df F value Pr(>F)
# group   1  1.0204 0.3148
#       102

shapiro.test(growth.theta)
# Shapiro-Wilk normality test
# data:  growth.theta
# W = 0.98514, p-value = 0.2987

stats::t.test(growth.theta[1:63], growth.theta[64:104], var.equal = T)
# data:  growth.theta[1:63] and growth.theta[64:104]
# t = 4.0155, df = 102, p-value = 0.0001135
# alternative hypothesis: true difference in means is not equal to 0
# 95 percent confidence interval:
#   0.3689927 1.0893455
# sample estimates:
#   mean of x  mean of y
# 0.6296132 -0.0995559
psych::cohen.d(c(growth.theta[1:63], growth.theta[64:104]), c(rep(1, 63), rep(2, 41)))
# -0.81

##################################### Density Plot for Growth #######################################
m.gr.flip <- mean(growth.theta[1:63])
m.gr.trad <- mean(growth.theta[64:104])

gr.flip <- growth.theta[1:63]
gr.trad <- growth.theta[64:104]

theta.growth <- c(gr.flip, gr.trad)
condition <- c(rep("Flipped", 63), rep("Traditional", 41))
df <- cbind.data.frame(theta.growth, condition)

ggplot(df, aes(x = theta.growth, fill = condition)) +
  geom_density() +
  geom_density(alpha=0.5) +
  xlim(-4, 4) +
  geom_vline(xintercept = c(m.gr.flip, m.gr.trad),
             linetype="solid",
             color = c("red", "green"),
             size=.9) +
  geom_vline(xintercept = c(0),
             linetype="dotted",
             color = c("black"),
             size=.9)

#############################################################################################################
# Density plots
```

```
range(mod$person$EAP)
range(mod.t2$person$EAP)

################################## Growth for Traditional Group ####################################
m.t1.trad <- mean(mod$person$EAP[64:104])
m.t2.trad <- mean(mod.t2$person$EAP[64:104])

t1.trad <- mod$person$EAP[64:104]
t2.trad <- mod.t2$person$EAP[64:104]

theta <- c(t1.trad, t2.trad)
time <- c(rep("T1", 41), rep("T2", 41))
df <- cbind.data.frame(theta, time)

seM.t1 <- sd(t1.trad)/sqrt(41)
seM.t2 <- sd(t2.trad)/sqrt(41)

ggplot(df, aes(x = theta, fill = time)) +
  geom_density() +
  geom_density(alpha=0.5) +
  xlim(-4, 4) +
  geom_vline(xintercept = c(m.t1.trad, m.t2.trad),
             linetype="solid",
             color = c("red", "green"),
             size=.9) +
  geom_vline(xintercept = c(m.t1.trad + (2*seM.t1), m.t1.trad - (2*seM.t1)),
              linetype="dotted",
              color = c("red", "red"),
              size=.6) +
  geom_vline(xintercept = c(m.t2.trad + (2*seM.t2), m.t2.trad - (2*seM.t2)),
              linetype="dotted",
              color = c("green", "green"),
              size=.6)

################################## Growth for Flipped Group ########################################
m.t1.flip <- mean(mod$person$EAP[1:63])
m.t2.flip <- mean(mod.t2$person$EAP[1:63])

t1.flip <- mod$person$EAP[1:63]
t2.flip <- mod.t2$person$EAP[1:63]

theta <- c(t1.flip, t2.flip)
time <- c(rep("T1", 63), rep("T2", 63))
df <- cbind.data.frame(theta, time)

seM.t1 <- sd(t1.flip)/sqrt(63)
seM.t2 <- sd(t2.flip)/sqrt(63)

ggplot(df, aes(x = theta, fill = time)) +
  geom_density() +
  geom_density(alpha=0.5) +
  xlim(-4, 4) +
  geom_vline(xintercept = c(m.t1.flip, m.t2.flip),
              linetype="solid",
              color = c("red", "green"),
              size=.9) +
```

```
  geom_vline(xintercept = c(m.t1.flip + (2*seM.t1), m.t1.flip - (2*seM.t1)),
             linetype="dotted",
             color = c("red", "red"),
             size=.6) +
  geom_vline(xintercept = c(m.t2.flip + (2*seM.t2), m.t2.flip - (2*seM.t2)),
             linetype="dotted",
             color = c("green", "green"),
             size=.6)


##############################################################################################
flip.g <- readxl::read_xlsx("spreadsheet post test _final data gender.xlsx", sheet = "flip")
colnames(flip.g)
table(flip.g$...2) # fem 28, m 35
trad.g <- readxl::read_xlsx("spreadsheet post test _final data gender.xlsx", sheet = "trad")
colnames(trad.g)
table(trad.g$...2) # fem 26, m 15

# Chi-square test
M <- rbind(c(28, 35), c(26, 15))
M <- as.table(M)
colnames(M) <- c("female", "male")
rownames(M) <- c("flipped","traditional")
Xsq <- chisq.test(M)  # Prints test summary
print(Xsq)  # not significant.

chisq.test(matrix(c(28,35,26,15), nrow=2, ncol=2), correct = T)

##############################################################################################
# Tatyana mastering equating
rm(list=ls())

# Generate simulated data for t1
set.seed(123)                                                          # The number you choose here will define your final graph; try
various numbers; share numbers
students <- 10
N <- students
I <- 10
ability <- seq(-2, 2,length=N)                                            # Code generates sequence of student ability from min to max
difficulty <- seq(-2, 2, length=I)                                        # Code generates sequence of item difficulty from min to max*
expected.perf <- plogis( outer( ability , difficulty , "-" ) )            # Run mathematical code to generate expected outcomes for each
student on each item
resp1 <- 1 * ( expected.perf > matrix( runif( N*I ) , nrow=N , ncol=I ) )  # Generate simulated responses/performance from expected
performance and random numbers
colnames(resp1) <- paste("I" , 1:I, sep="")                               # Generate column names from I1 to final item
# Order rows
tot <- apply(resp1, 1, function(x)sum(x, na.rm=TRUE))                     # Calculate all students' total scores
resp1 <- cbind.data.frame(resp1, tot)                                     # Bind the total score column to the left of resp1
resp1 <- resp1[order(resp1$tot, decreasing = TRUE),]                      # Order the students by total score
correct.tot.v <- resp1$tot
# Extract row ordered item-response matrix
row.ordered.resp1 <- resp1[,1:(ncol(resp1)-1)]
# Identify column totals
column.totals <- apply(row.ordered.resp1, 2, function(x)sum(x, na.rm=TRUE))
not.ordered.col <- rbind.data.frame(row.ordered.resp1, column.totals)
# Order columns by column totals
```

```
ordered.cols <- not.ordered.col[, order(not.ordered.col[nrow(not.ordered.col),], decreasing=T)]
print(ordered.cols)
# Remove column totals
ordered.matrix.t1 <- ordered.cols[-nrow(ordered.cols), ]
print(ordered.matrix.t1)
rownames(ordered.matrix.t1) <- 1:10
colnames(ordered.matrix.t1) <- paste("I", 1:10, sep = "")
print(ordered.matrix.t1)

# Generate simulated data for t2
set.seed(3210)                                                    # The number you choose here will define your final graph; try
various numbers; share numbers
students <- 10
N <- students
I <- 10
ability <- seq(-2, 2,length=N)                                      # Code generates sequence of student ability from min to max
difficulty <- seq(-2, 2, length=I)                                  # Code generates sequence of item difficulty from min to max*
expected.perf <- plogis( outer( ability , difficulty , "-" ) )      # Run mathematical code to generate expected outcomes for each
student on each item
resp1 <- 1 * ( expected.perf > matrix( runif( N*I ) , nrow=N , ncol=I ) )      # Generate simulated responses/performance from expected
performance and random numbers
colnames(resp1) <- paste("I" , 1:I, sep="")                         # Generate column names from I1 to final item
# Order rows
tot <- apply(resp1, 1, function(x)sum(x, na.rm=TRUE))               # Calculate all students' total scores
resp1 <- cbind.data.frame(resp1, tot)                               # Bind the total score column to the left of resp1
resp1 <- resp1[order(resp1$tot, decreasing = TRUE),]                # Order the students by total score
correct.tot.v <- resp1$tot
# Extract row ordered item-response matrix
row.ordered.resp1 <- resp1[,1:(ncol(resp1)-1)]
# Identify column totals
column.totals <- apply(row.ordered.resp1, 2, function(x)sum(x, na.rm=TRUE))
not.ordered.col <- rbind.data.frame(row.ordered.resp1, column.totals)
# Order columns by column totals
ordered.cols <- not.ordered.col[, order(not.ordered.col[nrow(not.ordered.col),], decreasing=T)]
print(ordered.cols)
# Remove column totals
ordered.matrix.t2 <- ordered.cols[-nrow(ordered.cols), ]
print(ordered.matrix.t2)
rownames(ordered.matrix.t2) <- seq(1:10)
colnames(ordered.matrix.t2) <- paste("I", 8:17, sep = "")
print(ordered.matrix.t2)

#############################################################################################
print(ordered.matrix.t1)
print(ordered.matrix.t2)

apply(ordered.matrix.t1, 1, FUN = function(x)sum(x))
apply(ordered.matrix.t1, 2, FUN = function(x)sum(x))

apply(ordered.matrix.t2, 1, FUN = function(x)sum(x))
apply(ordered.matrix.t2, 2, FUN = function(x)sum(x))

mod1 <- TAM::tam.jml(ordered.matrix.t1)
round(mod1$theta, 2)
item.diff <- round(mod1$xsi, 2)
```

```
# Combine the values into a equating df
link.df <-cbind.data.frame(1:3, item.diff[8:10])
rownames(link.df) <- c("I8", "I9", "I10")
colnames(link.df) <- c("item", "xsi.item")
print(link.df)    # this is the df to use as an argument in the "TAM::tam.mml" function's "xsi.fixed" argument.

# Equating procedure
str(link.df)
mod.equate <- TAM::tam.jml(ordered.matrix.t2, xsi.fixed = link.df)

# Print results
round(mod1$theta, 2)
round(mod1$theta, 2)
round(mod.equate$theta, 2)
round(mod.equate$xsi, 2)
round(plogis( outer( mod1$theta , mod1$xsi , "-" ) ), 2)
round(plogis( outer( mod.equate$theta , mod.equate$xsi , "-" ) ), 2)

# Consider residuals
exp.matrix <- plogis( outer( mod1$theta , mod1$xsi , "-" ) )
ordered.matrix.t1 - exp.matrix
res.matrix <- ordered.matrix.t1 - exp.matrix
sum(res.matrix)  # in other words, close to zero

2.72^2.20
## END ##
```

Appendix C. Mathematical Exposition of the Applied Rasch Modelling Approach

This purpose of this appendix is to provide a mathematical exposition of the applied Rasch modelling approach used in the current study. The exposition makes use of a frequentist statistical approach (see `TAM::tam.jml`) for simplicity. The example matrix and basic analysis is also provided in Appendix B of this manuscript. Each of the two example observed matrices below (pre- and post-test performance) pertain to the same 10 students (rows) and 10 columns (items). Note that student totals are provided in the far-left columns while item totals are provided in the top rows. Each of the 10 questions are dichotomous with 1 = correct and 0 = incorrect. Note that the final three columns represent student performance on the same questions administered at the pre- and post-tests.

The pre-test item-response matrix is presented in the center, while the person total scores (running from 1^{st} to the i^{th} [in this case, tenth]) are presented vertically to the left of the item-response matrix, and the item total scores (running from the 1^{st} to the j^{th}, in this case, tenth) are presented to horizontally above the item-response matrix.

Items	1	2	3	4	5	6	7	**8**	**9**	**10**
	[8	7	7	6	6	5	5	**2**	**2**	**1**]
[9	1	1	1	1	1	1	1	1	1	0
7	1	1	1	1	1	1	1	0	0	0
6	1	1	0	1	1	1	1	0	0	0
6	1	1	1	1	1	0	0	0	0	1
6	1	1	1	1	1	0	1	0	0	0
5	1	0	1	1	1	0	0	0	1	0
4	1	0	1	0	0	1	1	0	0	0
3	1	1	0	0	0	1	0	0	0	0
2	0	0	1	0	0	0	0	1	0	0
1]	0	1	0	0	0	0	0	0	0	0]

The post-test item-response matrix is presented in the center, while the person total scores are presented vertically to the left of the item-response matrix, and the item total scores are presented to horizontally above the item-response matrix.

	[10	8	7	6	5	4	3	3	2	1]
[10]	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	0
5	1	1	1	1	1	0	0	0	0	0
5	1	1	0	1	0	0	1	1	0	0
5	1	1	0	1	1	1	0	0	0	0
4	1	1	1	1	0	0	0	0	0	0
4	1	1	1	0	0	1	0	0	0	0
3	1	1	1	0	0	0	0	0	0	0
3	1	0	1	0	1	0	0	0	0	0
1]	1	0	0	0	0	0	0	0	0	0]

To ensure that the tests are sufficiently challenging (well targeted) for the students, the more difficult questions in the pre-test (Items 8, 9, and 10) were also included at post-test (see first three columns aligned in lower post-test matrix). For this example, as expected, the students generally exhibit better master of those three items at the post-test.

The application of the Rasch model to the observed item-response data states that the probability of student *i* being successful on item *j* is a function of student ability and item difficulty. Mathematically, the Rasch equation is as follows: $= \left(X_{ij} = 1\right) = \frac{e^{\theta_i - \delta_j}}{1+e^{\theta_i - \delta_j}}$, where *e* is the universal constant, approximately 2.72, θ_i = student ability, and δ_j = item difficulty. Note that θ_i is just a special transformation of the percentage correct score for each student. For example, for the pre-test, student 1 achieved 90%. In this instance, $\theta_{10} = \log\left(\frac{\frac{9}{10}}{1-\left[\frac{9}{10}\right]}\right) =$ $\log\left(\frac{0.9}{0.1}\right) = \log(9) = 2.20$ [i.e., $e^{2.20} = 9, or\ 2.72^{2.20} = 9$]. While this student's ability is ultimately estimated to be 3.32 (see expected the pre-test matrix below), 2.20 is used in the first iteration in the statistical software package until a final solution for the model is reached.

Note that the corresponding θ_i and δ_j estimates, and probabilities for each student on each item, i.e., $P = \left(X_{ij} = 1\right)$, are provided in the pre- and post-test expected matrices below.

Items	1	2	3	4	5	6	7	**8**	**9**	**10**
	$[-1.83$	-1.14	-1.14	-0.55	-0.55	-0.01	-0.01	$\mathbf{1.79}$	$\mathbf{1.79}$	$\mathbf{2.82}]$
$\begin{bmatrix}3.32\\1.33\\0.62\\0.62\\0.62\\-0.02\\-0.61\\-1.20\\-1.87\\-2.81\end{bmatrix}$	$\begin{bmatrix}.99\\.96\\.92\\.92\\.92\\.86\\.77\\.65\\.49\\.27\end{bmatrix}$	.99 .92 .85 .85 .85 .75 .63 .48 .32 .16	.99 .92 .85 .85 .85 .75 .63 .48 .32 .16	.98 .87 .76 .76 .76 .63 .49 .34 .21 .09	.98 .87 .76 .76 .76 .63 .49 .34 .21 .09	.97 .79 .65 .65 .65 .50 .36 .23 .13 .06	.97 .79 .65 .65 .65 .50 .36 .23 .13 .06	.82 .39 .24 .24 .24 .14 .08 .05 .03 .01	.82 .39 .24 .24 .24 .14 .08 .05 .03 .01	.62 .19 .10 .10 .10 .06 .03 .02 .01 .00

	[1.79	1.79	2.82	3.44	3.99	4.60	5.40	5.40	7.80	9.50]
$\begin{bmatrix}11.57\\9.47\\4.77\\4.77\\4.77\\3.99\\3.99\\3.18\\3.18\\1.17\end{bmatrix}$	$\begin{bmatrix}.99\\.96\\.92\\.92\\.92\\.86\\.77\\.65\\.49\\.27\end{bmatrix}$	.99 .92 .85 .85 .85 .75 .63 .48 .32 .16	.99 .92 .85 .85 .85 .75 .63 .48 .32 .16	.98 .87 .76 .76 .76 .63 .49 .34 .21 .09	.98 .87 .76 .76 .76 .63 .49 .34 .21 .09	.97 .79 .65 .65 .65 .50 .36 .23 .13 .06	.97 .79 .65 .65 .65 .50 .36 .23 .13 .06	.82 .39 .24 .24 .24 .14 .08 .05 .03 .01	.82 .39 .24 .24 .24 .14 .08 .05 .03 .01	.62 .19 .10 .10 .10 .06 .03 .02 .01 .00

As illustrated, the total score for each student (see data on previous page) is sufficient for theta (θ_i). For example, for the pre-test, total scores for students 3, 4, and 5 are 6, 6, and 6. Whereas, the corresponding theta estimates are 0.62, 0.62, and 0.62. Note that the item difficulties are held constant for the link items (Items 8, 9, and 10; $\delta = 1.79$, 1.79, and 2.82). This means that while the item difficulties for these items are "fixed"

for the post-test Rasch calibration, the student ability estimates for the post-test are "floating" and ultimately derived from the equating procedure. Also note that the improvement in theta (θ_g) for each student could then be calculated by subtracting the post-test theta estimates from the respective pre-test estimates.

As explained in the methodology chapter of this thesis, to provide valid estimates on a single ability scale (across both pre- and post-tests), this thesis makes use of fixed-item equating. An example of this procedure is provided in the matrices above whereby the last three items (Items 8, 9, and 10, considered difficult in the pre-test though easier in the post-test) are administered at both time points. As part of this thesis, students were administered well-targeted pre- and post-test assessments. This means that despite having improved grammatical ability at the completion of the intervention, the post-test was, overall, also challenging to students ensuring that students could be separated reliably for the construct of interest, grammatical ability. We note that student ability for the post test is higher than that of the pre-test, and that the application of the fixed-item equating procedure provides for valid estimates of student ability at the post-test. Some more math to consider is the assumption that the standard error of equating is minimized (see R code, Appendix B) as non-linearity of item difficulty estimates (a type of "system effect") cuts across all levels of comparisons between individual and average ability across the two time points (standard error of equating in the current study was 0.088, considered minimal).

Also note that by default, $\sum_{i=1}^{n} \theta_i = 0$. However, if this may not be consequential and $\sum_{j=1}^{m} \delta_j = 0$ may also be set in the software (where *n* is the maximum number of rows and *m* is the maximum number of columns in the matrix). In addition, the amount of information about each student (or item) is given by the information criterion (*IC*) element, where $IC = P \cdot (1 - P)$, such that information about student ability is maximized when P approaches .50. In addition, the total amount of information provided in the test is given by test information function (*TIF*), where $TIF = \sum_{i=1}^{n} \sum_{j=1}^{m} P \cdot (1 - P)$, i.e., the sum of all information criterion elements. Also, the precision of the estimates of θ_i, i.e., the standard error of student ability (SE) is defined as, $SE_i = \frac{1}{\sqrt{\sum_{i=1}^{n} IC_i}}$, whereby the more information about a student, the smaller the standard error

of the ability estimate. Finally, the test reliability from the Rasch framework perspective is given by the variance of the theta estimates (v), where, $v = \frac{\sum_{i=1}^{n}(\theta_i - \bar{\theta}_i)^2}{n-1}$; and the average of the squared error (s), where $s = \frac{1}{n}\sum_{i=1}^{n} SE_i^2$, such that reliability is defined as $1 - (v - s)$.

Note. The author, Tatyana Nam, acknowledges the contribution that her supervisor, Dr Matthew Courtney, made to this mathematical exposition and recognizes that its purpose is to provide some readers with an introduction to the mathematics of Rasch Measurement Theory (see Wu et al, 2016).