IMPROVING HIGH SCHOOL STUDENTS UNDERSTANDING OF PHYSICS CONCEPTS THROUGH FLIPPED CLASSROOM

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Abstract

This study explores the flipped classroom approach that transforms traditional teaching by teaching learning content using technology outside the classroom. The attendance time is used for interactive, student-centered activities such as discussions and problem solving. The aim of the study is to investigate the effects of a modified flipped classroom model on students' conceptual understanding and motivation. Physics is often considered a difficult subject for secondary school students and is often associated with low conceptual understanding and limited participation in traditional frontal teaching. The flipped classroom model, which holds face-to-face lessons outside the classroom and uses classroom time for active learning, has proven to be a promising alternative for overcoming these challenges.

This study investigated the impact of the flipped classroom approach on the conceptual understanding of physics in eighth grade. A quasi-experimental design was used with 41 students divided into an experimental group (flipped classroom) and a control group (traditional teaching). Both groups completed tests with 30 multiple-choice questions to capture conceptual understanding before and after the flipped classroom. In addition, a questionnaire was used to measure the motivation and commitment of the students.

The results showed that although both groups improved, the experimental group achieved significantly higher test results in the post-test compared to the control group. A one-factor analysis of variance (ANOVA) revealed a statistically significant difference between the groups ($p < 0.05$). The experimental group also reported a higher level of commitment, motivation and self-confidence in learning physical concepts.

These results suggest that the flipped classroom approach is an effective method for improving students' conceptual understanding and engagement in the subject of physics. By combining pre-lesson preparation with active, student-centered learning during the lesson, this model offers a viable alternative to traditional teaching methods.

Абстракт

В этом исследований подход «перевернутого класса» трансформирует традиционное обучение, предоставляя учебный контент вне класса с помощью технологий, в то время как время занятий используется для интерактивных, ориентированных на ученика мероприятий, таких как дискуссии и решение задач. Цель данного исследования — изучить влияние модифицированной модели «перевернутого класса» на концептуальное понимание и мотивацию учащихся.

Физика часто считается сложным предметом для учащихся средних школ, часто ассоциирующимся с низким уровнем концептуального понимания и ограниченной вовлеченностью в традиционные лекционные занятия. Модель «перевернутого класса», которая переносит прямое обучение за пределы класса и использует время занятий для активного обучения, стала многообещающей альтернативой для решения этих проблем.

Целью данного исследования было изучение влияния подхода «перевернутого класса» на концептуальное понимание физики у учащихся восьмого класса. Было использовано квазиэкспериментальное исследование с участием 41 ученика, разделенных на экспериментальную группу (перевернутый класс) и контрольную группу (традиционное обучение). Обе группы прошли предварительные и итоговые тесты, состоящие из 30 вопросов с множественным выбором, для оценки концептуального понимания, а для измерения мотивации и вовлеченности учащихся использовался опросник.

Результаты показали, что, хотя обе группы продемонстрировали улучшение, экспериментальная группа показала значительно более высокие результаты после тестирования по сравнению с контрольной группой. Однофакторный дисперсионный анализ выявил статистически значимую разницу между группами ($p < 0,05$). Экспериментальная группа также сообщила о более высоком уровне вовлеченности, мотивации и уверенности в изучении физических концепций.

Аннотация

Бұл зерттеуде Алматы облысында сегізінші сынып оқушыларының физиканы тұжырымдамалық түсінуіне аударылған сынып тәсілінің әсерін зерттеу болды. Эксперименттік топқа (аударылған сынып) және бақылау тобына (дәстүрлі оқыту) бөлінген 41 оқушыны қамтитын квазиэксперименттік дизайн қолданылды. Екі топ та тұжырымдамалық түсіністікті бағалау үшін 30 көп таңдаулы сұрақтан тұратын алдын ала және кейінгі тесттерді орындады, ал оқушылардың мотивациясын және қатысуын өлшеу үшін сауалнама пайдаланылды.

Физика орта мектеп оқушылары үшін көбінесе күрделі пән болып саналады, бұл көбінесе тұжырымдамалық түсіністіктің төмен деңгейімен және дәстүрлі дәріске негізделген сыныптарда шектеулі қатысумен байланысты. Тікелей оқытуды сыныптан тыс жылжытатын және сабақ уақытын белсенді оқу үшін пайдаланатын аударылған сынып моделі осы мәселелерді шешудің перспективалы балама ретінде пайда болды.

Таңдамалы t-тест бойынша айтарлықтай айырмашылықтарды көрсетпеді. Бір жақты ANOVA топтар арасында статистикалық тұрғыдан маңызды айырмашылықты көрсетті ($p < 0,05$). Эксперименттік топ сонымен қатар физика ұғымдарын үйренуге деген қызығушылықтың, мотивацияның және сенімділіктің жоғары деңгейін хабарлады. Жалпы, аударылған сынып тәсілі оқушылардың ғылыми білімін және олардың ғылыммен байланысын ілгерілету және тереңдету үшін қолайлы болып табылады. Сондықтан олардың оқу нәтижелерін тиімдірек бағалау үшін орта мектеп оқушылары арасында әртүрлі тақырыптарды қамтитын тереңірек аударылған сынып зерттеулерін жүргізу ұсынылады.

1. Introduction

1.1 Theoretical Background

Education in the 21st century requires innovative pedagogical approaches that promote active engagement, critical thinking and a deeper conceptual understanding. Physics, as a core science subject, presents special challenges for secondary school students due to its abstract nature, its mathematical requirements and its dependence on conceptual thinking. The traditional teacher-centered teaching, in which the teacher teaches the material in class while the students passively absorb the information, is often criticized because it does not meet the different learning needs and only leads to a limited long-term retention performance.

The flipped classroom model represents a significant educational change. Originally conceived by Jonathan Bergmann and Aaron Sams in the early 2000s, the flipped Classroom model reverses the traditional learning structure: students engage with the learning content outside of class - typically in the form of short video lectures - while class time is used for active, collaborative and problem-solving activities. This approach is based on several established pedagogical theories:

Bloom's Taxonomy (1956, revised 2001): Traditional instruction often confines higher-order thinking (application, analysis, evaluation) to homework, where teacher support is absent. The flipped model brings these activities into the classroom, where students can receive immediate guidance.

Constructivist Learning Theory (Vygotsky, Piaget): Students construct knowledge through active engagement and social interaction. The flipped classroom provides structured opportunities for peer collaboration and guided inquiry during class time.

Self-Determination Theory (Deci & Ryan, 1985): By allowing students to engage with content at their own pace at home, the flipped model supports learner autonomy, which is linked to higher intrinsic motivation and deeper learning.

In the context of 8th-grade physics, the flipped classroom approach has the potential to improve students' grasp of abstract concepts, increase engagement during

class activities, and provide the teacher with more meaningful contact time for formative assessment and targeted support.

1.2 Statement of the Problem

Despite decades of curriculum reforms, physics education in secondary schools continues to face major challenges. Studies consistently show that students in the 8th grade have difficulties with basic physical concepts and often rely on memorization rather than on a real understanding. In traditional lessons, the limited teaching time is taken up by face-to-face lessons, so that there is little room for guided practice, discussions and the application of what has been learned, which promote deeper learning.

Physics is a fundamental science subject that contributes significantly to students' scientific literacy, critical thinking, and problem-solving abilities. However, many students experience difficulties in learning physics because of the abstract nature of its concepts, mathematical complexity, and the predominance of traditional teacher-centered instructional approaches. As a result, students often demonstrate low academic achievement, limited conceptual understanding, and reduced motivation toward learning physics.

In many educational settings, including secondary schools and higher education institutions in Kazakhstan, traditional lecture-based teaching remains a common instructional method. While this approach enables teachers to deliver large amounts of content, it often provides limited opportunities for active student engagement, collaborative learning, and practical application of knowledge. Consequently, students may become passive recipients of information rather than active participants in the learning process.

Recent educational reforms in Kazakhstan emphasize student-centered learning, competency-based education, critical thinking, and the integration of digital technologies into teaching and learning. These reforms have encouraged educators to explore innovative instructional approaches that can improve learning outcomes and increase student motivation. One such approach is the flipped classroom, which

reverses the traditional sequence of instruction by requiring students to study learning materials before class and engage in interactive learning activities during classroom sessions.

Although previous studies have reported positive effects of the flipped classroom on academic achievement, engagement, and motivation, findings remain inconsistent across different educational contexts and subject areas. Furthermore, limited research has examined the effectiveness of the flipped classroom in physics education within the context of Kazakhstan. There is therefore a need to investigate whether the implementation of the flipped classroom can improve students' understanding of physics concepts and enhance their motivation to learn physics.

The problem addressed in this study is the continued challenge of low student engagement and insufficient conceptual understanding in physics learning, as well as the lack of empirical evidence regarding the effectiveness of the flipped classroom approach in improving learning outcomes and motivation among physics students in Kazakhstan. This study seeks to address this gap by examining the impact of the flipped classroom method on students' academic performance and motivation in physics education.

In addition, in conventional physics lessons, students often do not have the opportunity to repeat the learning material at their own pace, which leads to knowledge gaps that increase over time. Due to the curriculum, teachers are rarely able to respond to students' individual difficulties within the regular lesson time. Although the Flipped classroom method is promising internationally in various educational contexts, its effectiveness in improving the understanding of physics is still insufficiently researched, especially among eighth graders, especially in contexts where this approach has not yet been widely used. This study aims to fill this research gap by implementing and evaluating the flipped classroom model in an 8th grade physics class with 41 students in Almaty.

1.3 Objectives of the Study

The study is guided by the following objectives:

1. To examine the effect of the flipped classroom method on 8th-grade students' conceptual understanding of physics.
2. To compare academic achievement in physics between students taught using the flipped classroom method and those taught through conventional instruction.
3. To assess the impact of the flipped classroom approach on student motivation and engagement in physics lessons.
4. To identify the challenges and advantages experienced by students and the teacher during the implementation of the flipped classroom method.
5. To provide evidence-based recommendations for physics teachers and curriculum developers regarding the use of flipped learning strategies at the secondary level.

Significance of the Study

This study holds significance for several stakeholders within the educational community:

1. For students: The findings may lead to improved learning strategies that enhance understanding of physics, reduce anxiety toward the subject, and promote greater engagement and self-directed learning habits.
2. For teachers: The study provides practical insights into how the flipped classroom can be implemented in secondary physics education, including guidance on content design, classroom management, and student assessment within this model.
3. For school administrators and curriculum designers: The results can inform decisions about adopting technology-enhanced and student-centered instructional approaches within the school curriculum.

4. For researchers: This study contributes to the growing body of literature on flipped learning in STEM education, particularly at the middle school level, offering empirical data from a controlled quasi-experimental setting.
5. For education policy: Evidence from this study may support broader discussions around the integration of digital tools and active learning strategies into national science curricula.

1.4 Research Questions

This study seeks to answer the following research questions:

Does the flipped classroom method significantly improve 8th-grade students' understanding of physics concepts compared to conventional instruction?

How does the flipped classroom method affect student motivation and engagement in physics among 8th-grade learners?

1.5 Limitations of the Study

The following limitations are acknowledged in the design and conduct of this study:

1. Sample size: The study involves 41 eighth-grade students from a single school. The relatively small and non-random sample limits the generalizability of findings to other schools, regions, or student populations.
2. Duration: The intervention is conducted over a 4 week time period, which may not be sufficient to capture long-term effects of the flipped classroom method on physics understanding and student habits.
3. Technology access: The flipped classroom model relies on students having access to digital devices and a stable internet connection at home. Variations in home technology access among students may affect the quality and consistency of pre-class learning.
4. Control of extraneous variables: Despite efforts to control conditions, factors such as students' prior knowledge, home study habits, and parental support may influence learning outcomes beyond the scope of this study.

1.6. Hypothesis

H_1 :

8th-grade students taught physics through the flipped classroom method will demonstrate significantly higher conceptual understanding and academic achievement than students taught through conventional instruction.

H_0 :

There will be no statistically significant difference in physics understanding and academic achievement between 8th-grade students taught through the flipped classroom method and those taught through conventional instruction.

2 Literature Review

This chapter provides a comprehensive overview of the existing literature on the use of the flipped classroom concept in secondary school physics lessons. The review examines the conceptual foundations of the flipped classroom, the theoretical frameworks that underpin its effectiveness, and the role of technology in the implementation of this pedagogical approach. Furthermore, the influence of flipped learning on the performance, motivation and commitment of the students, its connection with problem-oriented learning and its practical implementation in the classroom will be examined. The chapter also explores the question of whether flipped learning actually improves academic performance, and concludes with a discussion about the importance of professional teacher training and the relationship between teacher quality and student performance.

2.1 Concept of the Flipped Classroom

The Flipped Classroom concept is a teaching model that reverses the conventional structure of teaching and learning. In traditional lessons, teachers teach new content during class time and give up homework that students should practice independently. In the Flipped Classroom model, this structure is reversed: students deal with the learning content at home before class – typically with the help of pre-recorded video lectures or digital materials. The teaching time is then used for active, collaborative and application-oriented activities (Bergmann & Sams, 2012).

Jonathan Bergmann and Aaron Sams, two chemistry teachers from Colorado, are considered pioneers of the flipped classroom concept in the mid-2000s. They began recording their lessons so that absent students could catch up on the missed material, and soon realized the broader potential of this approach to transforming face-to-face teaching. Since then, their model has been applied worldwide in a wide variety of educational contexts, subjects and age groups.

The flipped classroom is a student-centered instructional approach that reverses the traditional teaching model. In a conventional classroom, teachers typically deliver lectures during class time and assign practice activities as homework. In contrast, the

flipped classroom requires students to engage with instructional materials, such as videos, readings, or multimedia presentations, before class, while classroom time is devoted to active learning activities, discussions, problem-solving tasks, and collaborative work.

The concept of the flipped classroom emerged from the broader constructivist learning theory, which emphasizes that learners actively construct knowledge through interaction, experience, and reflection. The model gained international recognition through the work of educators Jonathan Bergmann and Aaron Sams, who began recording lectures for students to study outside class and used classroom time for deeper engagement and personalized instruction.

According to Bergmann and Sams (2012), the flipped classroom shifts the focus of learning from teacher-centered instruction to student-centered learning. Students are expected to take greater responsibility for their learning by reviewing content before class, which allows them to participate more actively in classroom activities. The teacher's role changes from being the primary source of knowledge to a facilitator, guide, and mentor who supports students' understanding and application of concepts.

Researchers have described the flipped classroom as an instructional strategy that integrates technology with active learning methodologies. Bishop and Verleger (2013) define the flipped classroom as an educational approach consisting of two key components: interactive group learning activities inside the classroom and direct computer-based instruction delivered outside the classroom. This combination enables students to learn theoretical content at their own pace while maximizing opportunities for interaction and higher-order thinking during class sessions.

The theoretical foundation of the flipped classroom is supported by Bloom's Taxonomy. Lower-order cognitive activities, such as remembering and understanding, are completed before class through instructional videos or readings. Higher-order cognitive processes, including applying, analyzing, evaluating, and creating, occur during classroom activities under the guidance of the teacher. This arrangement allows

students to receive immediate feedback and support when dealing with complex learning tasks.

Several studies have reported positive outcomes associated with flipped classroom implementation. Research indicates that the approach can improve student engagement, academic achievement, critical thinking skills, learner autonomy, and motivation. Students often appreciate the flexibility of accessing learning materials at their own pace and revisiting content whenever necessary. Additionally, teachers gain more time to address individual learning needs and facilitate meaningful classroom interactions.

Despite its advantages, the flipped classroom also presents certain challenges. Successful implementation depends on students' preparation before class, access to technological resources, and teachers' ability to design effective instructional materials. Some researchers have noted that students may initially resist the increased responsibility for independent learning. Furthermore, inadequate internet access and digital literacy can limit the effectiveness of the model, particularly in developing educational contexts.

In the context of higher education, the flipped classroom has become increasingly popular because it supports active learning, collaborative knowledge construction, and the development of 21st-century skills. As educational institutions continue to integrate digital technologies into teaching and learning, the flipped classroom remains an important pedagogical approach for enhancing student participation and improving learning outcomes.

The Flipped Classroom is not just about shifting the content delivery online. Rather, it represents a fundamental rethinking of the use of teaching time. By freeing the classroom time from passive listening, teachers can use this time for more challenging activities such as problem solving, peer discussion, practical experiments and formative assessment. This change is particularly important for physics lessons, as the subject requires not only conceptual understanding, but also the ability to apply

principles to new problems – a competence that is better developed by guided practice than by passive co-writing.

It is important to distinguish the Flipped classroom model from pure online or blended learning. The flipped classroom model is given the central role of the classroom and the teacher; it does not replace personal interaction, but restructures it. Students continue to come to class every day, but they should already be familiar with the new material and be ready to deal with it more intensively (Bishop & Verleger, 2013).

2.2 Theoretical Foundations

The flipped classroom model is based on several established pedagogical theories, which together explain why the inversion of the learning structure can lead to a deeper understanding and better learning outcomes. One of the most frequently cited theoretical justifications for the flipped classroom concept is Bloom's taxonomy of Learning Objectives (Bloom, 1956; Anderson & Krathwohl, 2001). Bloom's revised taxonomy divides cognitive learning into six hierarchical levels: remembering, understanding, applying, analyzing, evaluating and creating. In traditional teaching, the lower levels – remembering and understanding - dominate the lesson time through direct teaching, while higher-level tasks such as application and analysis are processed as homework, where the teacher's support is lacking.

The Flipped Classroom concept reverses this dynamic. The learners work out the basics at home with the help of videos or reading materials and thus independently develop a first understanding. The teaching time is then reserved for higher–level tasks – the application of concepts to problem scenarios, the analysis of experimental results, the evaluation of different explanations - with the teacher present to guide and support the learners. This correspondence between the structure of learning activities and the required cognitive demands is a central theoretical strength of the flipped classroom model (Roehl, Reddy & Shannon, 2013). Constructivist learning theory, associated with the works of Jean Piaget and Lew Wygotski, assumes that learners actively construct knowledge through experience and interaction, rather than passively

absorbing information from an authority figure. Piaget emphasized the role of individual cognitive activity in schema development, while Vygotsky introduced the concept of the zone of proximal development (ZPD) – the area between what a learner can independently achieve and what he can achieve with support.

The flipped classroom model largely corresponds to constructivist principles. By integrating collaborative, problem-solving activities into the classroom, it creates opportunities for learners to develop understanding through interaction with peers and teachers. The role of the teacher changes from a knowledge mediator to a moderator and coach who supports the learners during the face-to-face events in their ZPD. In the context of physics lessons in the 8th grade, this means that students can explore concepts such as strength, movement and energy through practical exercises and discussions with their classmates and thus develop more complex mental models than passive lessons alone would allow. The self-determination theory (SDT) by Deci and Ryan (1985) states that intrinsic motivation is promoted when three basic psychological needs are met: autonomy (the feeling of being able to control one's own learning process on one's own), competence (the feeling of being able and effective) and social involvement (the feeling of belonging and connection with others). Studies consistently show that intrinsically motivated students are more persistent, more committed and achieve better results than those who are primarily motivated by external rewards or fear.

The concept of the Flipped Classroom supports all three of these needs. Autonomy is promoted by the students being able to determine the pace and time of their preparation themselves – they can pause, rewind and re-watch videos as needed. Competence is developed through the guided activities in the classroom, in which the students apply knowledge under the guidance of the teacher before they independently work on problems. Connectedness is promoted by the collaborative nature of flipped classroom sessions, which favor interaction with each other and a shared sense of the learning community (Bhagat, Chang & Chang, 2016).

The flipped classroom approach is grounded in several educational theories that support active learning, learner autonomy, collaboration, and technology-enhanced instruction. As a pedagogical model, it shifts the transmission of basic content outside the classroom through digital resources while utilizing classroom time for interactive and higher-order learning activities. The theoretical foundations of the flipped classroom provide a framework for understanding its effectiveness in contemporary educational settings, including higher education institutions in Kazakhstan.

Constructivist Theory for Kazakhstan. Constructivism serves as one of the principal theoretical foundations of the flipped classroom. According to Piaget (1972), learning is an active process through which individuals construct knowledge based on their experiences and interactions with the environment. In a flipped classroom, students are exposed to instructional content before class and are expected to build preliminary understanding independently. During class sessions, they engage in activities that allow them to apply, analyze, and synthesize knowledge, thereby promoting deeper learning.

The constructivist perspective aligns closely with the educational reforms implemented in Kazakhstan, which emphasize student-centered learning and the development of critical thinking skills. Rather than acting as passive recipients of information, students become active participants in the learning process.

Social Constructivism

The flipped classroom is also supported by Vygotsky's (1978) theory of social constructivism, which emphasizes the importance of social interaction in cognitive development. Vygotsky introduced the concept of the Zone of Proximal Development (ZPD), suggesting that learners can achieve higher levels of understanding through guidance from teachers and collaboration with peers.

In flipped learning environments, classroom time is devoted to discussions, group work, problem-solving activities, and collaborative projects. Such activities provide opportunities for scaffolding and peer-assisted learning. Within the context of Kazakhstan's higher education system, where collaborative learning practices are

increasingly encouraged, social constructivism provides a strong theoretical justification for adopting flipped instructional strategies.

Bloom's Taxonomy. Bloom's Taxonomy offers another important theoretical basis for the flipped classroom model. Bloom (1956) classified cognitive learning objectives into hierarchical levels ranging from remembering and understanding to analyzing, evaluating, and creating. Traditional teaching methods often focus classroom time on lower-order cognitive processes, while higher-order thinking is expected to occur through homework assignments.

The flipped classroom reverses this arrangement. Students acquire foundational knowledge outside class through video lectures, readings, or other digital materials, while classroom activities focus on higher-order cognitive skills. This structure supports Kazakhstan's competency-based educational reforms, which prioritize critical thinking, problem-solving, creativity, and independent learning.

Self-Directed Learning Theory. Knowles' (1975) theory of self-directed learning is particularly relevant to flipped learning. According to this theory, learners should take responsibility for identifying their learning needs, selecting learning strategies, and evaluating learning outcomes. The flipped classroom requires students to engage with educational materials before attending class, thereby fostering independence and self-regulation.

The development of self-directed learning skills is especially important in Kazakhstan's higher education institutions, which aim to prepare graduates for lifelong learning and professional adaptability in a rapidly changing global environment.

Technology-Enhanced Learning. The flipped classroom is closely associated with technology-enhanced learning theories that emphasize the role of digital tools in supporting educational processes. Online videos, learning management systems, interactive platforms, and digital resources facilitate content delivery and learner engagement. The increasing integration of information and communication technologies (ICT) within Kazakhstan's education system has created favorable conditions for implementing flipped learning approaches.

National initiatives promoting digital education and technological innovation have encouraged universities to adopt blended and online learning strategies. As a result, the flipped classroom has become a viable model for supporting educational modernization and improving learning outcomes.

Relevance to the Educational Context of Kazakhstan. The theoretical foundations discussed above demonstrate that the flipped classroom is consistent with the objectives of Kazakhstan's educational reforms. Current policies emphasize student-centered instruction, competency-based learning, digital transformation, and internationalization of higher education. These priorities correspond closely with the principles underlying flipped learning.

Furthermore, the growing availability of digital technologies and online learning resources in Kazakhstan provides opportunities for wider implementation of flipped instructional practices. By encouraging active participation, critical thinking, collaboration, and learner autonomy, the flipped classroom can contribute to improving the quality of higher education and preparing students for the demands of the twenty-first century.

In summary, the flipped classroom is supported by constructivist theory, social constructivism, Bloom's Taxonomy, self-directed learning theory, cognitive load theory, and technology-enhanced learning theory. These theoretical perspectives collectively explain how flipped learning promotes meaningful engagement, deeper understanding, and improved educational outcomes within contemporary higher education settings.

2.3 Role of Technology in Flipped Learning

Technology is the foundation of the Flipped Classroom. Without accessible digital tools, this model cannot function as intended. The most basic technological requirement is the possibility of providing educational content outside the classroom. This usually requires an Internet connection, personal devices (smartphones, tablets or computers) and video platforms such as YouTube, Khan Academy or institutional learning management systems (LMS) such as Google Classroom or Moodle.

Pre-recorded video lectures are the most common medium for providing content outside the classroom in the flipped classroom. Studies suggest that short, concise videos of five to ten minutes are more effective than longer recordings, as they reduce cognitive load and maintain attention (Guo, Kim & Rubin, 2014). Teachers can create their own videos with screen recording software such as OBS Studio, Screencast-O-Matic or Loom or use existing, high-quality content from platforms such as the Khan Academy or PhET Interactive Simulations, which are particularly well suited for physics topics.

In addition to videos, technology also plays a role in checking the progress of learning before classes. Tools such as Google Forms, Quizizz or Edpuzzle allow teachers to embed comprehension questions in videos or assign short quizzes before class. This ensures the comprehensibility of learning outside the classroom and provides teachers with data for understanding the students, on the basis of which the course of the lesson can be adapted accordingly.

In the physics lessons of the 8th grade, technology also opens up access to virtual simulations and interactive demonstrations that would be difficult or expensive to implement at school. For example, PHET simulations (developed by the University of Colorado Boulder) allow students to explore Newton's laws, the behavior of electrical circuits, and wave phenomena in a dynamic, interactive digital environment. Studies have shown that the use of such simulations in physics lessons can significantly improve conceptual understanding, especially in combination with guided research learning tasks (Wieman et al., 2010). However, it is important to note that access to technology is not the same for everyone. Students from socially disadvantaged backgrounds may not have a reliable Internet connection or suitable devices at home. This can affect the effectiveness of the flipped classroom model and exacerbate existing educational inequalities. Teachers implementing the flipped classroom model must take this digital divide into account and develop strategies to ensure that all students have access to the teaching materials, for example by providing downloadable offline resources or by being able to watch videos before or after class at school.

2.4 Impact on motivation

A growing number of empirical studies have investigated the effects of the flipped classroom on student learning outcomes and motivation. The results are mostly positive, but differentiated. With regard to academic performance, several meta-analyses and systematic reviews show that students in the flipped classroom perform better in tests for conceptual understanding and problem-solving skills than students who are taught using conventional methods. Hew and Lo (2018) conducted a meta-analysis of 28 studies and found a statistically significant positive effect of the flipped classroom on the academic performance of students in various disciplines. Also van Alten et al. (2019) analyzed 114 studies and came to the conclusion that the flipped classroom has a small but consistent positive effect on performance, especially in STEM subjects.

Especially in the field of physics, studies report improvements in students' ability to apply principles to new problems – a higher competence that is often not sufficiently promoted in traditional teaching. Lo and Hew (2017) found that secondary school students showed greater conceptual understanding in inverted physics classes compared to control groups. They attributed this to the longer time available in class for guided problem solving.

The research literature is also encouraging in terms of motivation and commitment. Students in inverted classes often report more enjoyment of the learning process, a stronger sense of personal responsibility for their education and a higher perceived relevance of the learning material. The positive effects on motivation are often associated with the higher interactivity and cooperation among students that characterize inverted classes, as well as with the flexibility of self-directed learning before classes (Bergmann & Sams, 2012; Zainuddin & Halili, 2016).

However, not all results are consistently positive. Some studies report that students initially have difficulties with the higher responsibility for self-directed learning caused by the inverted model, especially those who are used to passive learning. Younger students and those with less academic self-regulation may need

additional support and structured assistance to succeed in inverted learning environments. These results underline the importance of a carefully planned implementation that does not just transfer content online, but actively supports students in developing the learning habits required for the new model.

The flipped classroom has attracted considerable attention in educational research because of its potential to improve students' academic performance, engagement, and motivation. By transferring direct instruction outside the classroom and dedicating class time to active learning activities, the flipped classroom creates opportunities for deeper learning and greater student participation. Numerous studies have examined the effects of this instructional approach on various educational outcomes, particularly in higher education.

Student motivation is another area in which the flipped classroom has demonstrated positive effects. Motivation plays a critical role in academic success because it influences students' willingness to engage in learning activities and persist in overcoming challenges.

According to Self-Determination Theory proposed by Deci and Ryan (1985), motivation is enhanced when learners experience autonomy, competence, and relatedness. The flipped classroom supports these psychological needs by allowing students to control the pace of their learning, actively participate in classroom activities, and collaborate with peers.

Studies have shown that students often perceive flipped learning as more engaging than traditional instruction. Gilboy, Heinerichs, and Pazzaglia (2015) reported that students appreciated the flexibility of accessing learning materials before class and valued opportunities for active participation during class sessions. Increased interaction with instructors and peers contributed to greater learning motivation and satisfaction.

Furthermore, active learning strategies commonly used in flipped classrooms, such as discussions, group projects, case studies, and problem-based learning, can increase students' intrinsic motivation. When students are actively involved in

constructing knowledge rather than passively listening to lectures, they are more likely to develop interest in the subject matter and take ownership of their learning.

2.4.1 Impact on Student Learning

Research indicates that the flipped classroom can positively influence student learning outcomes. According to Bergmann and Sams (2012), students in flipped learning environments have more opportunities to apply knowledge, solve problems, and receive immediate feedback from instructors. This active engagement promotes deeper understanding and facilitates knowledge retention compared to traditional lecture-based instruction.

Bishop and Verleger (2013) argue that the flipped classroom combines pre-class content delivery with interactive classroom activities, enabling students to engage in higher-order cognitive processes such as analysis, evaluation, and creation. This structure aligns with Bloom's Taxonomy and supports the development of critical thinking skills.

Similarly, O'Flaherty and Phillips (2015), in their review of flipped classroom research in higher education, found that many studies reported improvements in academic achievement, classroom participation, and student satisfaction. Students often demonstrated better conceptual understanding because they could review instructional materials at their own pace before attending class.

Research conducted by Lo and Hew (2017) further suggests that flipped learning contributes to improved academic performance by encouraging active participation and collaborative problem-solving. Students become more responsible for their learning and develop greater confidence in applying knowledge to practical situations.

2.4.2 Challenges Affecting Learning and Motivation

Despite its benefits, the flipped classroom may present challenges that influence learning outcomes and motivation. Some students may struggle with the increased responsibility for pre-class preparation. If learners do not engage with instructional

materials before class, they may have difficulty participating effectively in classroom activities.

Access to technology also remains an important consideration. Successful implementation of flipped learning depends on reliable internet access, digital resources, and students' technological competence. In educational contexts where technological infrastructure is limited, these factors may reduce the effectiveness of the approach.

Researchers have also noted that students unfamiliar with learner-centered methodologies may initially resist flipped learning because it requires greater independence and self-regulation. Therefore, instructors must provide appropriate guidance and support during the transition to this instructional model.

2.4.3 Implications for Higher Education in Kazakhstan

In Kazakhstan, educational reforms increasingly emphasize student-centered learning, digital competence, critical thinking, and learner autonomy. These priorities correspond closely with the principles of the flipped classroom. As universities continue to integrate digital technologies into teaching and learning, flipped instruction offers opportunities to improve both academic achievement and student motivation.

The growing adoption of online learning platforms and digital educational resources in Kazakhstan creates favorable conditions for implementing flipped learning approaches. By encouraging active engagement, collaborative learning, and independent study, the flipped classroom can contribute to enhancing the quality of higher education and preparing students for lifelong learning in the knowledge-based economy.

In conclusion, the literature suggests that the flipped classroom has a generally positive impact on students' learning and motivation. Through active learning, increased autonomy, and enhanced classroom interaction, the approach supports improved academic performance, higher levels of engagement, and greater motivation. Nevertheless, successful implementation requires careful instructional design, student preparation, and adequate technological support.

2.5 Flipped Classroom and Problem-Based Learning

The flipped classroom model is excellently compatible with problem-oriented learning (PBL), and both approaches are increasingly being combined in educational research and practice. Problem-oriented learning is a teaching method in which learners deal with complex, real problems, instead of first obtaining knowledge and applying it later. They work collaboratively to analyze problems, determine the need for knowledge, research solutions and present their results. They develop subject-specific knowledge as well as transferable skills such as critical thinking, communication skills and teamwork skills (Barrows & Tamblyn, 1980).

The connection between flipped learning and PBL is obvious and effective. In a flipped classroom environment with PBL, learners receive basic content through videos or texts before class. This leaves time for intensive discussion of complex problems that require the application and integration of this content in face-to-face lessons. The teacher acts more as a learning companion than as a lecturer by accompanying the learning processes of the learners and providing targeted support when groups encounter difficulties.

In physics lessons, the combination of flipped classroom and problem-oriented learning (PBL) is particularly suitable for topics that are suitable for research and applications, such as mechanics, energy and electricity. Instead of demonstrating a concept and then setting exercises, a flipped classroom approach with PBL could confront students with a real engineering challenge - for example, the construction of a vehicle with minimal friction losses - and encourage them to draw on the knowledge learned before the lesson to work out a solution during the lesson. This approach not only deepens the conceptual understanding, but also increases the perceived relevance and authenticity of physics learning (Hung, Hwang & Huang, 2012).

Studies on combined flipped classroom PBL models consistently report a high level of student participation and improved performance in transfer tasks – i.e. tasks that require students to apply knowledge in unfamiliar contexts. These findings are particularly relevant for the physics lessons of the 8th grade. A class in which the

development of the ability to explain physical phenomena from basic principles is a central educational goal.

2.6 Purpose of Methods to Teach Physics

The selection of instructional methods in physics education is not merely a matter of pedagogical preference but reflects deeper questions about what physics education is for and what kinds of understanding it aims to produce. Physics is a discipline that encompasses not only a body of factual knowledge — laws, formulae, and constants — but also a set of cognitive practices: forming hypotheses, designing investigations, interpreting data, building explanatory models, and communicating results. Effective physics teaching must therefore address both the content and the practices of the discipline.

Traditional didactic methods, in which the teacher presents content through lecture and demonstration while students take notes and complete structured exercises, have been the dominant approach in secondary physics education for decades. While such methods can efficiently convey factual content and standard problem-solving procedures, they are less effective at developing deeper conceptual understanding, scientific reasoning, and the ability to apply knowledge flexibly to new problems (Hake, 1998). Research consistently shows that students taught through passive methods often harbor persistent misconceptions about physical phenomena even after completing a course.

Active learning methods — including the flipped classroom, inquiry-based learning, collaborative problem-solving, and simulation-based exploration — have been shown to address these limitations more effectively. Hake's landmark study (1998) of over 6,000 students across 62 introductory physics courses found that interactive engagement methods produced learning gains approximately twice as large as traditional lecture-based instruction, as measured by the Force Concept Inventory. These findings have been widely replicated and have provided a strong evidence base for the adoption of active learning strategies in physics teaching at all educational levels, including secondary school.

The purpose of teaching methods in physics education, therefore, should be understood in terms of their ability to produce not only factual recall but genuine conceptual understanding, positive attitudes toward science, and the development of scientific thinking skills that students can apply beyond the classroom. The flipped classroom, by increasing the proportion of class time devoted to active engagement and reducing passive reception, is well aligned with these broader educational goals.

2.7 The Use of the Flipped Classroom Within the Classroom

The successful implementation of the flipped classroom in everyday school life requires careful planning, organization and class management. The model places new demands on teachers and learners, and its success largely depends on the quality of the preparatory materials, the design of teaching activities and the structures that promote personal responsibility and self-regulation of learners.

As far as the preparatory content is concerned, the research recommends that instructional videos should be short (five to ten minutes), clearly set to music and directly linked to the subsequent teaching activities. The videos should focus on core concepts and calculated examples that learners can use in the classroom. The integration of comprehension questions – either in the form of integrated quizzes or a short entrance test at the beginning of the lesson – is generally recommended to encourage learners to deal with the material before class and to give teachers information about their learning status (Bergmann & Sams, 2012).

The lessons in the Flipped Classroom typically follow a structured but flexible format. Many teachers start with a short repetition of the contents before the lesson and deal with common misunderstandings that have crystallized in the entrance test or in the homework check. The majority of the teaching time is then used for joint problem solving, group discussions, practical exercises or project work. The teacher walks through the rooms, observes, asks specific questions and gives individual support to individual students or small groups – a role that differs qualitatively from that of a frontal lecture and is perceived by many teachers as more professionally fulfilling.

For eighth graders, the implementation of the flipped classroom concept requires special empathy for their development needs. At this age, students develop their ability for self-directed learning and may initially find the expectation of independent preparation before class a challenge.

Teachers can support this transition by providing clear, structured instructions for watching the videos that draw students' attention to the core concepts, and by gradually increasing the complexity and openness of the tasks in the classroom as students feel more familiar with the flipped classroom format. The communication and support of the parents is also an important factor for a successful implementation. Parents who understand the logic and the functioning of the flipped classroom model can better support their children in studying at home before class and understand why their children's homework looks different than they might expect.

2.8 Can the Flipped Classroom Method Actually Help Students Learn?

A central question in the literature on the flipped classroom is whether the model actually causes measurable improvements in the learning success of the students or whether the observed advantages are due to other factors such as more teaching time, novelty effects or the enthusiasm of the teachers who introduced the model at an early stage. A critical examination of the research results is therefore necessary.

Most empirical studies support the conclusion that the flipped classroom can lead to significant learning progress, especially in STEM subjects. However, the data situation is not without limitations. Many studies have small samples, short implementation periods and methodological weaknesses, such as the absence of control groups or the use of self-assessments. The publication bias – the tendency of scientific journals to publish studies with positive results - can also overestimate the effectiveness of the model presented in the literature. Despite these limitations, several high-quality studies provide convincing evidence of the effectiveness of the Flipped classroom. The meta-analysis of Hew and Lo (2018), which applied strict inclusion criteria and took into account only studies with control group comparisons, revealed a statistically significant effect strength of 0.19 in favor of the flipped classroom. Although this effect

is small in absolute terms, it corresponds to the effects of other evidence-based pedagogical interventions and represents a significant improvement in learning outcomes.

It is crucial that the effectiveness of the flipped classroom does not occur automatically – it depends on the quality of the implementation. Studies comparing well-designed flipped classrooms with poorly designed ones show significant differences in results. The key factors for positive results include the quality and accessibility of the preparatory materials, the commitment of students to the content outside the classroom, the design of teaching activities to promote critical thinking, and the responsiveness of teachers to the needs of students during the lesson (Abeysekera & Dawson, 2015).

Especially for the physics lessons of the 8th grade, the answer to the question of whether flipped learning works depends on the context. In environments where students have reliable access to technology, teachers are sufficiently trained and supported, and class time is actually used for active and meaningful engagement, the research results strongly suggest that the flipped classroom concept can improve both students' conceptual understanding and attitude to physics. These conditions must be actively created and must not be taken for granted.

2.9 Professional Training and Development

The successful implementation of the Flipped Classroom largely depends on the preparation and continuous further training of the teachers. The transition from the traditional to the flipped classroom model requires teachers to acquire new technical competencies, revise their pedagogical approach, and develop new competencies in curriculum development and lesson design.

From a technical point of view, teachers must be able to create or compile high-quality digital content, use video production tools, manage digital content distribution platforms, and interpret data from online assessment tools to optimize face-to-face teaching. Many teachers, especially those who were trained before the widespread introduction of educational technologies, have not received systematic advanced

training in these areas and may not feel sufficiently equipped to effectively implement the flipped classroom model without targeted advanced training (Fulton, 2012).

In addition to the technical skills, the Flipped classroom requires a fundamental change in pedagogical thinking. Teachers have to give up the role of the primary knowledge mediator and accept that of the learning companion. This requires other skills and sensibilities: the ability to observe and analyze students' thinking, ask productive questions, lead group work and differentiate support in a class with students working on different tasks at the same time.

These are demanding pedagogical competencies, the development of which requires continuous practice and reflection. Advanced training programs to support the implementation of the flipped classroom are most effective if they are designed for the long term, are integrated into everyday teaching and link to specific specialist contexts, rather than being offered as general individual workshops (Darling-Hammond et al., 2017).

Collaborative models – such as professional learning communities in which teachers share resources, develop teaching units together and observe each other in the flipped classroom - have proven to be particularly effective in promoting both the acquisition of new skills and the maintenance of motivation during the challenging transition phase.

As part of this study, the teacher who implemented the flipped classroom concept was prepared accordingly. The preparation included familiarization with video production tools, the study of relevant literature on flipped learning in physics lessons, as well as the development of materials used in the framework of the intervention for the preparation and implementation of the lesson. The effects of teacher preparation on the study results are explained in more detail in the section "Limitations" of chapter 1 and in the subsequent methodological chapter.

2.10 Student Achievement and Teacher Quality

The relationship between teacher quality and student performance is one of the reliable findings of educational research. Decades of studies, including pioneering

works by Hanushek (1992) and Sanders and Rivers (1996), prove that the quality of teaching is by far the most important educational factor for learning success – more influential than class size, school equipment or teaching materials.

A highly qualified teacher can achieve up to three times higher learning progress with the same students over the course of a school year than a less qualified teacher. In this context, teacher quality includes a number of competencies, including specialist knowledge, subject-didactic knowledge (the ability to convey learning content in an understandable way), class leadership, the ability to respond to the needs of students, and the ability to reflect on teaching practice. Shulman's research (1987) introduced the concept of pedagogical content knowledge (PCK) – the specialized integration of subject knowledge and pedagogical knowledge that distinguishes expert teachers from those who only master their specialty – as a particularly important dimension of teacher quality in science teaching.

In physics lessons, the quality of teachers has proved to be especially significant, since the subject is considered difficult, and misconceptions are widespread among students and persist for many school years. Teachers with a solid PCK in physics are better equipped to anticipate common conceptual difficulties, design learning opportunities that address them directly, and use formative assessments to check and respond to students' understanding in real time (Kind, 2009).

The concept of the inverted classroom has the potential to increase the quality of teachers by restructuring the role of the teacher in such a way as to provide a more responsive, individual and high-quality interaction with students. By eliminating the need to give the same lecture repeatedly in front of a passive audience, the flipped classroom model allows teachers to engage more intensively with students - both individually and in small groups. This allows them to offer the targeted and flexible support that distinguishes excellent teaching. In this sense, the Flipped Classroom is not only a teaching tool, but a structural pioneer for higher-quality teaching.

However, this potential can only be exploited if the teacher has the necessary qualities – professional knowledge, pedagogical competence and a willingness to

reflect on one's own practice – in order to effectively use the newly structured teaching time. A flipped classroom in the hands of an insufficiently prepared or insufficiently supported teacher cannot achieve any improvement over conventional teaching, regardless of the quality of the video materials. This underlines the central importance of teacher qualification and professional development for the effectiveness of any didactic innovation, including the flipped classroom.

2.11 Summary and Research Gap

This chapter has reviewed the literature across ten areas relevant to the use of the flipped classroom in 8th-grade physics education. The review has established that the flipped classroom is a theoretically grounded and empirically supported instructional model, with demonstrated potential to improve student achievement, motivation, and engagement in STEM subjects including physics. Its effectiveness is contingent on several factors: the quality of pre-class digital content, the design of in-class active learning activities, the use of technology that is accessible to all students, and the quality and preparation of the implementing teacher.

The literature also reveals significant gaps. While research on the flipped classroom has grown substantially over the past decade, studies focusing specifically on secondary school physics at the 8th-grade level remain limited. Most existing studies have been conducted in higher education or in subjects other than physics, and many suffer from methodological limitations that reduce the confidence with which their findings can be generalized. Furthermore, research in the specific socio-educational context of this study — namely, secondary school physics instruction with a class of 41 eighth-grade students — is largely absent from the published literature.

This study seeks to address these gaps by providing empirical evidence from a quasi-experimental investigation of the flipped classroom method in an 8th-grade physics classroom. By comparing pre- and post-test scores and engagement data between a flipped classroom group and a control group, the study aims to contribute contextualized, methodologically rigorous evidence to the growing literature on

flipped learning in secondary science education. The methodology employed to achieve this is described in detail in Chapter Three.

2.12 Educational Context of Kazakhstan

Kazakhstan's educational system has transformed greatly since the country's independence from the Soviet Union in 1991. Education was highly centralized throughout Soviet rule, a consequence of the state's influence. Ideology drove it too. Following its independence, the government reformed education as it prioritized it, which changed policy and structure (OECD, 2018). At the start, reforms worked to decentralize power, revise curricula, and also establish a national identity for education. The Law on Education (2007) was what provided a legislative framework for modernizing educational standards. Kazakhstan takes part in endeavors like the Bologna Process. Kazakhstan put 12-year schooling models into practice while adopting global standards (OECD, 2014).

The educational system of Kazakhstan has undergone substantial transformation since the country achieved independence in 1991. Researchers have widely discussed the transition from the Soviet educational model toward a more internationally aligned and competency-based system. Educational reforms in Kazakhstan have mainly focused on modernization, internationalization, multilingual education, digitalization, and the improvement of higher education quality.

According to several studies, one of the most significant developments in Kazakhstan's education sector was the country's accession to the Bologna Process in 2010. This reform integrated Kazakhstan into the European Higher Education Area (EHEA) and introduced the three-cycle degree system consisting of bachelor's, master's, and doctoral education. Scholars argue that participation in the Bologna Process increased academic mobility, promoted credit transfer systems, and improved the international recognition of Kazakhstani degrees.

Research by Yergebekov and Temirbekova (2012) emphasizes that globalization strongly influenced higher education reforms in Kazakhstan. The authors note that the country attempted to harmonize its educational policies with European standards while

still facing challenges associated with its Soviet educational legacy. Their study highlights issues such as inconsistent implementation of reforms, insufficient institutional autonomy, and disparities in educational quality.

Similarly, Lodhi and Ilyassova-Schoenfeld examined the impact of the Bologna Process on higher education reforms in Kazakhstan and argued that policy transfer from European educational systems significantly shaped national reforms. Their research suggests that Kazakhstan adopted international educational models to improve competitiveness and global integration, although local adaptation remained necessary due to cultural and institutional differences.

Another major topic in the literature concerns multilingual education. Kazakhstan promotes a trilingual education policy involving Kazakh, Russian, and English languages. Scholars state that this policy aims to strengthen national identity while simultaneously increasing students' global competitiveness. English-medium instruction has become particularly important in higher education and STEM-related disciplines, especially in institutions such as Nazarbayev University. Researchers argue that multilingual education supports internationalization but may also create inequalities between urban and rural students because of differences in language preparation and educational resources.

The literature also highlights the role of digitalization and technological innovation in Kazakhstan's educational development. Following the COVID-19 pandemic, many studies emphasized the growing importance of online learning platforms, digital infrastructure, and information technology in schools and universities. Researchers note that while urban educational institutions adapted relatively quickly to digital learning, rural schools experienced challenges related to internet access, technological equipment, and teacher preparedness.

Nazarbayev Intellectual Schools or NIS and Nazarbayev University were in fact established, thus they introduced approaches that were research-based and revolutionary with English-medium instruction while influencing a broader educational reform across the whole country (OECD, 2018). The national curriculum

has shifted along toward a competency-based approach. It stresses the critical thinking, the inquiry, and also the student-centered learning. These changes aim for educators to move away from rote memorization to analytical as well as practical competencies (OECD, 2014). Reforms that are in STEM education and also particularly in physics have stressed inquiry-based learning, plus integration of ICT tools, plus cross-disciplinary projects. Implementation remains uneven for school resources, teacher preparedness being disparate (Gess-Newsome, 1999).

Since independence, teachers' profession has developed greatly. Content delivery was historically the focus for pedagogical institutes of the Soviet era. They did also place focus upon compliance of an ideological nature. Today, institutions such as Kazakh National Pedagogical University as well as Al-Farabi Kazakh National University play important roles within teacher education. Physics education programs at these institutions include both bachelor's degrees and master's degrees (OECD, 2018). Retraining programs are organized by the Kazakhstan Higher Education Institute plus the National Center for Professional Development “Orleu”. The programs provide certification which is professionally fit to present-day syllabus rules. NIS offers up wide ranging in service training. This training highlights subject-specific strategies and differentiated instruction (Ball & Forzani, 2011). With support derived from the World Bank, Kazakhstan has begun to implement STEM initiatives. These include lab-based instruction that is improved upon, robotics and coding education that is promoted, and STEM female participation that is encouraged (OECD, 2018). Few physics teachers possess specialized training which poses a major challenge. For in-service teachers having general science backgrounds there is often only limited access to a structured subject-specific professional development (Van Driel et al., 1998). Even despite salary increases that happened recently, teaching remains relatively low-paid. Physics graduates find this reduces the profession's attractiveness when they might choose better-paid technical careers (Rice, 2003).

Teachers are greatly strained on account of overcrowded classrooms especially while in urban areas. Without adequate lab support, the effectiveness of hands-on

learning diminishes because physics educators often manage large classes (Desimone, 2009). For many schools especially those in rural areas there is a lack of updated textbooks. Lab equipment plus digital tools are lacking too. For teachers, training that integrates ICT effectively into their instruction may be lacking (Heller et al., 2012). A more modern and more inclusive and more effective system is one supported by Kazakhstan's educational reforms. Physics teachers still face obstacles in academic growth, professional development, together with access to resources. It is important for improving academic achievement and student outcomes in physics education through policy support and targeted investment for addressing these challenges.

3 Research Design and Methodology

3.1 Research Design

This study used a quasi-experimental pre-post-test control group design. Quasi-experimental designs are often used in school-based educational research when a real random assignment of the participants to the various conditions is practically impossible, since the students cannot be distributed to existing classes without significant disruptions to school operations (Creswell, 2014). Since the 41 participants of this study were an established 8. A random assignment was not possible, which is why a quasi-experimental approach was chosen as the most suitable design.

In this context, the 41 students were divided into two groups: an experimental group, which received physics lessons according to the method of inverted teaching, and a control group, which was taught in conventional teacher-centered teaching. Both groups covered the same content of the physics lessons of the 8th grade, were taught by the same teacher and received the same number of lessons over the same four-week period. This controlled structure ensured that any differences in performance in the post-test between the two groups were due to the different teaching method and not to differences in teacher, content or processing time.

The pre-post test design made it possible to measure changes in the students' physical understanding from the beginning to the end of the intervention. By performing equivalent tests before and after the four-week period, the study was able to record the learning progress within the groups and compare the relative performances of the two groups. This design is well-established in intervention research in the field of education and is considered suitable for studies of this type and scale (Cohen, Manion & Morrison, 2018).

3.2 Research Setting and Participants

The study was conducted at a secondary school in Kaskelen, a city situated in the Almaty Region of Kazakhstan. The school provides instruction in accordance with the national secondary education curriculum of Kazakhstan, within which physics is

taught as a compulsory core subject at the 8th-grade level. The school was selected on the basis of convenience: it was accessible to the researcher, willing to participate in the study, and able to accommodate the intervention during the designated period from March 5 to April 5, 2026.

The physics content taught during the intervention was drawn from the standard 8th-grade curriculum and was selected to be appropriate for delivery through both the flipped classroom and conventional instructional formats. Both groups studied the same topics across the four weeks, ensuring content equivalence between conditions.

The study involved 41 eighth-grade students from a single class group at the school in Kaskelen. The participants included both male and female learners, reflecting the typical mixed-gender composition of an 8th-grade classroom in Kazakhstan. Students were of the standard age cohort for Grade 8 in the Kazakhstani school system. No students were excluded from participation on the basis of academic ability or gender, and the sample was treated as representative of a typical 8th-grade physics class.

For the purposes of the study, the 41 students were divided into two groups. The experimental group consisted of 21 students who received instruction through the flipped classroom method. The control group consisted of 20 students who received conventional teacher-led instruction. The allocation of students to groups was arranged by the researcher with the aim of achieving approximate equivalence between the groups in terms of prior physics knowledge, as indicated by performance on the pre-test administered at the start of the study.

Table 1. Summary of Study Participants

Group	Instructional Method	No. of Students	Gender
Experimental group	Flipped classroom	21	Male and female
Control group	Conventional instruction	20	Male and female

Total	—	41	Mixed

3.3 Sampling and Ethical Considerations

The sample was selected using convenience sampling, a non-probability technique in which participants are chosen on the basis of their availability and accessibility to the researcher (Bryman, 2016). The 41 eighth-grade students at the Kaskelen school were selected because the school was willing to participate, the researcher had direct access to the classroom, and the study period aligned with the school's regular academic calendar. Although convenience sampling limits the extent to which findings can be generalized to other populations and contexts, it is a widely accepted approach in small-scale school-based research where random or stratified sampling is not feasible.

A sample of 41 students is considered adequate for a quasi-experimental study of this scope. Prior research on flipped classroom interventions at the secondary level suggests that moderate effect sizes can be expected, and a sample of this size provides sufficient statistical power to detect such differences using an independent samples t-test at a significance level of $p < 0.05$.

The study was designed and conducted in accordance with established principles of educational research ethics, with particular care given to the rights and wellbeing of the participants, who were minors in compulsory secondary education.

Before the study began, formal permission was obtained from the school administration. Written informed consent was sought from the parents or legal guardians of all 41 student participants. The consent documentation explained the purpose of the study, described what participation would involve, confirmed that involvement was entirely voluntary, and assured parents and students that participation or non-participation would have no effect on students' grades or their standing at the school. Students were also informed directly, in age-appropriate language, of their right to withdraw from the study at any time without consequence.

The following ethical principles were upheld throughout the research:

1. Confidentiality: All data collected were treated as strictly confidential. Student names were replaced with numerical codes during data analysis, and no personally identifying information appears in this report.
2. Anonymity: Individual student scores and questionnaire responses were not disclosed to other students, parents, or school staff. Results are reported in aggregate form only.
3. Non-maleficence: The study posed no physical, psychological, or academic risk to participants. Both groups received high-quality physics instruction throughout the four-week period.
4. Beneficence: The experimental group was given the opportunity to engage with an innovative and potentially beneficial instructional approach. The control group continued to receive their standard physics instruction without any disadvantage.
5. Data security: All data were stored securely on a password-protected device and will not be shared with any third party or used for any purpose beyond this dissertation.

3.4 Research Instruments

Two instruments were used to collect data: a physics achievement test administered as both a pre-test and a post-test, and a student motivation and engagement questionnaire administered at the end of the intervention.

The physics achievement test was developed by the researcher in alignment with the 8th-grade curriculum topics covered during the four-week intervention. The test consisted of 20 items spanning three question formats: multiple-choice questions assessing conceptual recall, short-answer questions requiring students to explain physical phenomena in their own words, and structured problem-solving questions requiring the application of physics principles and formulae.

The test was administered on two occasions: as a pre-test on March 5, 2026, to establish each group's baseline level of physics understanding prior to the intervention, and as a post-test on April 5, 2026, to measure learning gains following the four-week period. The same instrument was used on both occasions to allow direct score comparison. Content validity was established through alignment of test items with the official 8th-grade curriculum objectives and review by the subject teacher. Internal consistency reliability was assessed using Cronbach's alpha, yielding a coefficient of 0.78, which is considered acceptable for a classroom-based research instrument (Pallant, 2020).

The present study employed two primary research instruments to collect quantitative data: Physics Achievement Test and Student Motivation and Engagement Questionnaire. These instruments were selected to measure the impact of the flipped classroom approach on students' academic achievement and motivation in physics. The achievement test provided objective data regarding students' learning outcomes, while the questionnaire assessed students' attitudes, motivation, and engagement throughout the instructional intervention.

Physics Achievement Test. The Physics Achievement Test was designed by the researcher to evaluate students' understanding of the physics concepts taught during the intervention period. The test was developed based on the Grade 8 physics curriculum and the specific learning objectives addressed in the instructional unit.

The instrument consisted of 20 questions representing different cognitive levels and learning outcomes. The test included multiple-choice questions, short-answer questions, and structured problem-solving tasks. The multiple-choice questions measured students' recall of factual knowledge and conceptual understanding. The short-answer questions assessed students' ability to explain scientific concepts and interpret physical phenomena. The problem-solving questions required students to apply formulas, analyze situations, and solve numerical physics problems using appropriate scientific reasoning.

The achievement test was administered twice during the study. The first administration served as a pre-test to determine students' prior knowledge and establish baseline equivalence between the experimental and control groups. The second administration served as a post-test to evaluate the effectiveness of the instructional intervention and measure any improvements in learning outcomes.

The total possible score for the achievement test was 100 marks. Each item was assigned a score according to its complexity and cognitive demand. A scoring rubric was developed to ensure consistency in evaluating students' responses, particularly for short-answer and problem-solving questions.

Student Motivation and Engagement Questionnaire

The Student Motivation and Engagement Questionnaire was used to assess students' attitudes and motivational responses toward learning physics through the flipped classroom approach. The questionnaire was administered after the intervention to capture students' perceptions of their learning experiences.

The questionnaire consisted of 25 items organized into four dimensions:

1.Interest in Physics Learning

2.Classroom Engagement

3.Self-Confidence and Self-Efficacy

4.Independent Learning and Responsibility

Students responded to each statement using a five-point Likert scale:

Scale Response

1-Strongly Disagree

2-Disagree

3-Neutral

4-Agree

5-Strongly Agree

Higher scores indicated higher levels of motivation and engagement.

Sample Questionnaire Items:

Interest in Physics

I enjoy learning physics concepts.

Physics lessons are interesting and enjoyable.

Classroom Engagement

I actively participated in classroom discussions.

I contributed ideas during group activities.

Self-Confidence

I feel confident when solving physics problems.

I can understand difficult physics concepts.

Independent Learning

I completed the assigned learning materials before class.

I took responsibility for my own learning.

The questionnaire was adapted from previous studies on student motivation and engagement and modified to suit the context of physics education and the flipped classroom model.

Validity of the Instruments, validity refers to the extent to which an instrument measures what it is intended to measure. To establish content validity, both instruments were reviewed by a panel of experts consisting of physics educators, curriculum specialists, and educational researchers. The experts evaluated the relevance, clarity, accuracy, and appropriateness of each item in relation to the research objectives and curriculum standards.

Based on the experts' recommendations, several items were revised to improve wording, eliminate ambiguity, and ensure alignment with the intended learning outcomes.

Reliability of the Instruments. A pilot study was conducted prior to the main data collection process to determine the reliability of the research instruments. The pilot participants were students from a school with characteristics similar to those of the target population but who did not participate in the main study.

The internal consistency of the Student Motivation and Engagement Questionnaire was calculated using Cronbach's Alpha coefficient. A reliability

coefficient of 0.70 or higher was considered acceptable. Similarly, the achievement test was examined for reliability using appropriate statistical procedures to ensure consistency in measuring students' performance.

The pilot testing process enabled the researcher to identify problematic items and make necessary revisions before administering the instruments in the main study.

Administration of the Instruments

The pre-test was administered to both the experimental and control groups before the commencement of the intervention. Following four weeks of instruction, the post-test was administered to assess students' learning achievement. The motivation and engagement questionnaire was distributed immediately after the intervention period to gather students' perceptions of their learning experiences.

The use of multiple instruments allowed for comprehensive data collection and provided a more complete understanding of the effects of the flipped classroom method on students' academic achievement and motivation in physics.

Student Motivation and Engagement Questionnaire. A 30-item questionnaire was administered to all 41 participants on April 5, 2026, following the post-test. The instrument was adapted from validated questionnaires used in prior flipped classroom research (Zainuddin & Halili, 2016) and used a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The questionnaire addressed three dimensions: motivation (interest and enjoyment in learning physics), autonomy (sense of control over one's own learning), and perceived effectiveness (students' own judgement of whether the instructional approach helped them understand physics). Items were written at a level appropriate for 8th-grade students and were piloted with a small group before the main administration to confirm clarity.

3.5 Intervention and Teaching Procedure

The intervention ran from March 5 to April 5, 2026. During this period, both the experimental and control groups received physics lessons on the same topics from the same teacher. The difference between the two groups lay entirely in the instructional method applied.

Students in the experimental group (n = 21) followed a structured flipped classroom programme. Before each lesson, students were assigned short instructional videos of five to eight minutes in duration, prepared by the teacher and shared via a digital platform accessible on students' devices. Students were required to watch the videos and complete a brief viewing guide or short comprehension quiz before attending class, creating accountability for pre-class engagement and allowing the teacher to identify areas of difficulty in advance.

During in-class sessions, all available time was devoted to active learning. Activities included guided problem-solving, peer discussion of physics concepts, small-group collaborative exercises, and targeted teacher-led clarification of difficulties identified through the pre-class quizzes. The teacher's role during class was that of a facilitator and coach: circulating among students, asking probing questions, and providing differentiated support to individuals and groups. Approximately 70% of class time was student-led, with the remaining 30% used for structured review and feedback.

Students in the control group (n = 20) received physics instruction using the school's standard conventional approach. Each lesson followed a traditional format: the teacher introduced new content through direct instruction and board-based explanation, demonstrated worked examples, and assigned structured practice exercises for completion in class or as homework. Students in the control group did not receive pre-class video materials and did not engage in the collaborative in-class activities used with the experimental group.

Both groups attended the same number of physics lessons per week and studied identical curriculum content throughout the four weeks. This equivalence was essential to ensure that post-test differences between the groups reflected the effect of the instructional method rather than differences in exposure to content.

Table 2. Comparison of Instructional Procedures

Feature	Experimental group (flipped)	Control group (conventional)
Pre-class activity	Instructional video + quiz/guide	None assigned
In-class activity	Problem-solving, peer discussion, group tasks	Teacher lecture, worked examples, exercises
Teacher role	Facilitator and coach	Instructor and knowledge transmitter
Student role	Active, collaborative, self-directed	Receptive, note-taking, exercise completion
Content covered	Identical 8th-grade physics curriculum	Identical 8th-grade physics curriculum

3.6 Data Collection Procedure

Data were collected at three points across the study period, as summarized in Table 3 below.

Table 3. Data Collection Timeline

Date	Activity	Purpose
5 March 2026	Physics pre-test	Establish baseline understanding in both groups
5 March – 4 April 2026	Four-week instructional intervention	Deliver flipped (experimental) and conventional (control) instruction
5 April 2026	Physics post-test	Measure learning gains after the intervention
5 April 2026	Motivation and engagement questionnaire	Assess student attitudes toward their instructional experience

Both the pre-test and post-test were administered during regular class periods under standard conditions, with all students completing the assessment individually. The motivation questionnaire was distributed to all 41 students immediately following the post-test on April 5, 2026. Students were reminded that responses were anonymous, that results would not affect their grades, and that they should answer as honestly as possible.

3.7 Data Analysis

The data collected from the Physics Achievement Test and the Student Motivation and Engagement Questionnaire were analyzed using both descriptive and inferential statistical methods. Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software.

Analysis of Physics Achievement Test Scores

The scores obtained from the pre-test and post-test were analyzed to determine the effect of the flipped classroom method on students' academic achievement in physics.

Descriptive statistics, including mean scores, standard deviations, frequencies, and percentages, were calculated to summarize students' performance in both the experimental and control groups.

To determine whether there were significant differences in students' achievement, an independent samples t-test was used to compare the post-test scores of the experimental and control groups. In addition, a paired samples t-test was conducted to compare pre-test and post-test scores within each group. These analyses helped determine whether students demonstrated significant improvement after the intervention.

The significance level for all statistical tests was set at $p < 0.05$.

Analysis of Student Motivation and Engagement Data

Responses from the Student Motivation and Engagement Questionnaire were coded and entered into SPSS for analysis. Each response on the five-point Likert scale

was assigned a numerical value ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Descriptive statistics, including means and standard deviations, were calculated for each questionnaire item and for each motivation dimension. The overall motivation score for each participant was also computed.

To determine whether there were significant differences in motivation levels between groups, an independent samples t-test was performed. The results were used to assess the impact of the flipped classroom approach on students' motivation and engagement in physics learning.

Prior to conducting inferential statistical analyses, the data were examined to ensure compliance with the assumptions of parametric tests.

The Shapiro-Wilk test was used to determine whether the data were normally distributed. A significance value greater than 0.05 indicated that the assumption of normality was met.

Levene's Test for Equality of Variances was performed to assess whether the variances of the two groups were equal. A significance value greater than 0.05 indicated homogeneity of variance.

Effect Size Analysis in addition to statistical significance testing, effect size was calculated using Cohen's d to determine the magnitude of the differences between groups. Effect sizes were interpreted according to Cohen's (1988) guidelines:

Cohen's d Interpretation:0.20 Small effect, 0.50 Medium effect, 0.80 or above Large effect

The calculation of effect size provided additional information regarding the practical significance of the flipped classroom intervention.

Decision Rule for Hypothesis Testing. The study tested the following hypotheses:

H_0: There is no significant difference in students' physics achievement and motivation between those taught using the flipped classroom method and those taught using traditional instruction.

H_1: There is a significant difference in students' physics achievement and motivation between those taught using the flipped classroom method and those taught using traditional instruction.

The null hypothesis was rejected when the p-value was less than 0.05 and accepted when the p-value was greater than 0.05.

Data from the physics achievement test and the motivation questionnaire were analysed using both descriptive and inferential statistical methods. All analyses were performed using ANOVA and t-test.

Descriptive statistics were calculated for the pre-test and post-test scores of both the experimental and control groups. These included the mean, standard deviation, minimum, and maximum for each group at each time point, as well as the mean learning gain — the difference between each group's post-test and pre-test means. Descriptive statistics provided an initial picture of the distribution and central tendency of the data and enabled a preliminary comparison of the two groups' performance before inferential testing.

An independent samples t-test was conducted to determine whether the difference in post-test scores between the experimental and control groups was statistically significant. This test is appropriate for comparing the means of two independent groups on a continuous variable and assumes approximate normality of the data — an assumption verified using the Shapiro-Wilk test prior to analysis (Pallant, 2020).

The null hypothesis (H_0) stated that there would be no statistically significant difference in post-test physics scores between the experimental and control groups. The alternative hypothesis (H_1) stated that the experimental (flipped classroom) group would achieve significantly higher post-test scores. A significance level of $p < 0.05$ was applied, consistent with standard practice in educational research.

Cohen's d was also calculated as a measure of effect size, indicating the practical magnitude of any observed group difference. Effect sizes were interpreted using Cohen's (1988) conventions: small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$).

Responses to the motivation and engagement questionnaire were analysed using descriptive statistics, with mean scores calculated for each item and for each of the three subscales (motivation, autonomy, and perceived effectiveness). Where appropriate, independent samples t-tests were applied to subscale scores to test for statistically significant differences between the experimental and control groups' reported experiences.

3.8 Validity and Reliability

Several measures were taken to strengthen the internal and external validity of the study and to ensure the reliability of the instruments used.

Internal validity — the degree to which outcomes can be attributed to the intervention rather than to confounding factors — was supported by the use of a control group, the administration of a pre-test to control for pre-existing differences in physics knowledge, and the use of the same teacher and identical curriculum content for both groups. Potential threats such as the Hawthorne effect, where students perform better simply because they are aware of being observed, were acknowledged as unavoidable limitations of a naturalistic school-based study.

External validity — the extent to which findings can be generalized — is limited by the use of a convenience sample of 41 students from a single school in Kaskelen. Findings should therefore be interpreted as context-specific and not assumed to apply universally. The detailed description of the study provided in this chapter is intended to support readers in assessing the transferability of the findings to similar educational contexts.

The reliability of the physics achievement test was confirmed through a Cronbach's alpha coefficient of 0.78, indicating acceptable internal consistency. The motivation questionnaire was adapted from a previously validated instrument and piloted before use, further supporting its reliability in this context.

3.9 Summary

This chapter has described the research design and methodology of a quasi-experimental study examining the effect of the flipped classroom method on 8th-grade students' physics understanding. The study was conducted at a high school in Kaskelen, Kazakhstan, from March 5 to April 5, 2026, with 41 eighth-grade students — 21 in the experimental (flipped classroom) group and 20 in the control (conventional instruction) group. Data were collected using a 20-item physics achievement test administered as a pre-test and post-test, and a 15-item student motivation and engagement questionnaire. Statistical analysis involved descriptive statistics, independent samples t-tests, and Cohen's d effect size calculations. The results of these analyses are presented in Chapter Four, and their implications are discussed in Chapter Five.

4 Results

4.1 Description of Participants

The study involved 41 eighth-grade students from a single class group at a secondary school in Kaskelen, Almaty Region, Kazakhstan. All students were enrolled in the standard 8th-grade physics course. The sample comprised 25 male students (61.0%) and 16 female students (39.0%), reflecting the gender composition of the class group as constituted at the school.

The 41 students were divided into two groups for the purpose of the study. The experimental group consisted of 21 students — 13 males and 8 females — who received physics instruction through the flipped classroom method over the four-week intervention period. The control group consisted of 20 students — 12 males and 8 females — who received physics instruction through the school's conventional teacher-led approach over the same period. Table 4.1 below summarises the demographic composition of both groups.

Table 4. Demographic Composition of Study Participants

Group	Total (n)	Male (n)	Female (n)	% of Sample
Experimental group	21	13	8	51.2%
Control group	20	12	8	48.8%
Total	41	25	16	100%

Pre-test scores collected on March 5, 2026 confirmed that the two groups were broadly comparable in their baseline physics knowledge. The experimental group recorded a mean pre-test score of 52.52 (SD = 7.30) and the control group recorded a mean of 49.15 (SD = 9.34). An independent samples t-test confirmed that this difference was not statistically significant ($t(36) = 1.284$, $p > 0.05$), indicating that both groups began the study at equivalent levels of physics understanding.

4.2 Data Analysis Strategies

The data collected in this study were analysed using both descriptive and inferential statistical techniques. The following strategies were employed:

1. Descriptive statistics: Means, standard deviations, minimum and maximum scores, and mean learning gains were calculated for both groups at pre-test and post-test to provide an overview of performance and change over the intervention period.

2. Independent samples t-test: Used to determine whether the difference in post-test scores between the experimental and control groups was statistically significant. The significance threshold was set at $p < 0.05$.

3. Paired samples t-test: Used to assess within-group learning gains by comparing each group's pre-test and post-test means, determining whether each group's improvement from March 5 to April 5 was statistically significant.

4. One-way ANOVA: Used to compare post-test scores across four sub-groups defined by group membership (experimental/control) and gender (male/female), testing whether any differences in outcomes were associated with gender.

5. Questionnaire analysis: Descriptive statistics and independent samples t-tests were used to analyse student motivation and engagement questionnaire responses across the three subscales.

Before conducting inferential tests, the normality of the score distributions was verified using the Shapiro-Wilk test. Results indicated that scores in both groups approximated a normal distribution at both time points (all $p > 0.05$), supporting the use of parametric statistical tests.

4.3 Descriptive Statistics

Table 4.1 presents the descriptive statistics for the pre-test and post-test scores of both the experimental and control groups, collected on March 5, 2026 and April 5, 2026 respectively.

Table 4.1. Descriptive Statistics for Pre-Test and Post-Test Scores by Group

Group / Test	n	Mean	SD	Min	Max	Mean Gain
Experimental — Pre-test	21	52.52	7.30	42	68	—
Experimental — Post-test	21	75.90	8.65	64	97	23.38
Control — Pre-test	20	49.15	9.34	39	67	—
Control — Post-test	20	60.10	9.54	46	79	10.95

Note: table 4.1 presents the descriptive statistics for the pre-test and post-test scores of students in the experimental and control groups.

The pre-test results indicate that the experimental group (M = 52.52, SD = 7.30) and the control group (M = 49.15, SD = 9.34) had relatively similar levels of prior knowledge before the intervention. The difference in mean scores between the two groups was small (3.37 points), suggesting that the groups were reasonably comparable at the beginning of the study.

Following the intervention, both groups demonstrated improvement in their physics achievement. However, the experimental group, which received instruction through the flipped classroom approach, showed a substantially greater increase in performance than the control group.

The post-test mean score of the experimental group increased from 52.52 to 75.90, representing a mean gain of 23.38 points. In contrast, the control group improved from 49.15 to 60.10, resulting in a mean gain of 10.95 points. The difference in gain scores suggests that students exposed to the flipped classroom method achieved greater learning progress than those taught using traditional instructional methods.

The maximum score in the experimental group increased from 68 in the pre-test to 97 in the post-test, while the minimum score increased from 42 to 64. Similarly, the control group demonstrated improvement, with scores ranging from 39–67 in the pre-test and 46–79 in the post-test. Nevertheless, the experimental group achieved higher overall post-test performance.

The standard deviation of the experimental group increased slightly from 7.30 to 8.65, while the control group's standard deviation increased from 9.34 to 9.54. These results indicate that although variation among students remained present, the overall improvement in achievement was considerably greater among students who participated in the flipped classroom intervention.

Overall, the descriptive statistics provide preliminary evidence that the flipped classroom approach had a positive effect on students' physics achievement. Students in the experimental group demonstrated higher post-test scores and larger learning gains compared to students in the control group. Further inferential statistical analysis using t-tests was conducted to determine whether these differences were statistically significant.

The results in Table 4.2 reveal that both groups began the study with comparable pre-test means — 52.52 for the experimental group and 49.15 for the control group — confirming the equivalence of baseline knowledge established in Section 4.2. Following the four-week intervention, the experimental group's mean post-test score rose to 75.90 (SD = 8.65), representing a mean learning gain of 23.38 points. The control group's mean post-test score increased to 60.10 (SD = 9.54), representing a mean gain of 10.95 points. The experimental group's mean learning gain (23.38 points) was more than double that of the control group (10.95 points), indicating a substantially larger improvement in physics understanding among students who received flipped classroom instruction.

4.4 Independent Samples T-Test: Post-Test Score Comparison

An independent samples t-test was conducted to determine whether the difference in mean post-test scores between the experimental group (M = 75.90, SD =

8.65) and the control group (M = 60.10, SD = 9.54) was statistically significant. The null hypothesis (H_0) stated that there would be no significant difference in post-test scores between the two groups.

Table 4.2. Independent Samples T-Test: Post-Test Scores (Experimental vs Control)

Group	n	Mean	SD	SE	t	df
Experimental group	21	75.90	8.65	—	5.547	38
Control group	20	60.10	9.54	2.849		

Note: $t(38) = 5.547$, $p < 0.001$ (two-tailed). The significance level was set at $p < 0.05$.

An independent samples t-test was conducted to determine whether there was a significant difference in physics achievement between students taught using the flipped classroom method and those taught using the traditional teaching method.

The results presented in Table 4.2 show that the experimental group (n = 21) obtained a higher mean post-test score (M = 75.90, SD = 8.65) than the control group (n = 20), which achieved a mean score of 60.10 (SD = 9.54). The difference in mean scores between the two groups was 15.80 points in favor of the experimental group.

The independent samples t-test revealed a t-value of 5.547 with 38 degrees of freedom (df = 38). This result indicates a substantial difference between the achievement levels of the two groups following the intervention.

The findings suggest that students who learned through the flipped classroom approach performed significantly better than those who received traditional instruction. The higher mean score achieved by the experimental group provides

evidence that the flipped classroom method contributed positively to students' understanding of physics concepts and problem-solving abilities.

Therefore, the results support the hypothesis that the flipped classroom approach has a positive effect on students' academic achievement in physics. Students exposed to pre-class learning materials and in-class active learning activities demonstrated greater improvement than students taught through conventional lecture-based instruction.

Based on these findings, the null hypothesis (H_0), which states that there is no significant difference in physics achievement between students taught using the flipped classroom method and those taught using traditional instruction, was rejected. The alternative hypothesis (H_1) was accepted, indicating that the flipped classroom method significantly improved students' physics achievement.

The independent samples t-test yielded a t-value of 5.547 with 38 degrees of freedom. This result is statistically significant at $p < 0.001$, well below the predetermined threshold of $p < 0.05$. The null hypothesis is therefore rejected: students in the flipped classroom group achieved significantly higher post-test scores than students in the control group following the four-week intervention from March 5 to April 5, 2026.

Cohen's d was calculated as an effect size measure. The pooled standard deviation was used, yielding $d = 1.74$. According to Cohen's (1988) conventions, this constitutes a large effect, indicating that the difference in post-test performance between the experimental and control groups is not only statistically significant but also practically meaningful. Students in the flipped classroom group scored, on average, approximately 15.80 percentage points higher than the control group on the post-test.

4.5 One-Way ANOVA: Post-Test Scores by Group and Gender

A one-way Analysis of Variance (ANOVA) was conducted to examine whether post-test scores differed significantly across four sub-groups defined by group membership and gender: Experimental-Male ($n = 13$), Experimental-Female ($n = 8$),

Control-Male (n = 12), and Control-Female (n = 8). This analysis was designed to explore whether the effectiveness of the flipped classroom method varied by gender, and whether any gender-based differences in achievement were present within or between the instructional groups.

Table 4.3. Descriptive Statistics by Group and Gender (Post-Test)

Sub-group	n	Mean	SD	Min	Max
Experimental — Male	13	76.00	8.09	64	93
Experimental — Female	8	75.75	10.08	66	97
Control — Male	12	56.25	8.29	46	76
Control — Female	8	65.88	8.69	55	79

Table 4.4. One-Way ANOVA Summary Table (Post-Test Scores)

Source	SS	df	MS	F	Sig.
Between groups	3003.81	3	1001.27	13.31	< .001
Within groups	2782.63	37	75.21		
Total	5786.44	40			

The one-way ANOVA a statistically significant result, $F(3, 37) = 13.31$, $p < 0.001$. This indicates that post-test scores differed significantly across at least two of the four sub-groups. Inspection of the sub-group means in Table 4.5 reveals that the two experimental sub-groups (male and female) both outperformed their respective control sub-groups, with the Experimental-Female sub-group recording the highest mean post-test score (75.75) and the Control-Male sub-group recording the lowest (56.25).

A one-way analysis of variance (ANOVA) was conducted to examine differences in post-test physics achievement among the four sub-groups: Experimental-Male, Experimental-Female, Control-Male, and Control-Female. The results revealed a statistically significant effect, $F(3, 37) = 13.31$, $p < .001$, indicating that significant differences existed among the sub-groups in terms of post-test achievement scores.

An examination of the group means presented in Table 4.5 showed that students in the experimental condition achieved substantially higher post-test scores than students in the control condition regardless of gender. Among all sub-groups, the Experimental-Female group obtained the highest mean score ($M = 75.75$), followed closely by the Experimental-Male group ($M = 76.00$). In contrast, the Control-Male group recorded the lowest mean score ($M = 56.25$), while the Control-Female group achieved a mean score of 65.88.

The relatively small difference between male and female students within the experimental group suggests that the flipped classroom approach benefited both genders in a similar manner. Male students in the experimental group achieved a mean score of 76.00, while female students achieved a mean score of 75.75, indicating nearly identical levels of academic performance following the intervention. This finding suggests that the effectiveness of the flipped classroom method was not dependent on gender.

Within the control group, female students outperformed male students, achieving a mean score of 65.88 compared to 56.25. Although a gender-related difference was observed within the traditional instruction condition, the magnitude of this difference was considerably smaller than the overall difference between the experimental and control groups.

Overall, the findings indicate that the instructional method exerted a stronger influence on students' physics achievement than gender. Students who participated in the flipped classroom intervention consistently achieved higher post-test scores than their counterparts in the traditional classroom, regardless of gender. Therefore, the results suggest that the flipped classroom approach was effective in enhancing students'

academic performance and that its benefits were distributed relatively equally among male and female learners.Within the experimental group, the difference between males (M = 76.00) and females (M = 75.75) was modest, suggesting that the benefits of the flipped classroom method were distributed relatively equitably across genders. Within the control group, female students (M = 65.88) outperformed male students (M = 56.25), though this difference was smaller in magnitude than the between-method differences observed. These findings suggest that instructional method was the primary driver of achievement differences, with gender playing a secondary and less consistent role.

4.6 Paired Samples T-Test: Within-Group Learning Gains

Paired samples t-tests were conducted separately for the experimental and control groups to determine whether each group's improvement from the pre-test (March 5, 2026) to the post-test (April 5, 2026) was statistically significant. These tests assess the significance of within-group change, complementing the between-group comparison reported in Section 4.5.

Table 4.5. Paired Samples T-Test: Within-Group Pre- to Post-Test Gains

Group	n	Mean Gain	SD Gain	SE	t	df
Experimental (Flipped)	21	23.38	3.87	0.84	27.713	20
Control (Conventional)	20	10.95	3.15	0.71	15.529	19

Note: Both t-values are significant at $p < 0.001$ (two-tailed). $df = n - 1$.

Both groups showed statistically significant improvement from pre-test to post-test. For the experimental group, the paired t-test yielded $t(20) = 27.713$, $p < 0.001$, indicating that the mean gain of 23.38 points achieved by flipped classroom students

between March 5 and April 5, 2026 was highly significant and cannot be attributed to chance. For the control group, $t(19) = 15.529$, $p < 0.001$, confirming that the conventional instruction group also made a statistically significant improvement of 10.95 points over the same period.

To determine whether students' physics achievement improved significantly within each group over the course of the intervention, paired samples t-tests were conducted comparing pre-test and post-test scores for both the experimental and control groups.

The results indicated that both groups demonstrated statistically significant improvements in physics achievement from pre-test to post-test. For the experimental group, which received instruction through the flipped classroom method, the paired samples t-test revealed a highly significant increase in scores, $t(20) = 27.713$, $p < .001$. The mean score increased from 52.52 on the pre-test to 75.90 on the post-test, representing a mean gain of 23.38 points. This substantial improvement suggests that the flipped classroom intervention had a strong positive effect on students' understanding of physics concepts and their ability to apply scientific knowledge to problem-solving tasks.

Similarly, the control group, which received conventional instruction, also demonstrated significant improvement between the pre-test and post-test, $t(19) = 15.529$, $p < .001$. The mean score increased from 49.15 to 60.10, resulting in a mean gain of 10.95 points. This finding indicates that traditional instruction contributed to students' learning progress during the study period.

However, a comparison of the gain scores reveals that the improvement observed in the experimental group was considerably greater than that of the control group. The experimental group achieved a gain of 23.38 points, whereas the control group achieved a gain of 10.95 points, resulting in a difference of 12.43 points. This suggests that students exposed to the flipped classroom method experienced more substantial learning gains than those taught through conventional instructional approaches.

The larger t-value obtained for the experimental group further reflects the strength of the improvement associated with the flipped classroom intervention. These findings provide strong evidence that the flipped classroom approach was more effective than traditional instruction in enhancing students' physics achievement.

Overall, the paired samples t-test results support the conclusion that both instructional methods contributed to student learning; however, the flipped classroom method produced significantly greater improvements in academic performance. Therefore, the findings support the study's hypothesis that the flipped classroom approach positively influences students' learning outcomes in physics.

Crucially, however, the experimental group's mean gain (23.38 points) was more than twice as large as the control group's mean gain (10.95 points). This difference in the magnitude of learning gains — confirmed as statistically significant by the independent samples t-test in Section 4.5 — provides strong evidence that the flipped classroom method produced substantially greater improvements in physics understanding than conventional instruction over the four-week intervention period.

4.7 Student Motivation and Engagement Questionnaire Results

The student motivation and engagement questionnaire was administered to all 41 participants on April 5, 2026. The instrument comprised 15 items rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree), organized into three subscales: Motivation, Autonomy, and Perceived Effectiveness. Table 4.8 presents mean subscale scores for the experimental and control groups.

Table 4.6. Mean Questionnaire Subscale Scores by Group

Subscale	Exp. Mean	Ctrl. Mean	Difference	Interpretation
Motivation (5 items)	4.45	3.19	1.26	Large
Autonomy (3 items)	4.46	3.15	1.31	Large

Perceived Effectiveness (7 items)	4.48	3.16	1.32	Large
Overall mean (all 15 items)	4.46	3.17		

Students in the experimental group reported substantially higher scores across all three subscales compared to students in the control group. The largest gap was observed on the Motivation subscale, where the experimental group mean (4.45) exceeded the control group mean (3.19) by 1.26 points. Similarly, experimental group students reported notably higher Autonomy (4.46 vs 3.15) and Perceived Effectiveness (4.48 vs 3.16) compared to the control group.

These findings indicate that students who received flipped classroom instruction not only achieved higher scores on the physics post-test but also reported a more positive and motivating learning experience. The high Autonomy scores among experimental group students suggest that the ability to control the pace and timing of pre-class video learning was perceived positively, supporting the theoretical prediction from Self-Determination Theory that autonomous learning conditions foster greater motivation and engagement. The high Perceived Effectiveness scores suggest that experimental group students recognized and appreciated the impact of the flipped approach on their own understanding of physics.

4.8 Summary of Results

This chapter has presented the quantitative results of the study investigating the effect of the flipped classroom method on 8th-grade physics understanding at a school in Kaskelen, Kazakhstan. The key findings, based on data collected between March 5 and April 5, 2026 from 41 students (25 male, 16 female), are summarised as follows:

- Pre-test equivalence: Both groups began the study with statistically equivalent physics knowledge (Exp: $M = 52.52$; Ctrl: $M = 49.15$; $p > 0.05$).

- Post-test difference: The experimental group achieved a significantly higher post-test mean (75.90) than the control group (60.10), $t(38) = 5.547$, $p < 0.001$.
- Effect size: Cohen's $d = 1.74$ indicates a large practical effect, confirming the educational significance of the observed difference.
- Learning gains: The experimental group gained an average of 23.38 points compared to 10.95 points for the control group — a difference of 12.43 points.
- ANOVA: Significant differences across the four gender-by-group sub-groups were confirmed, $F(3, 37) = 13.31$, $p < 0.001$, with instructional method identified as the primary source of variation.
- Motivation and engagement: Experimental group students reported substantially higher motivation, autonomy, and perceived effectiveness than control group students across all questionnaire subscales.

Together, these results provide strong quantitative evidence in support of the alternative hypothesis (H_1): the flipped classroom method significantly improved 8th-grade students' physics understanding compared to conventional instruction over the four-week intervention period from March 5 to April 5, 2026.

5 Discussion

5.1 Motivating Aspects of the Flipped Classroom in the context of Kazakhstan

One of the most striking results of this study was the marked difference in student motivation and engagement between the experimental and control groups, as measured by the post-intervention questionnaire. The students in the flipped classroom group achieved an average motivation score of 4.52 out of a possible 5 points, compared to 3.21 in the control group – a difference of 1.31 points on a five-point scale. This result is especially significant in the context of Kazakh secondary education, where physics is traditionally considered one of the most demanding and unpopular subjects of middle school.

Student motivation is a critical factor influencing academic achievement and engagement in physics education. The flipped classroom approach has gained attention as a pedagogical model capable of enhancing both intrinsic and extrinsic motivation by shifting students from passive recipients of information to active participants in the learning process. In the context of Kazakhstan's ongoing educational reforms, which emphasize learner-centered instruction, critical thinking, and digital competence, the flipped classroom presents several motivational advantages.

First, the flipped classroom promotes learner autonomy. By providing instructional materials before class, students are given greater control over the pace, time, and place of learning. According to self-determination theory, autonomy is a fundamental psychological need that contributes to increased intrinsic motivation. In Kazakhstan, where traditional teacher-centered practices remain common in many educational settings, the flipped model can encourage students to assume greater responsibility for their own learning.

Second, the approach enhances classroom engagement through active learning activities. Rather than using class time primarily for lectures, teachers can facilitate problem-solving exercises, laboratory experiments, collaborative discussions, and inquiry-based tasks. Such activities are particularly important in physics education,

where conceptual understanding develops through active application of knowledge. Increased participation and interaction can foster students' interest and motivation to learn.

Third, the flipped classroom supports differentiated learning. Students possess varying levels of prior knowledge, learning preferences, and language proficiency. Access to recorded lectures and digital resources allows learners to review content multiple times and at their own pace. This flexibility can reduce cognitive overload and learning anxiety, thereby increasing students' confidence and willingness to engage with challenging physics concepts.

Another motivating aspect is the integration of digital technologies. Kazakhstan has made substantial investments in educational digitalization, including the expansion of online learning platforms and digital resources. The use of multimedia materials, interactive simulations, and online assessments can increase students' interest in learning and contribute to a more dynamic educational experience. For contemporary learners who are accustomed to digital environments, technology-enhanced instruction may increase motivation and engagement.

Furthermore, the flipped classroom facilitates more meaningful teacher–student interaction. As direct instruction is moved outside the classroom, teachers can devote more time to providing individualized support, monitoring student progress, and addressing misconceptions. Personalized feedback has been shown to strengthen students' self-efficacy and motivation, particularly in complex subjects such as physics.

The approach is also consistent with the goals of educational modernization in Kazakhstan, which emphasize the development of twenty-first-century competencies, including critical thinking, communication, collaboration, and digital literacy. Students may demonstrate higher levels of motivation when learning activities are perceived as relevant to future academic and professional success.

Despite these advantages, several factors may limit the motivational impact of the flipped classroom. These include unequal access to digital technologies, differences in students' self-regulation skills, and the need for adequate teacher training. Therefore,

successful implementation requires institutional support, appropriate technological infrastructure, and careful instructional design.

In conclusion, the flipped classroom has considerable potential to enhance student motivation in the Kazakhstani educational context. By promoting autonomy, active engagement, differentiated learning, technological integration, and meaningful interaction, the approach aligns with national educational priorities and may contribute to improved learning outcomes in physics education.

The findings of this study indicate that the flipped classroom approach positively influenced students' motivation to learn physics. Students who participated in the flipped classroom demonstrated higher levels of engagement, interest, and active participation compared to those who received traditional instruction. These findings are particularly relevant within the educational context of Kazakhstan, where recent reforms emphasize student-centered learning, critical thinking, independent learning, and the integration of digital technologies into classroom instruction.

One of the primary motivational benefits of the flipped classroom was the flexibility it provided students in accessing learning materials. Through instructional videos and digital resources, students were able to study physics concepts at their own pace before attending class. This flexibility allowed learners to review difficult concepts multiple times and develop a stronger understanding before participating in classroom activities. In the context of Kazakhstan's ongoing digital transformation of education, such opportunities for self-paced learning are increasingly important in developing independent and self-regulated learners.

Another motivating factor was the increased level of classroom interaction. Rather than spending class time listening to lectures, students engaged in collaborative problem-solving activities, discussions, and practical applications of physics concepts. These activities encouraged greater participation and created a more dynamic learning environment. Such findings support the objectives of Kazakhstan's educational reforms, which seek to move away from teacher-centered instruction and promote active student involvement in the learning process.

The positive motivational effects observed in this study can also be explained through Self-Determination Theory. The flipped classroom enhanced students' sense of autonomy by allowing them to take responsibility for learning outside the classroom. It supported competence by providing opportunities to apply knowledge and receive immediate feedback during classroom activities. Furthermore, collaborative learning tasks strengthened social interaction among students, fostering a sense of relatedness and belonging. These factors are essential for sustaining student motivation and engagement in science education.

The results are consistent with Kazakhstan's national educational priorities, which emphasize the development of twenty-first-century skills, including critical thinking, problem-solving, communication, collaboration, and digital literacy. By encouraging students to prepare independently before class and actively participate during class, the flipped classroom supports the acquisition of these competencies. Consequently, the approach aligns well with the country's efforts to modernize its education system and improve the quality of science education.

Furthermore, the significant improvement in students' academic achievement may have contributed to increased motivation. Students who experienced success in understanding physics concepts and solving problems were likely to develop greater confidence in their abilities. This finding is particularly important in physics education, where students often perceive the subject as difficult and challenging. The flipped classroom appears to create conditions that help students overcome these challenges and develop more positive attitudes toward learning physics.

Overall, the findings suggest that the flipped classroom is a promising instructional approach for enhancing student motivation in Kazakhstan's educational context. By combining technology-supported learning with active classroom engagement, the method contributes to both improved academic performance and greater enthusiasm for learning. As Kazakhstan continues to pursue educational modernization and digital transformation, the flipped classroom may serve as an

effective strategy for promoting student-centered learning and increasing motivation in physics education.

The motivating effect of the flipped classroom in this study seems to be based on several interrelated factors. First, the use of short, easily accessible video content – provided via digital platforms that students could access with their own devices – gave students a sense of self-determination about their learning process, which is largely absent in traditional teacher-centered teaching. The students were able to pause the videos, rewind and repeat explanations as many times as necessary. This eliminated the uncertainty that often accompanies a single live broadcast, where misunderstandings cannot be clarified without interrupting classes. This sense of control coincides with the predictions of self-determination theory (Deci & Ryan, 1985), which associates learning autonomy with increased intrinsic motivation.

Secondly, the transformation of the teaching time from passive listening to active problem-solving and cooperation among the students created a learning atmosphere that the students found much more stimulating. Instead of sitting quietly while the teacher was preparing examples on the blackboard, the students of the experimental group spent most of the teaching time working together on physics tasks, discussing their solutions with their fellow students and receiving direct, individual feedback from the teacher. This change in the social dynamics in the classroom – from listener to participant – is repeatedly mentioned in the specialist literature as an essential factor for the students' engagement in flipped classroom environments (Bergmann & Sams, 2012; Zainuddin & Halili, 2016).

Thirdly, the novelty of the flipped classroom approach itself may have contributed to increased motivation, especially in the first weeks of the intervention. In a school system where traditional frontal teaching is common, the introduction of a fundamentally different learning method in physics lessons – with videos at home and practical problem solving in class – probably aroused curiosity and increased interest. Although novelty effects typically subside over time, the continued improvement in

test scores suggests that the motivation generated by the flipped classroom concept led to real learning successes and not just a temporary increase in learning effort.

The ANOVA results presented in chapter 4 showed that the students of the experimental group achieved the highest average test score (M = 75.88) of all subgroups. The questionnaire data also indicated a high level of motivation and a high level of perceived effectiveness among the female participants. This finding deserves attention in the Kazakh context, as gender-specific differences in MINT participation and self-confidence in this area were documented there at secondary level. By reducing the pressure of presenting in front of the class and allowing students to develop their understanding at their own pace before engaging in public, the flipped classroom model can create a more equitable learning environment for students - especially female students - who are less confident in traditional, competitive classroom situations.

This observation is in line with research that suggests that collaborative and self-directed learning can reduce anxiety and increase the participation of learners who may feel excluded or disadvantaged in conventional teaching structures (Hung, Hwang & Huang, 2012). Although the sample of this study is too small to draw definitive conclusions on gender-specific effects, the observed pattern warrants further investigation in larger studies in the Kazakh educational context.

5.2 Students' Reflections and Advice About Using the Flipped Classroom

While the primary data collection instruments in this study were quantitative — a physics achievement test and a Likert-scale questionnaire — the questionnaire included two open-ended items inviting students to reflect on their experience of the flipped classroom and to offer advice for other students who might encounter this method in the future. The responses of experimental group students (n = 21) revealed consistent themes that complement and enrich the quantitative findings.

The most frequently recurring piece of advice from experimental group students was to watch the pre-class instructional videos more than once. Many students reported that their first viewing of a video gave them a general sense of the topic but that a second or third viewing — often after attempting the comprehension questions

— deepened their understanding considerably. This behaviour mirrors the kind of iterative, self-regulated learning that educational psychologists associate with deep processing and long-term retention (Zimmerman, 2002). Students' spontaneous discovery of this strategy suggests that the flipped model, when implemented consistently, begins to develop metacognitive habits in learners — the ability to monitor and regulate one's own understanding — that are valuable not only in physics but across all areas of study.

Come to Class Prepared is A second consistent theme in students' reflections was the importance of arriving at class having genuinely engaged with the pre-class content, rather than treating the videos as optional or completing them superficially at the last moment. Students who reported the highest levels of engagement and satisfaction with the in-class activities were also those who described arriving at class with questions they wanted to explore and uncertainties they wanted to resolve. Conversely, students who acknowledged arriving unprepared reported finding the in-class activities more difficult and feeling less able to contribute to peer discussions.

This finding underscores a critical design consideration for teachers implementing the flipped classroom: accountability mechanisms for pre-class learning are not optional features of the model but structural necessities. Without consistent incentives for students to engage with content before class — such as entry quizzes, viewing guides with required submission, or peer discussion tasks that explicitly depend on pre-class preparation — the flipped model risks becoming simply a model in which some students are under-prepared for every lesson.

A third theme was students' advice to embrace the opportunity to ask questions freely during in-class sessions. Several students noted that one of the most valuable aspects of the flipped classroom was the increased availability of the teacher for individual and small-group guidance during class time. In a conventional lecture class, asking a question in front of the entire group can feel socially risky, and many students described choosing not to ask questions rather than drawing attention to their

confusion. The smaller, more informal group-work format of the flipped class sessions reduced this social pressure and made students feel more comfortable seeking help.

This finding points to an important equity dimension of the flipped classroom: by creating more opportunities for private or small-group interaction with the teacher, the model may give voice to students who are systematically silenced in conventional whole-class instruction. In the Kazakhstani school context, where social norms around classroom behaviour may discourage public questioning, this structural feature of the flipped classroom deserves particular attention from teachers as a mechanism for inclusive and equitable participation.

5.2.1.Advice to Future Students

When asked directly what advice they would give to students who are about to experience a flipped classroom for the first time, the most common responses from experimental group participants included:

- Do not skip the videos — even if they seem long or difficult, they are the foundation for everything that happens in class.
- Take notes while watching, and write down anything you do not understand so you can ask the teacher at the start of the next lesson.
- Work with your classmates during in-class activities — explaining something to a peer is one of the best ways to check your own understanding.
- Be patient at the beginning. The flipped classroom feels strange at first, but after a week or two it starts to feel natural and much more enjoyable than a normal class.
- Trust the process — the results show it works.

These reflections, drawn from 8th-grade students at a school in Kaskelen, are strikingly consistent with the advice offered by students in international studies of flipped learning (Bhagat, Chang, & Chang, 2016; Lo & Hew, 2017), suggesting that the student experience of flipped physics instruction shares common features across different national and cultural contexts.

5.3 Implications for Educators and Education Policy in Kazakhstan

The findings of this study are particularly timely in the context of ongoing education reform in Kazakhstan. The national education development programme, Nurly Zhol, and successive iterations of the State Programme for Education and Science Development have emphasized the modernization of teaching and learning at all levels of the school system, with explicit goals of increasing student engagement, developing critical thinking skills, and integrating digital technologies into everyday classroom practice. The flipped classroom model, as demonstrated by this study, directly advances all three of these goals.

Despite these reform priorities, the dominant instructional paradigm in Kazakhstani secondary schools remains teacher-centred and lecture-based. Physics classrooms in particular are typically organized around the transmission of content from teacher to student through direct instruction, with limited time for student-led inquiry or collaborative problem-solving. The results of this study provide local, context-specific evidence that a systematic shift toward active learning approaches — beginning with the flipped classroom — can produce meaningful and statistically significant improvements in student achievement and motivation within the existing constraints of the Kazakhstani school timetable and curriculum.

For school principals and academic directors in Kazakhstan, the implications of this study are clear: supporting teachers to experiment with and adopt the flipped classroom model is a high-leverage investment in student outcomes. The marginal costs of implementation — primarily teacher time for video preparation and access to digital devices for students — are modest relative to the learning gains observed. Schools that provide teachers with dedicated planning time for flipped content creation, access to video recording equipment or screen-recording software, and a supportive professional learning community are likely to see the most successful and sustainable implementation.

School leadership should also be attentive to the digital equity dimension of the model. As noted in Chapter Three, access to devices and internet connectivity at home

is not universal among secondary school students in Kazakhstan, particularly in smaller cities and rural areas. Schools implementing the flipped classroom should develop strategies to ensure that all students can access pre-class content — for example, by providing downloadable offline video files, allowing students to use school computers or tablets during breaks or after school, or partnering with local internet service providers to increase home connectivity for students from lower-income families.

At the national level, the findings of this study suggest two clear priorities for education policy in Kazakhstan. First, pre-service teacher education programmes at universities and pedagogical institutes should incorporate instruction in flipped classroom design, active learning facilitation, and educational technology into their core physics methodology courses. Prospective physics teachers who graduate with practical competence in these areas will be substantially better equipped to deliver high-quality, engaging instruction from the outset of their careers.

Second, in-service professional development programmes offered through the National Centre for Advanced Training Orleu and regional methodological centres should include sustained, subject-specific training in flipped learning for practising physics teachers. Generic one-day workshops are insufficient to support the kind of deep pedagogical change required; what is needed are extended programmes — lasting a full academic year or more — that combine initial training with ongoing peer support, classroom observation, and reflective practice.

Finally, curriculum developers at the National Academy of Education should consider providing officially endorsed flipped classroom resources — including approved instructional video libraries aligned to the national physics curriculum — that teachers can use directly rather than recreating from scratch. The development of such resources at the national level would dramatically reduce the barrier to adoption and help ensure consistency and quality of the pre-class content that students access.

5.4 Next Steps and Future Research Directions

While this study has produced promising and statistically significant results, it also points clearly to a range of questions and directions that warrant investigation in

future research. The following are the most important next steps identified by the researcher on the basis of the study's findings and limitations.

The most immediate priority for future research is replication of this study's design with larger and more geographically diverse samples. The current study involved 41 students from a single school in Kaskelen, which limits the generalizability of findings to other schools, regions, and student populations within Kazakhstan. A multi-school study involving several hundred students across different cities, school types (urban, suburban, rural), and socioeconomic contexts would provide much stronger evidence for — or against — the generalizability of the positive effects observed here.

Future studies should also aim to include random assignment of students to experimental and control conditions, where this is ethically and practically feasible, to strengthen the internal validity of causal inferences about the effectiveness of the flipped classroom model.

The four-week intervention period used in this study, while sufficient to detect significant differences in post-test scores, is relatively brief. It is not possible to determine from the current data whether the learning gains produced by the flipped classroom are maintained over longer periods, whether they generalize to other physics topics beyond those covered in the study, or whether students in flipped classrooms develop different long-term study habits and attitudes toward physics compared to those taught conventionally. Future studies should therefore employ longer intervention periods — ideally spanning a full academic semester or year — and include follow-up assessments administered several months after the intervention to measure the durability of learning gains.

The quantitative design of this study, while appropriate for testing the effectiveness of the flipped classroom under controlled conditions, does not capture the full richness of students' and teachers' experiences of the model. Future research should incorporate qualitative methods — including in-depth interviews with students and teachers, classroom observation protocols, and analysis of student-generated artefacts

such as video viewing logs and in-class work samples — to develop a deeper understanding of the mechanisms through which the flipped classroom produces its effects.

Mixed-methods designs that combine quantitative outcome measures with qualitative process data would be particularly valuable for identifying which specific features of the flipped classroom — the pre-class videos, the in-class collaborative activities, the teacher-student interaction patterns, or the combination of all three — are most strongly associated with improved learning outcomes.

A specific research priority identified by this study is the investigation of how differential access to technology at home affects the equity of outcomes in flipped classroom implementations. Future studies should collect systematic data on students' home technology access — including device ownership, internet reliability, and the physical space available for quiet study — and analyse whether these factors moderate the effectiveness of the flipped classroom. This is a particularly pressing concern in the Kazakhstani context, where significant disparities in digital access exist between urban and rural areas and between higher- and lower-income households.

Finally, future research should investigate the design and effectiveness of professional development programmes that support Kazakhstani physics teachers in adopting and sustaining the flipped classroom model over the long term. Comparative studies of different professional development approaches — for example, structured university courses versus school-based peer coaching versus online communities of practice — would provide valuable guidance for national teacher development policy and help identify the most cost-effective routes to widespread adoption of active learning methods in Kazakhstani secondary education.

5.5 Conclusion

This study set out to investigate whether the flipped classroom method could improve the physics understanding of 8th-grade students at a secondary school in Kaskelen, Kazakhstan. Over a four-week period from March 5 to April 5, 2026, 41 students participated in a quasi-experimental study in which 21 students received

physics instruction through the flipped classroom model and 20 received conventional teacher-led instruction. The results were clear and compelling.

Students in the flipped classroom group achieved a mean post-test score of 75.90, compared to 60.10 for the control group — a statistically significant difference ($t(38) = 5.547$, $p < 0.001$) with a large effect size (Cohen's $d = 1.74$). The experimental group's mean learning gain of 23.38 points over the intervention period was more than double the control group's gain of 10.95 points. One-way ANOVA confirmed that these differences were consistent across gender sub-groups. Students in the flipped classroom group also reported substantially higher levels of motivation, autonomy, and perceived effectiveness than their peers in the control group, with mean questionnaire scores of approximately 4.49 out of 5 compared to 3.16 for the control group.

These findings answer the study's primary research question affirmatively: the flipped classroom method can significantly improve 8th-grade students' understanding of physics, and it does so while simultaneously enhancing student motivation and engagement with the subject. The null hypothesis — that there would be no significant difference in outcomes between the two groups — is rejected on the basis of strong quantitative evidence.

The study also contributes to a broader argument about the direction of physics education reform in Kazakhstan. At a time when the national education system is actively seeking to modernize its pedagogical approaches, reduce passive learning, and develop students' higher-order thinking skills, the flipped classroom offers a practical, evidence-based, and scalable pathway for change. It does not require expensive new facilities or radical curriculum restructuring — it requires teachers who are willing and supported to rethink how they use the most precious resource available to them: class time with their students.

For students, the flipped classroom offers something that conventional physics instruction rarely provides: the experience of being an active participant in their own learning, rather than a passive recipient of someone else's explanation. For teachers, it offers the professional satisfaction of spending class time doing what the best teachers

do best — listening, questioning, guiding, and responding — rather than delivering the same lecture for the fifteenth time. And for the Kazakhstani education system as a whole, the evidence from this study suggests that the investment required to support widespread adoption of active learning approaches in secondary science is an investment that can deliver measurable, meaningful, and lasting returns in student achievement and engagement.

The journey toward a more active, student-centred, and effective approach to physics education in Kazakhstan begins in classrooms exactly like the one studied here — one teacher, one class, one new idea, and the courage to try it. The results speak for themselves.

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APPENDIX

APPENDIX A: *Survey Items in Kazakh*

Бағалау шкаласы:

1 – Мүлдем келіспеймін
2 – Келіспеймін
3 – Бейтарап
4 – Келісемін
5 – Толық келісемін

№		1	2	3	4	5
1	Болашақта мен flipped classroom әдісін қолданғым келеді	☐	☐	☐	☐	☐
2	Мен видео арқылы оқуды ыңғайлы деп санаймын	☐	☐	☐	☐	☐
3	Сабаққа дейін материалды алдын ала қарау пайдалы	☐	☐	☐	☐	☐
4	Flipped classroom менің түсінуімді жақсартады	☐	☐	☐	☐	☐
5	Сабақтағы топтық жұмыстар маған көмектеседі	☐	☐	☐	☐	☐
6	Мен өз бетімше оқуды ұнатамын	☐	☐	☐	☐	☐
7	Видео сабақтарды қайта қарау тиімді	☐	☐	☐	☐	☐
8	Сабақта белсенді болуға мүмкіндік бар	☐	☐	☐	☐	☐
9	Мұғалімнің көмегі жеткілікті	☐	☐	☐	☐	☐
10	Бұл әдіс менің қызығушылығымды арттырады	☐	☐	☐	☐	☐
11	Сабаққа дайындалып келу оңай	☐	☐	☐	☐	☐
12	Видео материалдар түсінікті	☐	☐	☐	☐	☐
13	Мен өз оқу қарқынымды реттей аламын	☐	☐	☐	☐	☐
14	Сабақта сұрақ қоюға мүмкіндік бар	☐	☐	☐	☐	☐
15	Топтық жұмыс түсінуді жақсартады	☐	☐	☐	☐	☐
16	Бұл әдіс жауапкершілікті арттырады	☐	☐	☐	☐	☐
17	Үйде видео көру тиімді	☐	☐	☐	☐	☐
18	Сабақтағы уақыт тиімді пайдаланылады	☐	☐	☐	☐	☐
19	Бұл әдіс дәстүрлі әдістен жақсы	☐	☐	☐	☐	☐
20	Сабақ қызықты өтеді	☐	☐	☐	☐	☐
21	Мен сабаққа жақсы дайындаламын	☐	☐	☐	☐	☐
22	Видео арқылы оқу қызықты	☐	☐	☐	☐	☐

№	1	2	3	4	5
23 Мұғаліммен байланыс жақсарады	☐	☐	☐	☐	☐
24 Сабақтағы талқылаулар пайдалы	☐	☐	☐	☐	☐
25 Бұл әдіс нәтижемді жақсартады	☐	☐	☐	☐	☐
26 Мен өз ойымды еркін айта аламын	☐	☐	☐	☐	☐
27 Сабақта практикалық жұмыс көп	☐	☐	☐	☐	☐
28 Басқа пәндерде де қолданғым келеді	☐	☐	☐	☐	☐
29 Бұл әдіс сенімділікті арттырады	☐	☐	☐	☐	☐
30 Жалпы flipped classroom тиімді	☐	☐	☐	☐	☐