



**Reasons behind demotivation of middle school mathematics students**

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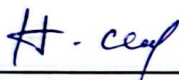
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# ABSTRACT

This study aims to explore the reasons behind the demotivation of middle school students in mathematics and to analyze how various emotional and pedagogical factors contribute to this phenomenon. Understanding the roots of demotivation is crucial for educators seeking to enhance student engagement and academic performance. The research was conducted using a modified questionnaire based on the work of Gur, Balta, Dauletkulova, Assanbayeva, and Fernández-César (2023). The survey was carefully designed to measure multiple factors influencing motivation, including enjoyment, pride, anger, hopelessness, and boredom, as they relate specifically to mathematics lessons.

The sample consisted of middle school students from grades 7, 9, and 10, with approximately 30 participants overall. The study not only examined correlations between motivation levels and academic performance but also included comparative analyses between different classes. For example, motivation levels were compared between 7K and 7L classes, as well as between 9th and 10th grades. Additionally, an experimental intervention was conducted in which Desmos, a dynamic mathematics technology tool, was introduced to the 7K class, while the 7L class continued with traditional instruction. This allowed for analysis of the potential impact of technology on student motivation.

Quantitative data were analyzed using correlation analysis, factor analysis, and internal consistency measures, providing a detailed view of how different motivational factors interact and influence students' attitudes toward studying mathematics. The findings offer insights for developing targeted strategies to foster motivation and reduce demotivation in mathematics classrooms.

Key words: motivation, mathematics, Desmos, Geogebra, student engagement, demotivation factors.

## АНДАТПА

Бұл зерттеу орта мектеп оқушыларының математикадағы демотивациясының себептерін зерттеуге және әртүрлі эмоционалдық және педагогикалық факторлардың осы құбылысқа қалай ықпал ететінін талдауға бағытталған. Демотивацияның түп-тамырын түсіну студенттердің белсенділігі мен оқу үлгерімін арттыруға ұмтылатын педагогтар үшін өте маңызды. Зерттеу Гур, Балта, Даулеткулова, Асанбаева және Фернандес-Сезардың (2023) жұмысына негізделген өзгертілген сауалнаманы қолдану арқылы жүргізілді. Сауалнама мотивацияға әсер ететін көптеген факторларды, соның ішінде ләззат, мақтаныш, ашу, үмітсіздік және зерігуді өлшеу үшін мұқият әзірленген, өйткені олар арнайы математика сабақтарына қатысты.

Іріктеме 7, 9 және 10-сыныптардағы орта мектеп оқушылары, жалпы саны 30-ға жуық қатысушыдан тұрды. Зерттеу мотивация деңгейлері мен оқу үлгерімі арасындағы корреляцияны зерттеп қана қоймай, әртүрлі сыныптар арасындағы салыстырмалы талдауларды да қамтыды. Мысалы, мотивация деңгейлері 7К және 7L сыныптары арасында, сондай-ақ 9 және 10 сыныптар арасында салыстырылды. Сонымен қатар, эксперименттік араласу жүргізілді, онда динамикалық математика технологиясының құралы Desmos 7К сыныбына енгізілді, ал 7L сыныбы дәстүрлі оқытуды жалғастырды. Бұл технологияның студенттердің мотивациясына ықтимал әсерін талдауға мүмкіндік берді.

Сандық деректер корреляциялық талдау, факторлық талдау және ішкі жүйелілік өлшемдерін қолдану арқылы талданды, бұл әртүрлі мотивациялық факторлардың өзара әрекеттесуі және оқушылардың математиканы оқуға деген көзқарасына әсер ету туралы егжей-тегжейлі көрініс береді. Нәтижелер математика кабинеттерінде мотивацияны арттыру және демотивацияны азайту үшін мақсатты стратегияларды әзірлеуге арналған түсініктерді ұсынады.

Түйінді сөздер: мотивация, математика, Десмос, Геогейбра, студенттердің белсенділігі, демотивация факторлары.

## АННОТАЦИЯ

Целью данного исследования является изучение причин демотивации учащихся средней школы по математике и анализ того, как различные эмоциональные и педагогические факторы способствуют этому явлению. Понимание корней демотивации имеет решающее значение для педагогов, стремящихся повысить вовлеченность учащихся и академическую успеваемость. Исследование проводилось с использованием модифицированного опросника, основанного на работе Гура, Балты, Даулеткуловой, Ассанбаевой и Фернандес-Сезара (2023). Опрос был тщательно разработан для измерения множества факторов, влияющих на мотивацию, включая удовольствие, гордость, гнев, безнадежность и скуку, поскольку они связаны конкретно с уроками математики.

Выборка состояла из учащихся средней школы 7, 9 и 10 классов, всего около 30 участников. Исследование не только изучало корреляции между уровнями мотивации и академической успеваемостью, но и включало сравнительный анализ между различными классами. Например, уровни мотивации сравнивались между классами 7К и 7L, а также между 9 и 10 классами. Кроме того, было проведено экспериментальное вмешательство, в ходе которого Desmos, инструмент динамической математической технологии, был представлен классу 7К, в то время как класс 7L продолжил традиционное обучение. Это позволило проанализировать потенциальное влияние технологий на мотивацию учащихся.

Количественные данные были проанализированы с использованием корреляционного анализа, факторного анализа и мер внутренней согласованности, что дало подробное представление о том, как различные мотивационные факторы взаимодействуют и влияют на отношение учащихся к изучению математики. Результаты предлагают идеи для разработки целевых стратегий для стимулирования мотивации и снижения демотивации в классах математики.

Ключевые слова: мотивация, математика, Desmos, Geogebra, вовлеченность учащихся, факторы демотивации

# INTRODUCTION

Middle school represents an important phase in the academic and personal development of students. This period, typically encompassing early adolescence, is marked by profound changes in cognitive abilities, emotional regulation, social dynamics, and identity formation. During this stage, students face increasing academic demands together with challenges related to their social relationships and self-concept (Eccles & Roeser, 2009). As students navigate these complexities, their motivation to engage with school tasks, especially in subjects such as mathematics, can change significantly.

Motivation is widely recognized as a central psychological construct that underpins learning, perseverance, and academic achievement (Deci & Ryan, 2000; Pintrich & Schunk, 2002). It determines not only whether students begin a task but also how much effort they invest, how resilient they are in the face of difficulty, and how they feel about their academic experiences. High levels of motivation are associated with greater persistence, deeper learning, and better academic outcomes (Ryan & Deci, 2000). Conversely, demotivation can lead to disengagement, poor performance, and a negative attitude toward school.

Mathematics, as a core academic subject, often presents unique challenges to middle school students. The abstract nature of mathematical concepts, coupled with cumulative skill demands, can contribute to anxiety, frustration, and ultimately, demotivation (Ramirez et al., 2018). Studies have shown that students' interest and motivation in mathematics tend to decline during adolescence, with middle school being a particularly vulnerable period (Pinxten et al., 2014). This decline can have long-term consequences, as negative attitudes toward mathematics in middle school often persist into high school and beyond, limiting students' future academic and career opportunities (Gottfried et al., 2001).

For teachers, sustaining student engagement in mathematics classrooms is a complex and often daunting task. Lessons that fail to capture students' interest can result in passive participation, disruptive behavior, and a loss of valuable instructional time. This not only hinders the learning process for demotivated students but also affects the classroom environment as a whole, diminishing the educational experience for other students (Marzano & Marzano, 2003). Consequently, understanding the causes of demotivation and identifying strategies to counteract it are essential objectives for educators, curriculum designers, and policymakers alike.

Several factors contribute to demotivation in mathematics. Psychological factors such as math anxiety, low self-efficacy, and fixed mindset beliefs can undermine students' confidence and willingness to engage with challenging tasks (Dweck, 2006; Ashcraft & Kirk, 2001). Pedagogical factors, including teaching

methods that emphasize rote learning over conceptual understanding, may fail to inspire curiosity or relevance (Boaler, 2016; Brophy, 2010). Social influences—such as peer attitudes, teacher-student relationships, and parental expectations—further shape students’ motivation levels (Hughes & Cao, 2017; Fan & Chen, 2001).

Importantly, motivation and demotivation are not static traits. They are dynamic, context-dependent states that evolve in response to students’ experiences in the classroom and beyond (Eccles & Wigfield, 2002). This underscores the importance of examining demotivation within real educational settings, where interventions and supportive practices can be designed to address the specific needs of students.

Technology offers promising avenues for supporting student motivation. Tools like Desmos, a dynamic mathematics platform, enable interactive exploration of mathematical concepts, making abstract ideas more tangible and engaging (McCulloch et al., 2021). Integrating such technologies thoughtfully into instruction may help counteract demotivation by providing students with more meaningful, hands-on learning experiences. However, empirical evidence is needed to evaluate the actual impact of these tools on student motivation in diverse classroom contexts.

In the 21st-century educational landscape, digital technologies have become integral to teaching and learning. Schools worldwide are increasingly incorporating Information and Communication Technologies (ICT) into curricula to enhance student engagement and learning outcomes. Mathematics education, in particular, can benefit greatly from digital tools that help to visualize abstract concepts and provide interactive learning experiences. Researchers have long argued that computer-based tools can empower students to explore mathematical ideas in new ways – a vision articulated by Papert (1980), who suggested that computers offer “powerful ideas” that can transform children’s learning. Modern students are often digital natives comfortable with technology, and leveraging this familiarity in the classroom may help align instruction with their skills and interests.

There is growing evidence that well-integrated technology can improve mathematics achievement. A comprehensive meta-analysis by Cheung and Slavin (2013) found that educational technology applications had a positive, though modest, effect on K-12 students’ mathematics performance. Similarly, Fabian et al. (2016) reported that the use of mobile devices in math instruction improved students’ attitudes, engagement, and achievement. However, despite global trends, integrating digital tools into everyday math lessons is still a challenge in many contexts. For example, in Kazakhstan the use of interactive digital resources in math classrooms remains limited, even as students’ daily lives are saturated with gadgets. This gap between students’ digital lives and classroom practice presents a problem – one that innovative tools like Desmos and GeoGebra might help address.

Desmos is a free online graphing calculator platform that allows students to plot functions, adjust parameters, and visually explore algebraic relationships in real time. GeoGebra, on the other hand, is a dynamic mathematics software that integrates geometry, algebra, and calculus capabilities; it enables constructions and manipulations of geometric figures and graphs. Both tools exemplify how technology can make abstract mathematics more concrete: Desmos by instantly graphing equations and allowing interactive experimentation, and GeoGebra by letting students construct and transform geometric shapes and functions. These technologies align with student-centered and constructivist learning approaches – they invite learners to actively explore, conjecture, and discover mathematical concepts rather than passively absorb information. Numerous small-scale studies have reported promising outcomes using such tools (detailed in the Literature Review), yet there is a need for more research on their effectiveness in typical secondary school settings, especially within local educational contexts.

**Purpose of the Study:** The present study aims to investigate the impact of integrating digital technologies – specifically Desmos and GeoGebra – into middle school mathematics teaching. The focus is on evaluating both student academic performance in mathematics and student motivation/engagement when these tools are used, compared to traditional teaching methods. By implementing these tools in a series of lessons and measuring outcomes, the study seeks to provide empirical evidence and pedagogical insights into how digital tool usage influences learning in mathematics. The results will contribute to the growing body of knowledge in digital math pedagogy and inform teachers and educators about the potential benefits and challenges of using interactive technology in their classes.

### **Research Aims and Questions**

This study seeks to contribute to the understanding of middle school students' demotivation in mathematics by exploring the interplay of psychological, pedagogical, and social factors. In particular, the research addresses the following aims:

- To identify key factors contributing to demotivation in mathematics among middle school students.
- To compare motivation levels across different middle school classes (e.g., 7K, 7L, 9th, and 10th grades).
- To assess the potential impact of using Desmos on student motivation by comparing the experiences of students in classes with and without the technology intervention.

### **Significance of the Study.**

#### **Theoretical Significance of the Study.**

Student motivation has long been recognized as one of the key factors that affect learning outcomes, especially in elementary and middle school. With the rise of

digital technology in education, new opportunities have emerged to support and enhance students' motivation and engagement. The theoretical importance of this study lies in expanding the understanding of how technology-supported learning environments influence students' emotional, behavioral, and cognitive involvement in the learning process.

This research builds on the principles of Self-Determination Theory (SDT), which highlights the importance of autonomy, competence, and relatedness for developing intrinsic motivation (Deci & Ryan, 1985, 2000). Many technology-based tools—such as interactive simulations, gamified apps, and visual platforms like GeoGebra or Desmos—can create learning experiences that allow students to make choices, solve problems, and receive immediate feedback. These elements contribute to students' sense of ownership and confidence in their learning, which in turn increases motivation.

The study also contributes to the field of educational psychology by examining how engagement in technology-supported environments connects with different types of motivation: intrinsic (learning for its own sake) and extrinsic (learning for rewards or approval). For example, research shows that game-like tasks, when used appropriately, can support both types of motivation and lead to more positive attitudes toward subjects like mathematics (Dicheva et al., 2015; Hamari et al., 2016).

In addition, the study integrates ideas from constructivist learning theory (Jonassen, 1999), which emphasizes active, hands-on learning. Technology tools that allow students to manipulate data, visualize mathematical models, or explore patterns can support deeper understanding and spark curiosity. As such, this research helps clarify how learning technologies can support both academic success and long-term interest in school subjects.

### **Practical Significance of the Study**

This research has practical value for teachers, school administrators, and educational technology designers. One of the most pressing problems in schools today is the decline of student motivation, especially in middle grades, where academic pressure increases and interest often drops. The findings of this study can help teachers identify and use technology tools that make learning more engaging, accessible, and meaningful for their students.

For example, interactive platforms such as GeoGebra and Desmos can help students visualize abstract mathematical concepts and experiment with equations in real time. These tools are especially useful for students who struggle with traditional instruction, as they offer visual, exploratory, and hands-on ways to understand math topics. Teachers can use these technologies not only to explain content more clearly but also to encourage students to think critically and solve problems creatively (Dodeen et al., 2020; McCulloch et al., 2021).

In addition, the study's insights may help guide professional development programs for teachers who want to integrate technology effectively in their classrooms. Many educators are interested in using digital tools but are unsure how to align them with learning goals or differentiate instruction. By showing concrete examples of how technology supports motivation and learning, this research can inform training strategies and help educators feel more confident in using digital platforms.

School leaders and policymakers may also benefit from this study. Understanding the motivational benefits of educational technology can support decisions about school resources, curriculum design, and equity. For instance, technology can help personalize learning for students with different needs and abilities, which is particularly important in inclusive classrooms or schools with diverse student populations (Ertmer & Ottenbreit-Leftwich, 2010).

Finally, this study contributes to the practical understanding of how to reduce math anxiety and improve student attitudes by creating a more interactive, responsive, and enjoyable learning environment. With technology, students can take more control over their learning, make mistakes without fear, and see their progress in real time—key factors that support emotional well-being and long-term success in school.

# 1. LITERATURE REVIEW

The present study builds upon Self-Determination Theory (SDT), which posits that intrinsic motivation is fostered when students' needs for autonomy, competence, and relatedness are met (Deci & Ryan, 1985, 2000). According to SDT, students are more likely to engage deeply with learning activities when they feel in control of their learning, believe in their capabilities, and experience positive social interactions in the classroom. Constructivist learning theories further emphasize the importance of active, student-centered learning environments in promoting motivation and engagement (Jonassen, 1999). In mathematics education, constructivist approaches encourage students to explore, manipulate, and reflect on mathematical concepts, which can lead to greater interest and persistence (Boaler, 2016).

## 1.1 Psychological Factors

Math anxiety has been widely documented as a significant barrier to motivation and achievement in mathematics. This form of anxiety interferes with working memory, limiting students' ability to focus on problem-solving and reasoning tasks, and often results in the avoidance of mathematical activities altogether (Ashcraft & Kirk, 2001). Students who experience high levels of math anxiety tend to show lower levels of persistence, greater fear of failure, and an increased likelihood of disengagement during mathematics lessons (Ramirez et al., 2018).

High math anxiety is also strongly linked to decreased self-efficacy, which refers to students' beliefs in their own ability to succeed in mathematical tasks (Huang et al., 2018). When students doubt their competence, they are less likely to attempt challenging problems, leading to a cycle of avoidance and further declines in confidence and performance. This negative feedback loop contributes to long-term demotivation and can hinder students' future academic trajectories in mathematics.

However, psychological research highlights the potential of fostering a growth mindset as a way to mitigate the negative impact of math anxiety. Growth mindset is the belief that abilities and intelligence can be developed through effort, perseverance, and learning from mistakes (Dweck, 2006). Students with a growth mindset are more likely to embrace challenges, persist in the face of setbacks, and view errors as opportunities for growth rather than as indicators of failure (Yeager & Dweck, 2012). Importantly, interventions aimed at promoting growth mindset have been shown to increase students' resilience and motivation in mathematics, while simultaneously reducing anxiety (Dweck, 2006; Yeager & Dweck, 2012).

In addition to math anxiety and mindset, other psychological factors, such as perfectionism and fear of negative evaluation, can further undermine motivation. Perfectionist tendencies may lead students to set unrealistically high standards for themselves, increasing anxiety when they fall short of these expectations (Elliott &

Dweck, 2005). Similarly, fear of being judged by teachers or peers can discourage students from participating in class, asking questions, or attempting difficult tasks—all of which are critical behaviors for learning and growth.

Addressing these psychological factors requires creating supportive classroom environments where mistakes are normalized as part of the learning process, and where students receive constructive feedback that builds confidence and fosters intrinsic motivation (Shute, 2008). By understanding and addressing the psychological barriers to motivation, educators can play a crucial role in helping students develop positive attitudes toward mathematics and supporting their long-term academic success.

## **1.2 Pedagogical Factors**

Pedagogical approaches are central to shaping students' motivation, emotional engagement, and long-term interest in mathematics. The way in which mathematical concepts are introduced, explored, and reinforced profoundly influences whether students experience the subject as stimulating and meaningful or as tedious and anxiety-inducing. Numerous studies emphasize that teaching methods that rely heavily on rote memorization and repetitive testing tend to diminish students' intrinsic motivation and promote surface-level learning (Brophy, 2010). When students are primarily tasked with memorizing procedures or preparing for standardized assessments, they may come to view mathematics as disconnected from real life and focused solely on performance rather than understanding. Such environments often heighten anxiety, reduce curiosity, and foster avoidance behaviors.

In contrast, pedagogical strategies that emphasize conceptual understanding, problem solving, and discovery learning have been shown to enhance both motivation and achievement (Boaler, 2016). When students are encouraged to explore patterns, make conjectures, and apply mathematical reasoning to real-world contexts, they are more likely to develop positive emotions such as enjoyment and pride. These approaches help students see mathematics as a dynamic and creative discipline rather than as a collection of fixed rules. For example, Boaler (2016) advocates for open-ended tasks that allow multiple solution paths, thereby giving students a sense of agency and control over their learning—factors known to contribute to greater engagement according to control-value theory (Pekrun, 2006).

Inquiry-based learning, project-based assignments, and collaborative group work are additional pedagogical techniques that support motivation. Such methods not only deepen conceptual understanding but also create classroom environments that value student voice, encourage peer support, and promote persistence. Hattie (2009) found that when students are given opportunities to take ownership of their learning through active participation and reflection, their motivation and achievement

are significantly enhanced. These pedagogies contrast sharply with teacher-centered models that emphasize passive absorption of information.

Moreover, research suggests that feedback practices embedded within instruction play a crucial role in supporting student motivation. Effective feedback is timely, specific, and focused on strategies for improvement rather than simply indicating correctness (Shute, 2008). Feedback that encourages a growth mindset—emphasizing effort, strategy use, and learning from mistakes—helps students develop resilience and a willingness to engage with challenging tasks (Dweck, 2006).

It is also important to note that the integration of technology and digital tools within pedagogical frameworks can further strengthen motivation, particularly when used to support active learning. Dynamic mathematics software, online simulations, and interactive platforms provide opportunities for students to visualize abstract concepts, test ideas, and receive immediate feedback, all of which contribute to sustained engagement and reduced boredom (Holmes et al., 2019).

However, the literature cautions that pedagogical innovations must be thoughtfully designed and implemented. Simply introducing problem-solving tasks or technology without aligning them to meaningful learning objectives and providing appropriate scaffolding may fail to achieve motivational gains (Brophy, 2010). Teachers must be supported through professional development to effectively adopt and adapt these pedagogical practices to meet diverse student needs.

In sum, pedagogical factors are among the most powerful levers available to educators for influencing student motivation. Instruction that prioritizes deep understanding, relevance, and student agency fosters environments where learners are more likely to thrive emotionally and academically.

### **1.3 Social and Cultural Factors**

Social dynamics, including peer relationships and teacher-student interactions, significantly influence student motivation. Positive relationships with teachers and supportive peer networks have been linked to higher levels of engagement and achievement (Hughes & Cao, 2017; Eccles & Roeser, 2009). Conversely, experiences of social exclusion, bullying, or low teacher expectations can contribute to feelings of alienation, helplessness, and reduced motivation, particularly in challenging subjects like mathematics (Totura et al., 2014). The social climate of the classroom plays a crucial role in shaping whether students feel safe to take academic risks and participate actively.

In Kazakhstan and similar contexts, the cultural emphasis on high academic achievement and respect for authority can have both positive and negative effects on motivation. On one hand, strong family expectations and cultural values that prioritize education can inspire students to strive for excellence and persevere in the face of difficulties (Leung, 2001). On the other hand, excessive academic pressure and fear of

disappointing parents or teachers may increase anxiety, promote surface-level learning strategies aimed at performance rather than understanding, and ultimately contribute to demotivation (Pomerantz et al., 2007).

Gender expectations also intersect with cultural factors to shape students' experiences in mathematics. Research indicates that in some cultural contexts, girls may report higher levels of math anxiety and lower confidence, despite performing at levels comparable to boys (Else-Quest et al., 2010). These patterns may reflect broader societal stereotypes about gender and mathematics ability, which can influence how students view themselves and their potential in the subject.

Moreover, cultural attitudes toward technology and innovation can affect how students engage with modern instructional tools such as Desmos or GeoGebra. In environments where technology is viewed as a valuable educational resource, students may be more open to interactive and exploratory learning methods that promote intrinsic motivation (Livingstone & Helsper, 2007). Conversely, in more traditional settings, students might initially resist or underutilize these tools unless guided effectively by teachers.

Overall, the interaction of social and cultural factors creates a complex motivational landscape. Understanding how these elements influence students' attitudes and behaviors in mathematics classrooms is essential for designing interventions that are culturally responsive and socially supportive.

#### **1.4 Role of Technology**

The integration of educational technologies offers promising avenues for enhancing motivation in mathematics. Interactive tools like GeoGebra and Desmos provide visual and exploratory learning experiences that can help demystify abstract concepts and support students with diverse learning needs (Dodeen et al., 2020; McCulloch et al., 2021). Personalized learning platforms and gamified applications have also been associated with increased engagement and persistence (Dicheva et al., 2015; Wang, 2015).

However, the success of these technologies depends on thoughtful implementation. Research underscores the importance of aligning technological tools with pedagogical goals and ensuring that teachers receive adequate training to use these tools effectively (Ertmer & Ottenbreit-Leftwich, 2010).

To overcome the challenges, modern education is turning to digital technologies. Among the most effective tools are GeoGebra and Desmos - interactive mathematical environments that stimulate visualization and research work.

According to research by Dodeen, Abdelfattah and Alshumrani (2020), the use of GeoGebra efficiently reduces anxiety and increases motivation since it places abstract mathematical concepts within view and within grasp. GeoGebra allows students to build and verify hypotheses independently, for example, in research of a

parabola's properties by changing the coefficients of the equation of a quadratic function and observing the change in the graph in real time, increasing their active participation in the learning process. In Russian pedagogical practice, as Kozlova (2022) states, GeoGebra is used extensively by students in project and research work. Desmos, as the research of McCulloch, Hunter and Burgess (2021) verifies, helps to create interesting lessons in which not only are problems being solved but also mathematical dynamic patterns are being explored. This sparks curiosity, constructs critical thinking and makes a contribution to the formation of an extended positive attitude towards the subject.

In addition, technology offers a chance to implement a differentiated and personalized approach, which is especially useful for low self-esteem students. For example, using Desmos, you can adjust assignments to the level of each student and track their progress in real time. The study by Duran and Mert (2022) reported that not just does interaction improve with the help of digital means, but also reduces test anxiety. The interactivity factor is also important - seeing the impact of your action instantly is what provides good feedback.

Thus, digital technologies can serve not only as a means of increasing motivation. They are not only a means of evading and transcending demotivation related to feelings of fear, anxiety and uncertainty, but also a means of evading and transcending demotivation related to feelings of fear, anxiety and uncertainty.

## **1.5 Integration of Real-World Applications and Technology in Mathematics Motivation**

A growing body of literature emphasizes the importance of integrating real-world applications and technology into mathematics instruction as a means of sustaining student engagement and reducing negative emotions such as boredom. Real-world contexts help students perceive mathematics as meaningful and relevant, which in turn enhances intrinsic motivation and persistence (Boaler, 2016). When students understand how mathematical concepts apply to practical problems—whether in science, engineering, economics, or daily life—they are more likely to value the subject and invest effort in learning.

Technological tools, including dynamic software like GeoGebra and Desmos, as well as emerging AI-based platforms, provide interactive environments where students can explore mathematical relationships, test hypotheses, and receive immediate feedback (Holmes et al., 2019; Luckin et al., 2016). These technologies support active learning, which has been shown to reduce boredom and increase cognitive engagement by shifting students from passive recipients of information to active participants in constructing knowledge (Pekrun & Linnenbrink-Garcia, 2012). Moreover, integrating real-world applications often facilitates collaborative problem solving and project-based learning, which further enhances motivation by allowing

students to work together on meaningful challenges. This approach not only sustains attention but also fosters positive emotions such as enjoyment and pride, while reducing frustration and disengagement (Pekrun, 2006).

Empirical evidence suggests that classrooms where technology and authentic contexts are effectively integrated report lower rates of boredom and higher levels of motivation compared to traditional instruction (Zhao et al., 2005). However, researchers caution that the effectiveness of these approaches depends on thoughtful pedagogical design. Simply introducing technology or real-world problems without aligning them to learning objectives and student interests may fail to achieve the desired motivational outcomes.

### **1.6 Demotivation: understanding the decision making**

Motivation can be seen as the driving force which is divided into two types: extrinsic and intrinsic (Morris et al., 2022). The first describes one's engagement in an activity for its own sake, while the last refers to an engagement as a means to an end (Pintrich & Schunk, 2002). These two types cover some of the important factors which contribute to demotivation such as persistence, coping mechanisms towards failure, anxiety, study strategy, effort and learning engagement and self-efficacy (Morris et al., 2022). Deci and Ryan (1985) describe intrinsic motivation as "personal and internal factors, interests and gratifications" and extrinsic motivation as "external factors of rewards, punishments, and social pressure". These two motivation types influence every decision people do. Motivation is an incredibly important factor when it comes to academic learning and achievement (Elliot & Dweck, 2005). Muola (2010) also agrees that motivation appears to be one of the crucial factors that contribute to academic success, whilst mentioning the importance of guidance and encouragement from their parents and educators early on.

Motivation can be seen as the driving force behind goal-directed behavior and learning. It is typically categorized into two main types: intrinsic and extrinsic (Morris et al., 2022). Intrinsic motivation refers to engagement in an activity for its own inherent satisfaction—learning because it is interesting or enjoyable—while extrinsic motivation describes behavior driven by external factors such as rewards, grades, or social approval (Pintrich & Schunk, 2002). These two motivational orientations shape how learners approach academic challenges, persist through difficulties, and ultimately make decisions about their learning efforts. Both types are closely associated with psychological constructs such as self-efficacy, engagement, anxiety, persistence, and coping mechanisms (Morris et al., 2022). When one or more of these components is disrupted, demotivation occurs, often manifesting as disengagement, procrastination, or emotional withdrawal from schoolwork.

Deci and Ryan (1985), the creators of Self-Determination Theory (SDT), define intrinsic motivation as "personal and internal factors, interests and gratifications," and

extrinsic motivation as “external factors of rewards, punishments, and social pressure.” According to SDT, optimal learning and motivation occur when three basic psychological needs are fulfilled: autonomy (a sense of control over one’s actions), competence (feeling capable), and relatedness (feeling connected to others). When these needs are frustrated—such as when students feel incapable, pressured, or isolated—motivation declines. For example, a student who constantly fails math tests may lose their sense of competence and begin to view effort as pointless, ultimately reducing engagement. Therefore, understanding decision-making in demotivated learners requires examining the psychological environment of the classroom and how it supports or undermines these fundamental needs (Ryan & Deci, 2000).

Motivation is a central factor in academic learning and success (Elliot & Dweck, 2005). Students who are motivated are more likely to set goals, utilize effective study strategies, and demonstrate resilience in the face of failure. Muola (2010) emphasizes that motivation—especially when supported by parental encouragement and positive teacher relationships—is key to student achievement. However, when students feel disconnected from academic goals, see no value in the content, or doubt their ability to succeed, demotivation becomes a natural response. This decision not to engage is rarely a conscious rejection of learning but rather a protective adaptation to an environment perceived as threatening, confusing, or unrewarding.

Another relevant model in understanding student demotivation is the Expectancy-Value Theory of motivation (Wigfield & Eccles, 2000). This theory posits that students’ motivation to engage in a task depends on two main judgments: whether they expect to succeed (expectancy) and how much they value the task (value). If a student believes they are unlikely to succeed in solving a math problem (low expectancy) or perceives the topic as irrelevant or boring (low value), they are likely to opt out of effortful engagement. Over time, this decision-making pattern becomes habitual, especially in environments that do not challenge negative beliefs or offer opportunities to rebuild confidence. This theory also highlights why simply increasing external rewards often fails to reignite motivation—it does not address the underlying beliefs about ability and purpose.

In middle school contexts, these decision-making patterns are especially relevant. Students at this stage face increased academic demands, new social pressures, and heightened self-awareness. Their motivation often fluctuates depending on how well their experiences match their personal goals and emotional needs. Research suggests that peer comparison, fear of failure, and rigid academic structures contribute significantly to demotivation in adolescence (Tanaka, 2017). For example, when students are repeatedly told they are behind their peers or not “math people,” they may internalize these labels and begin to disengage. Teachers who emphasize

competition or correctness over growth may inadvertently heighten anxiety and lower perceived competence, pushing students further into avoidance behavior.

The Attribution Theory of Motivation (Weiner, 2010) also provides a lens through which to understand demotivation. According to this theory, how students explain their academic successes or failures influences their future motivation. If a student attributes poor performance to a lack of ability (“I’m just bad at math”), rather than controllable factors like effort or strategy (“I didn’t study enough”), they are more likely to feel hopeless and give up. These attributional patterns become deeply embedded over time, making it crucial for teachers to reframe failure as a normal part of learning and emphasize the role of effort and persistence in success.

Another factor is the misalignment between school tasks and students’ personal goals. Many demotivated learners report that their academic tasks feel disconnected from their interests or life aspirations. When students do not see the relevance of what they are learning, they are less likely to engage meaningfully. This gap can be especially problematic in subjects like mathematics, which are often taught in abstract or procedural ways without showing how concepts apply to real-world contexts (Boaler, 2016). Providing opportunities for authentic, project-based learning and incorporating students’ voices into lesson planning can help bridge this motivational gap.

Demotivation can also stem from cognitive overload and stress. If students are consistently assigned work that exceeds their skill level or available time, they may experience learned helplessness, where repeated failure leads them to believe they have no control over outcomes (Krawitz & Schukajlow, 2018). As a result, they stop trying—not because they do not care, but because they no longer believe effort will make a difference. To counter this, effective teaching involves differentiating instruction, offering scaffolded support, and celebrating small successes that build momentum and self-efficacy.

A promising approach to combat demotivation is incorporating digital technologies like Desmos or GeoGebra into instruction. These tools provide interactive and exploratory environments where students can visualize mathematical relationships, receive instant feedback, and experiment safely with mathematical structures. As shown in the experimental phase of this research, when Desmos was used in the 7L classroom, students not only improved their test scores but also reported increased motivation and engagement. These results underscore that motivation is context-dependent and that thoughtfully integrated technology can support student agency and reduce fear of failure.

Finally, understanding demotivation requires educators to look beyond surface behaviors such as laziness or noncompliance and ask: What barriers is this student experiencing? What supports are missing? Reframing demotivation as a logical response to an unsupportive or irrelevant learning context allows teachers to become

more empathetic and proactive in their strategies. When students feel emotionally safe, respected, and capable, they are more likely to make decisions that favor persistence and learning. Therefore, improving student motivation is not about forcing compliance but about creating conditions in which students choose to learn because it feels meaningful and possible.

### **1.7 Importance of Teacher's Professionalism**

The professionalism of teachers plays a critical role in shaping students' academic motivation, engagement, and overall success. While possessing a strong theoretical foundation in mathematics is essential, effective teaching requires much more than subject matter expertise. True professionalism encompasses a range of competencies, including the ability to adapt instruction to meet diverse student needs, manage classroom dynamics, and create an environment that fosters both cognitive and emotional growth.

In modern classrooms, teachers face numerous challenges that require them to go beyond traditional methods of knowledge transmission. One of the most significant challenges is maintaining students' attention in an era of constant digital distraction. The widespread use of smartphones and other devices has made it increasingly difficult for students to stay focused during lessons, leading to interruptions and disengagement. Middle school teachers, in particular, must develop strategies to ensure that learners remain actively involved and mentally present throughout the instructional process.

Professionalism in teaching involves the capacity to design and implement lessons that are engaging, relevant, and responsive to students' motivational needs. As OCUFA (1992) emphasized, the teacher bears a primary responsibility for sustaining student interest and facilitating learning, especially in elementary and secondary education. The transmission of knowledge must be clear, purposeful, and adapted to students' developmental stages for effective learning to occur. During the initial 12 to 13 years of formal schooling, students rely heavily on teachers not only for information but also for the structure, guidance, and inspiration needed to acquire and apply that knowledge.

Effective teachers employ a variety of pedagogical strategies to promote student motivation. These may include interactive teaching methods, real-world problem solving, the integration of technology, and differentiated instruction tailored to varying ability levels. Moreover, professional educators recognize the importance of fostering positive relationships with their students, as trust and mutual respect contribute significantly to students' willingness to engage in learning activities (Hattie, 2009).

Another key component of teacher professionalism is the ability to manage classroom behavior in ways that support a positive learning environment. Rather than

relying solely on punitive measures, professional teachers use proactive strategies to prevent disruptions, such as setting clear expectations, providing meaningful tasks, and offering timely feedback. These practices help minimize off-task behaviors and keep students focused on academic goals, even in the presence of potential distractions like mobile devices (Marzano & Marzano, 2003).

The importance of teacher professionalism extends beyond individual classrooms to the broader educational system. Research shows that teachers' professional competencies—including their pedagogical skills, classroom management abilities, and emotional intelligence—are among the most powerful school-based factors influencing student achievement and motivation (Darling-Hammond, 2000). In mathematics, where many students struggle with anxiety or low confidence, the role of a professional teacher is particularly vital. Skilled educators not only convey mathematical concepts but also help students develop positive attitudes toward the subject and build the resilience needed to persist through challenges.

In sum, teacher professionalism is a multidimensional construct that encompasses deep content knowledge, adaptive teaching practices, effective classroom management, and the capacity to inspire and support students. As the educational landscape continues to evolve with technological advances and shifting societal expectations, the need for highly professional teachers who can navigate these complexities while maintaining a focus on student motivation and success has never been greater. Investing in teacher development programs that enhance these competencies is essential for ensuring that all students have the opportunity to thrive academically.

## **1.7 Causes of Demotivation of Secondary School Students to Study Mathematics**

The motivation to study mathematics is a priority question in educational psychology. During the past few years, there has been an increasing number of studies and investigations into the issues of development of positive motivation as well as causes of loss of motivation to study mathematics. Based on research from the last decade, a demotivation to study mathematics among students stems from a cognitive, emotional, pedagogical, and social complex of reasons (Pinxten et al., 2014).

One of the most critical demotivating influences is mathematics anxiety, which in scientific literature is understood as a form of "mathematics anxiety". Based on research conducted by Ramirez and others (Ramirez et al., 2018), this type of anxiety emerges when performing tasks which require calculations or logical reasoning, and has physiological and psychological impacts similar to stress. Ashcraft and Kirk (2001) found that high anxiety levels have a negative impact on working memory and, consequently, on academic performance.

Emotional reactions to math difficulties may be:

- helplessness;
- annoyance and hostility;
- inferiority in society (mostly when compared with peers);
- learned helplessness.

They typically emerge at the primary and secondary school levels amidst ineffective pedagogical communication, overabundance of work, or evaluation attitudes towards learning. Dweck (2006) discovered that emphasis on stable intellectual skills increases anxiety and less motivation to tackle challenges.

Among pedagogical factors of demotivation are:

- frontal teaching without an individual approach (Brophy, 2010);
- focus on control and testing, not research and discovery;
- absence of ties between studied material and the life of students (Boaler, 2016);
- lack of visualization and application of contemporary digital technologies.

Social problems also play a significant role: parent pressure, teachers' low expectations, lack of support from peers and family. Students who are not supported or criticized are more likely to experience a decrease in self-confidence, leading to a decrease in interest and motivation (Eccles & Roeser, 2009).

## **1.8 Cultural Context and Motivation**

Cultural values significantly influence students' motivation and attitudes towards learning, especially in mathematics education. In collectivist societies, such as Kazakhstan and many other Central Asian countries, academic success is often viewed not only as a personal achievement but as a reflection of family honor and societal expectations (Hofstede, 2001). This cultural emphasis can create both positive and negative motivational forces. On one hand, strong family and community support can encourage persistence and dedication. On the other hand, excessive pressure to perform may lead to increased anxiety, fear of failure, and ultimately demotivation (Salili et al., 2001). Comparative studies have highlighted that students from collectivist cultures tend to experience higher levels of external motivation, driven by the desire to meet family and societal expectations (Markus & Kitayama, 1991).

Furthermore, research suggests that cultural attitudes toward mathematics itself may shape students' motivation. In some educational systems, mathematics is perceived as a prestigious subject, leading to higher expectations and potential stress for students (Leung, 2001). However, limited studies have examined how these cultural factors interact with students' self-efficacy, mindset, and engagement in the Kazakhstani context, pointing to an important direction for future research.

Cultural values significantly influence students' motivation and attitudes toward learning, particularly in subjects such as mathematics. In many educational

psychology frameworks, motivation is often viewed as an individual trait, yet research increasingly recognizes that the cultural environment plays a vital role in shaping how learners approach academic tasks. In collectivist societies such as Kazakhstan and other Central Asian countries, academic success is often viewed not only as a personal achievement but also as a contribution to the family's status and well-being (Hofstede, 2001). In these settings, motivation is deeply intertwined with values such as obedience, respect for elders, and group harmony. As a result, students may pursue academic goals not solely out of personal interest, but to fulfill family expectations and maintain social reputation.

This cultural emphasis can generate a dual effect on student motivation. On one hand, strong support from family and the broader community can foster persistence, resilience, and a deep sense of responsibility in learners. Students may develop a commitment to their studies due to the collective goals shared within the family or community. On the other hand, the pressure to meet high academic expectations can create emotional stress and anxiety, especially in competitive subjects like mathematics. When students perceive their self-worth as being conditional on academic success, fear of failure can become a powerful demotivating force (Salili et al., 2001). For instance, in cases where a student underperforms on a mathematics test, the emotional consequences may go beyond personal disappointment, extending to a sense of having let down one's family or community.

Studies comparing motivation across cultures have consistently shown that students from collectivist societies report higher levels of external motivation. In particular, they are more likely to be driven by the desire to fulfill expectations from parents, teachers, and society at large (Markus & Kitayama, 1991). This form of motivation, often categorized as introjected regulation in motivational theories, can be powerful in driving effort but is also fragile when outcomes are not favorable. If students internalize academic failure as a source of shame or disappointment, their long-term engagement may decline. Consequently, educators working in collectivist cultures need to be especially sensitive to the social-emotional dimensions of motivation, and strive to balance encouragement with psychological support.

In Kazakhstan, these dynamics are especially relevant given the country's educational landscape and cultural heritage. Success in academic subjects such as mathematics is often associated with discipline, intelligence, and future professional opportunity. For many students and their families, high achievement in math is seen as a gateway to respected careers in engineering, economics, or technology. This adds another layer of societal significance to mathematics performance, which in turn can elevate the stakes for students. Leung (2001) notes that in many Asian educational systems, mathematics is viewed as a prestigious and difficult subject, associated with national pride and intellectual rigor. This perception can increase motivation in some

students, but also leads others to feel overwhelmed, especially when the subject is taught in a rigid or highly competitive environment.

In classrooms where mathematics is emphasized as a measure of student capability, the risk is that students who struggle with the subject may feel stigmatized. Cultural narratives that associate success with intelligence can lead to fixed mindsets, where students believe that mathematical ability is innate rather than developable. If students from a young age internalize the belief that they are “not good at math,” this mindset can become reinforced through repeated failure and lack of support, eventually contributing to long-term demotivation. Such outcomes may be more pronounced in cultures where failure is less openly discussed and where academic success is tied to family reputation.

Furthermore, the role of language and cultural communication styles in education must be considered. In many Central Asian classrooms, there is a traditional emphasis on teacher authority and student passivity. This may limit students' opportunities to ask questions, express confusion, or engage in discussion-based learning. As a result, students may not develop the self-regulatory or metacognitive skills associated with intrinsic motivation. Encouraging student agency, curiosity, and open dialogue can be especially important in such contexts to counteract passive learning habits. Teachers who create a safe and responsive classroom environment may help shift student motivation from primarily external to more internal and self-directed forms.

The integration of culturally responsive teaching practices has been shown to improve motivation and engagement. When teachers acknowledge and incorporate students' cultural identities and backgrounds into the learning process, students are more likely to feel connected and valued. In the Kazakhstani context, this could include drawing examples from local traditions, community issues, or national history to make math content more relatable. Additionally, involving families in the educational process in meaningful and supportive ways—not just as sources of pressure—can strengthen motivation. For example, when parents are engaged as partners in their children's learning, rather than as enforcers of discipline, students may feel more supported and less afraid of disappointing their families.

Another critical consideration is how cultural values intersect with self-efficacy. Students in collectivist cultures may underestimate their own abilities due to modesty norms or lack of positive reinforcement. If a student is taught that humility is a virtue, they may hesitate to express confidence or pride in their academic skills. While this humility can foster collaboration and respect, it may also obscure the development of self-belief. Since self-efficacy is a strong predictor of motivation and persistence, especially in mathematics (Bandura, 1997), educators must find culturally sensitive ways to build students' confidence without undermining their values.

Unfortunately, there is limited empirical research specifically focused on how cultural factors shape motivation among Kazakhstani students. While international frameworks provide useful insights, they must be adapted and examined in local educational contexts. Future research could explore how cultural beliefs, school structures, and family expectations interact with students' goal-setting behaviors, attitudes toward mathematics, and long-term academic outcomes. Such studies would help inform teacher training and policy development to ensure that motivational strategies are both effective and culturally appropriate.

In conclusion, culture profoundly influences how students understand, pursue, and respond to academic challenges. In collectivist societies like Kazakhstan, the desire to meet family and societal expectations can serve as both a motivating and demotivating force. When educational systems rely heavily on external motivation and social pressure, students may achieve short-term success but risk long-term disengagement if emotional and psychological needs are unmet. Educators must therefore adopt a culturally informed approach to motivation—one that respects traditional values while also fostering autonomy, self-efficacy, and emotional resilience. Only then can learning be both meaningful and sustainable across diverse cultural settings.

### **1.9 The Role of Parental Involvement**

Parental involvement plays a vital role in shaping students' academic motivation, emotional well-being, and achievement, particularly in subjects like mathematics that are often associated with high levels of performance pressure. Positive forms of involvement, such as providing encouragement, setting high but realistic academic expectations, and offering support with homework, have been consistently linked to greater student engagement and success. A comprehensive meta-analysis by Fan and Chen (2001) demonstrated that students whose parents are actively and positively involved in their education tend to exhibit higher levels of intrinsic motivation, stronger work habits, and better academic outcomes.

However, the quality and nature of parental involvement are crucial determinants of its effects. While supportive and autonomy-promoting behaviors tend to enhance student motivation, overly controlling or authoritarian parenting can lead to adverse outcomes. Pomerantz et al. (2007) found that controlling parental behaviors, characterized by excessive monitoring, pressure, or criticism, were associated with increased student anxiety and lower motivation, particularly in mathematics where students often already face challenges to their confidence and self-efficacy.

In mathematics education specifically, supportive parental actions—such as engaging in conversations about math-related topics, showing interest in students' problem-solving efforts, and expressing positive attitudes toward mathematics—can

significantly foster intrinsic motivation and curiosity (Gunderson et al., 2012). These interactions help students perceive mathematics as a valuable and approachable subject rather than an obligatory or intimidating task. On the other hand, research indicates that parents' own emotional experiences with mathematics can directly impact their children's motivation. Maloney et al. (2015) highlighted that parents who experience high levels of math anxiety may unintentionally transmit their negative attitudes and anxieties to their children, leading to increased avoidance behaviors and reduced persistence when faced with mathematical challenges.

The evidence underscores the importance of designing interventions that not only target students but also involve parents in efforts to promote healthy motivational development. Parent-focused workshops, informational sessions, and resources that help parents adopt supportive communication styles, manage their own math-related anxieties, and create positive home learning environments can play a crucial role in shaping students' attitudes and emotions toward mathematics. Such initiatives may help break the intergenerational transmission of math anxiety and promote a more positive and resilient approach to learning.

Motivation is not a static trait but evolves over time, influenced by developmental changes, educational experiences, and social contexts. Longitudinal studies have provided valuable insights into how students' academic motivation changes throughout schooling. For instance, Gottfried et al. (2001) found that intrinsic motivation in mathematics tends to decline from late childhood through adolescence, particularly among students who face repeated academic struggles.

Similarly, Pinxten et al. (2014) observed that declines in motivation are often accompanied by decreases in academic achievement, creating a negative feedback loop that can be difficult to break. These findings highlight the importance of early interventions and sustained support to maintain motivation across critical educational transitions.

Although existing literature provides a rich understanding of factors influencing student motivation, several gaps remain. There is a need for more culturally specific research examining how traditional values, parental expectations, and societal pressures interact with individual motivational constructs in Kazakhstan and similar contexts.

Moreover, while the role of technology in supporting motivation is well-documented in Western settings, studies focusing on its implementation and impact in Central Asian educational systems are scarce. Future research should also explore the long-term effects of technology-enhanced learning interventions and the ways in which digital tools can support not only cognitive but also emotional and social aspects of motivation.

## **1.10 Technological Factors of GeoGebra and Desmos**

The increasing prevalence of smartphone use among middle school students, as highlighted by Cha and Seo (2018), raises concerns regarding its impact on academic motivation. Excessive smartphone use can lead to distractions, reducing time spent on academic tasks, including math homework. Addressing smartphone addiction may be vital for improving students' focus and motivation in mathematics.

### **Desmos and GeoGebra**

Desmos is an interactive graphing calculator and digital learning platform that has gained popularity in mathematics education due to its accessibility, versatility, and ability to engage students in dynamic exploration of mathematical concepts. Unlike traditional static tools, Desmos allows students to visualize mathematical relationships in real time, fostering active learning and deeper conceptual understanding.

Desmos and GeoGebra represent a modern generation of educational technology in math. Desmos, launched in 2011, is widely used in algebra and calculus teaching for its powerful graphing calculator and simulation capabilities. It runs on web browsers and mobile devices, making it highly accessible. Teachers can create interactive Desmos activities where students adjust sliders to see how parameters affect graph shapes, or collaborate in an online environment to solve problems. GeoGebra, first introduced in 2002, has become one of the most popular dynamic mathematics software programs globally. It allows users to construct geometric figures, plot functions, and even perform algebraic computations in one integrated platform. GeoGebra's strength lies in its versatility: a student can draw a triangle and dynamically change its angles and sides while observing measurements update in real time, or graph a function and then alter its equation to see the effect. Both tools are free to use and have a strong community of educators sharing materials, which has accelerated their adoption in many schools. Hoyles (2018) observed that such digital resources are transforming the practices of learning and teaching mathematics by enabling new forms of inquiry and visualization that were not possible with traditional methods (e.g. paper-and-pencil).

The use of Desmos can have a significant impact on students' emotional experiences during mathematics lessons. By enabling immediate feedback and offering an interactive environment, Desmos promotes enjoyment and pride, as students successfully manipulate parameters and observe results. The dynamic nature of the platform can reduce boredom and hopelessness, as learners engage in discovery rather than rote procedures. Furthermore, the collaborative features of Desmos Classroom Activities support positive social interactions, which may decrease anger associated with frustration or isolation during problem solving.

The integration of Desmos into mathematics instruction offers teachers practical ways to design lessons that are more engaging and emotionally supportive. For example:

- Exploration-based tasks using Desmos encourage curiosity and reduce anxiety by allowing students to experiment without fear of making irreversible mistakes.
- Visual and interactive representations help clarify complex ideas, which can enhance students' sense of control over the material.
- Collaborative Desmos activities can foster a sense of community and shared success, counteracting negative emotions linked to isolation.

While Desmos offers significant benefits, its effective use requires thoughtful integration into the curriculum. Teachers need appropriate training to design meaningful activities rather than using the tool solely for demonstration. Additionally, issues of digital access and equity must be considered, as not all students may have reliable access to devices or the internet.

GeoGebra is an open-source dynamic mathematics software that integrates geometry, algebra, calculus, and statistics into a single interactive environment. Its versatility makes it a valuable resource for educators seeking to enhance students' motivation and engagement in mathematics. Unlike traditional teaching tools, GeoGebra allows students to manipulate mathematical objects dynamically and see the immediate consequences of their actions. This interactive nature fosters exploration and discovery, encouraging learners to take an active role in constructing mathematical knowledge.

The use of GeoGebra in mathematics lessons can significantly influence students' emotional responses. By offering a hands-on, visual approach to learning, GeoGebra increases students' enjoyment by making abstract concepts more accessible and engaging. As students successfully complete dynamic constructions or visualize solutions, they often experience pride, reinforcing their belief in their own mathematical abilities.

Importantly, GeoGebra helps combat boredom by transforming routine exercises into exploratory tasks where students can test hypotheses, adjust parameters, and observe results in real time. It provides multiple entry points to problems, which is particularly valuable for reducing hopelessness in students who may struggle with purely symbolic representations. The ability to check and refine solutions visually also reduces anger and frustration, as students feel more in control of their learning process.

GeoGebra's capacity to connect symbolic, numerical, and graphical representations aligns with principles of universal design for learning, supporting diverse learners and promoting inclusivity. This multidimensional approach enhances

cognitive engagement, as students can approach problems from different angles and select strategies that align with their strengths.

Empirical studies support the motivational benefits of GeoGebra. For example, Zengin (2017) found that pre-service mathematics teachers using GeoGebra demonstrated more positive attitudes toward proof and proving tasks, highlighting the tool's potential to increase interest in traditionally challenging areas of mathematics. Similarly, Ünlü and Ertekin (2013) reported that students using GeoGebra in geometry lessons showed higher levels of intrinsic motivation and greater persistence compared to peers taught with conventional methods.

These findings are consistent with the control-value theory (Pekrun, 2006), which posits that emotional experiences in learning contexts are shaped by perceptions of control and the value assigned to tasks. GeoGebra enhances both: it gives students greater control through interactive manipulation, and it increases task value by demonstrating real-world relevance and connections.

In practice, teachers can use GeoGebra to design lessons that nurture positive emotions and minimize negative ones. Examples include:

- Dynamic geometry investigations, where students explore properties of figures by dragging vertices and observing invariant relationships.
- Modeling of real-world scenarios, such as analyzing motion along curves or visualizing statistical data, to highlight the applicability of mathematics beyond the classroom.
- Collaborative projects, where students create and present GeoGebra constructions, fostering communication skills and shared accomplishment.

GeoGebra can also be integrated into formative assessment, allowing teachers to provide immediate, visual feedback and guide students' reasoning in real time.

While GeoGebra offers considerable advantages, its effective use requires careful instructional design. Without clear goals and guidance, students may focus on superficial features rather than developing deep conceptual understanding. Furthermore, equitable access to technology remains a challenge in some educational contexts. To maximize the benefits of GeoGebra, professional development for teachers and infrastructure support are essential.

While tools like GeoGebra and Desmos have significantly transformed mathematics instruction by enabling interactive and visual learning, the ongoing development of emerging educational technologies—particularly those powered by artificial intelligence (AI)—presents new opportunities for enhancing motivation, engagement, and personalization in mathematics education.

One of the most promising areas is the use of AI-driven learning platforms that adapt dynamically to students' learning profiles. These systems analyze student behavior, performance, and patterns of response to provide personalized feedback, adjust task difficulty, and offer targeted support. Luckin et al. (2016) note that such

adaptive systems can sustain learner engagement by reducing frustration and offering tasks that are appropriately challenging — a critical balance in maintaining motivation, especially in mathematics where students often face cognitive overload.

A notable example of this technological evolution is the development of intelligent tutoring systems (ITS). These systems simulate human tutoring by providing step-by-step guidance, real-time assessment, and context-sensitive feedback. Research by VanLehn (2011) demonstrated that students who used ITS environments often achieved learning gains comparable to those working with human tutors, particularly in the area of mathematical problem solving. Furthermore, ITS can offer affective support, responding not only to correctness but also to indicators of frustration or disengagement, which are essential emotional components in sustaining motivation.

Beyond tutoring, AI technologies are increasingly used in adaptive assessment, game-based learning, and learning analytics dashboards. These tools can visualize students' progress, identify learning bottlenecks, and help teachers make timely, data-informed instructional decisions. When integrated with pedagogical strategies that promote growth mindset and self-regulated learning, these systems can foster deeper engagement and reduce emotional barriers like math anxiety.

However, the integration of AI into mathematics education must be approached with critical consideration of pedagogical and ethical dimensions. Holmes et al. (2019) emphasize that technological effectiveness is not merely a function of the algorithm but depends on how it is aligned with instructional goals, classroom practices, and individual learner needs. Additionally, concerns related to data privacy, algorithmic bias, and student autonomy must be addressed. Educational AI should be transparent, equitable, and respectful of learners' rights.

### **Digital Technologies in Mathematics Education**

Over the past decades, educational systems have increasingly emphasized the integration of digital technologies to enhance teaching and learning. This push is grounded in the belief that technology can facilitate more interactive, student-centered learning environments and equip learners with essential 21st-century skills (e.g. problem-solving, critical thinking, and digital literacy). Mathematics, often perceived as abstract and challenging by students, can particularly benefit from technologies that make concepts more tangible. Dynamic mathematics software, graphing applications, and educational games are some examples of digital resources that have been introduced into math classrooms. These tools are rooted in constructivist learning theory, which posits that learners construct knowledge best through active engagement and exploration. Nicaise and Barnes (1996) argued that combining technology with constructivist pedagogy allows students to take a more active role in learning, as technology offers open-ended environments for exploration and immediate feedback. Similarly, Duffy and Jonassen (2013) note that technology can

support authentic learning experiences where students build understanding through interaction and experimentation (as opposed to rote learning). In essence, digital tools can serve as cognitive amplifiers – they extend students’ ability to visualize, manipulate, and experiment with mathematical objects, thereby deepening conceptual understanding.

### **Rationale and Context**

Despite the availability of tools like Desmos and GeoGebra, their implementation in everyday classroom practice is not yet universal. Teachers may face barriers such as insufficient training, limited technology access, or uncertainty about how to effectively integrate these tools into the curriculum. In some educational contexts, there is still a reliance on traditional teaching methods with minimal use of computers or tablets during math lessons. In Kazakhstan, for instance, studies have noted that while students are highly dependent on gadgets in their personal lives, interactive digital tools are underutilized in mathematics lessons. This underutilization represents a missed opportunity to connect with students in a medium they find engaging. It also raises concerns that the education system may not be fully preparing students for a digitally rich world. National education strategies have begun to call for increased “informatization” of education, and schools are gradually acquiring more technology infrastructure. However, effectively using that technology for pedagogical benefit requires evidence-based strategies and teacher development.

Within this context, the current research addresses an important need: to demonstrate how using Desmos, GeoGebra and similar technologies can enhance learning in a real classroom setting. By conducting an intervention in a middle school math class, the study provides a model for how digital tools can be embedded in teaching specific math topics (such as functions and geometry) in alignment with the standard curriculum. The focus on student motivation is also crucial. Mathematics anxiety and disinterest are common issues that educators attempt to overcome; interactive technologies may offer a way to make learning more fun and relevant for students, thus increasing their motivation. Indeed, research suggests that making math instruction more game-like or interactive can improve student attitudes. In a recent Kazakhstani experiment, for example, incorporating interactive digital games into 10th-grade math lessons led to higher engagement and students scoring approximately 50% higher on a math test compared to a control group. These findings underscore the potential impact of digital interventions on student learning and enthusiasm.

### **Educational Significance**

If tools like Desmos and GeoGebra can be shown to improve learning outcomes and motivation, it would support a shift toward more technology-rich pedagogy in mathematics. It could encourage schools to invest in necessary resources (like classroom computers or tablets) and teacher training for technology integration. Moreover, it would contribute to the theoretical understanding of how digital media

influences learning processes in math – for instance, through enhanced visualization, immediate feedback, or increased student agency in learning. This study is grounded in the belief that when used thoughtfully, technology can not only make mathematics more accessible but also cultivate a deeper conceptual grasp and a more positive disposition towards the subject. The following Literature Review examines prior studies that have explored these possibilities, providing a foundation for the expectations and design of the present research.

Finally, the successful implementation of emerging technologies requires adequate teacher training, infrastructure support, and careful curriculum alignment. Teachers need to be not only consumers of these technologies but also collaborators in shaping how they are used. When appropriately implemented, emerging technologies can complement traditional and digital tools like GeoGebra and Desmos, offering a multilayered ecosystem that supports motivation across cognitive, emotional, and behavioral domains. The integration of technology into classrooms has shown a strong potential for increasing motivation and engagement among elementary and middle school students. Research suggests that when educational technologies are interactive, adaptive, and student-centered, they can support intrinsic motivation and deepen engagement with academic content (Deci & Ryan, 2000). For example, digital platforms like Kahoot, Nearpod, and Classcraft allow students to participate actively, receive immediate feedback, and collaborate with peers, which contributes to a more dynamic learning environment (Wang, 2015).

Technology-supported environments also provide personalized learning paths, helping students progress at their own pace and according to their interests. According to Pane et al. (2017), students in personalized digital classrooms demonstrated greater academic growth and reported higher motivation, especially when they had some control over their learning activities. Similarly, gamified learning environments—those that include elements like points, levels, and badges—can boost student persistence and positive emotional responses toward learning tasks (Dicheva et al., 2015).

Furthermore, interactive tools such as GeoGebra and Desmos in mathematics, offer students the opportunity to experiment, visualize, and construct knowledge in ways that traditional textbooks cannot. These tools are especially effective with middle school students, who benefit from visual and kinesthetic engagement (Papadakis et al., 2018).

However, the success of technology integration depends heavily on teacher facilitation and digital literacy. If technology is used only to replicate traditional instruction, its motivational potential is lost (Ertmer & Ottenbreit-Leftwich, 2010). Effective use requires intentional instructional design, scaffolding, and alignment with student needs and learning goals.

Overall, literature indicates that technology-supported learning environments, when used thoughtfully, can significantly increase motivation and engagement among younger learners by offering interactive, personalized, and visually rich experiences.

### **1.11 Teacher-Student Relationships**

The quality of teacher-student relationships is widely recognized as a central factor in shaping students' academic motivation, emotional well-being, and overall school engagement. Positive interactions between teachers and students provide a supportive environment that fosters a sense of belonging, security, and intrinsic motivation to learn. According to Hughes and Cao (2017), teacher-student relationships characterized by warmth, responsiveness, and low conflict are associated with greater academic engagement and achievement across diverse educational contexts.

When students perceive their teachers as caring and supportive, they are more likely to approach learning tasks with confidence and persistence, even in the face of challenges. This supportive dynamic enhances students' perceived control and the value they place on academic tasks — key components of the control-value theory of achievement emotions (Pekrun, 2006). In mathematics education specifically, where anxiety and fear of failure can be particularly pronounced, positive teacher-student relationships can act as a buffer against negative emotional states, reducing feelings of hopelessness, anger, and boredom while promoting enjoyment and pride in learning. Conversely, conflictual or distant relationships with teachers may contribute to student demotivation. When students experience criticism, rejection, or indifference from teachers, they may feel alienated from the learning process, leading to disengagement and avoidance behaviors. Such experiences can exacerbate negative emotions related to mathematics, including frustration and a sense of futility, which in turn lower achievement and increase the risk of long-term disinterest in the subject (Ryan & Deci, 2000).

To address these challenges, educational researchers and practitioners advocate for professional development programs that help teachers cultivate strong, positive relationships with students. Training initiatives may include strategies for effective communication, classroom management that emphasizes respect and inclusivity, and approaches for providing constructive feedback that supports students' self-efficacy. By equipping teachers with these relationship-building skills, schools can create emotionally supportive environments that enhance both the motivation and academic success of students.

Furthermore, interventions aimed at strengthening teacher-student relationships can be particularly impactful for students at risk of academic underachievement or demotivation. For example, mentoring programs or regular check-in meetings between teachers and students can help establish trust and provide personalized

support. These practices contribute to the development of a classroom climate where all students feel valued and motivated to engage in mathematical learning.

Self-Determination Theory (SDT) has been one of the most influential frameworks in understanding student motivation. It posits that intrinsic motivation is fostered when individuals' basic psychological needs for autonomy, competence, and relatedness are satisfied (Deci & Ryan, 1985, 2000). In educational settings, students who feel in control of their learning, capable of success, and connected to their teachers and peers are more likely to engage deeply with academic tasks. Studies have shown that when these needs are thwarted, motivation diminishes, leading to disengagement and poorer academic outcomes (Ryan & Deci, 2000).

Constructivist learning theories emphasize active learning and knowledge construction through exploration and problem-solving (Jonassen, 1999). In mathematics, Boaler (2016) argues that constructivist approaches help students develop a growth mindset by encouraging them to view challenges as opportunities for learning rather than threats to their self-worth. Expectancy-Value Theory (Eccles et al., 1983) further explains motivation as a function of students' beliefs about their likelihood of success and the value they place on the task. This theory highlights how cultural, social, and personal factors shape students' motivation for learning mathematics.

Peer interactions significantly influence students' emotional well-being and academic motivation, particularly during adolescence when peer acceptance becomes increasingly important. Positive peer relationships, characterized by mutual respect, encouragement, and cooperation, can enhance students' sense of belonging in the classroom and promote active engagement in mathematics learning. Cooperative learning structures and group problem-solving activities, for example, have been shown to increase motivation by fostering collaborative rather than competitive dynamics (Hughes & Cao, 2017).

In contrast, negative peer experiences such as bullying, exclusion, or social comparison can have severe consequences for students' motivation and mental health. Victimized students often show signs of psychological distress, withdrawal, and reduced academic performance (Totura et al., 2014). These experiences can contribute to feelings of incompetence and further demotivation, especially in subjects perceived as difficult, like mathematics.

### **1.12 Homework and Motivation in Mathematics**

Homework is often considered a key component of mathematics education, providing students with opportunities to practice skills, consolidate learning, and develop independent problem-solving abilities (Cooper et al., 2006). However, its impact on student motivation is complex and influenced by various factors, including the quality, quantity, and perceived relevance of assignments.

Research indicates that the nature and purpose of homework play a significant role in shaping students' motivational responses. Trautwein et al. (2002) found that homework perceived as meaningful and well-aligned with classroom instruction positively influences student motivation and engagement. Conversely, repetitive or excessively challenging homework can contribute to frustration, anxiety, and demotivation, particularly among students who already struggle with mathematics (Dettmers et al., 2010).

The amount of homework assigned also matters. Excessive homework loads have been associated with increased stress and reduced intrinsic motivation, as students may begin to view mathematics as a source of pressure rather than intellectual curiosity (Kohn, 2006). In contrast, moderate amounts of thoughtfully designed homework can promote a sense of competence and autonomy—two critical components of intrinsic motivation as identified in Self-Determination Theory (Deci & Ryan, 2000).

Parental involvement in homework further mediates its motivational impact. When parents provide supportive help rather than controlling oversight, students tend to develop more positive attitudes toward homework and mathematics in general (Pomerantz et al., 2007). However, parental pressure to achieve high performance on homework tasks can contribute to performance anxiety and avoidance behaviors (Silinskas et al., 2013).

Digital technologies have introduced new dimensions to mathematics homework, offering interactive platforms that can make homework more engaging and personalized. For example, homework tools that provide immediate feedback, hints, or adaptive problem sets may enhance motivation by supporting mastery and reducing frustration (Rosário et al., 2015). However, disparities in access to such technologies can exacerbate existing motivational gaps among students from different socioeconomic backgrounds (Warschauer, 2004).

Finally, recent studies have highlighted the importance of student perceptions of homework purpose. Xu (2005) argues that when students see homework as a tool for learning and self-improvement rather than as mere compliance, they are more likely to approach assignments with interest and persistence. This suggests that teachers can boost motivation by clearly communicating the goals and relevance of homework tasks.

### **1.13 The Role of Emotions in Mathematics Education**

Emotions play a critical role in students' engagement, motivation, and achievement in mathematics. Contemporary educational psychology emphasizes that academic emotions are not simply by-products of learning, but integral components that shape cognitive processes, self-regulation, and performance (Pekrun et al., 2002). Positive emotions such as enjoyment and pride can foster deeper engagement,

persistence, and adaptive learning strategies. Conversely, negative emotions like anger, hopelessness, and boredom are often linked to disengagement, avoidance behaviors, and lower academic outcomes (Pekrun & Perry, 2014).

In the context of mathematics, where students frequently encounter challenges that test their cognitive and emotional resources, it is particularly important to understand and measure these emotional experiences. The Achievement Emotions Questionnaire—Mathematics (AEQ-M) was designed precisely for this purpose, to provide a comprehensive assessment of students' emotional responses specific to mathematics learning and testing situations (Schukajlow et al., 2023).

Emotions play a critical role in students' engagement, motivation, and achievement in mathematics. Contemporary educational psychology emphasizes that academic emotions are not simply by-products of learning but integral components that shape cognitive processes, self-regulation, and performance (Pekrun et al., 2002). Positive emotions such as enjoyment, pride, and interest can foster deeper engagement, persistence, and adaptive learning strategies. Conversely, negative emotions like anger, hopelessness, anxiety, and boredom are often linked to disengagement, avoidance behaviors, and lower academic outcomes (Pekrun & Perry, 2014). In many cases, emotions experienced in mathematics class can either fuel a student's desire to engage further or trigger withdrawal and resistance to learning.

The mathematics classroom, in particular, presents a unique emotional landscape for students. Mathematics is often perceived as a high-stakes, performance-driven subject, where answers are either right or wrong, and feedback is immediate. As a result, students may develop emotional responses based on success or failure experiences. Repeated struggles with mathematical content can lead to feelings of shame or incompetence, especially among students who have internalized the belief that mathematical ability is innate. These beliefs can make students more vulnerable to negative emotions, particularly math anxiety, which is one of the most well-documented affective barriers in math education (Ashcraft & Krause, 2007).

Math anxiety is characterized by feelings of tension, apprehension, or fear that interfere with math performance (Hembree, 1990). Students experiencing math anxiety often avoid math-related tasks, underperform on tests, and develop a fixed mindset about their capabilities. Importantly, this emotional response can start in early childhood and become more deeply rooted over time if not addressed. In middle school, where academic expectations increase and students begin to compare themselves to peers more critically, negative emotions around math can intensify. High levels of math anxiety have also been associated with deficits in working memory, further compounding performance difficulties (Ramirez et al., 2013). Teachers and schools must therefore be equipped to recognize and address these emotional challenges, rather than treating them as mere side effects of poor performance.

Positive academic emotions, by contrast, have been shown to enhance mathematical engagement and achievement. When students experience enjoyment while solving problems, or pride after mastering a new concept, they are more likely to persist through difficult tasks and use deeper processing strategies. Pekrun's (2006) Control-Value Theory of Achievement Emotions argues that emotions in academic settings are shaped by two key appraisals: the perceived control over learning activities and the value attached to those activities. For example, a student who believes they can influence their success (high control) and who finds math useful or interesting (high value) is more likely to experience enjoyment, hope, and pride. Conversely, low control and low value predict emotions such as anxiety, hopelessness, and boredom. This theoretical framework provides a helpful lens for understanding why some students become emotionally disengaged while others thrive.

Measurement of academic emotions has advanced in recent years. Tools such as the Achievement Emotions Questionnaire – Mathematics (AEQ-M) offer researchers and educators a structured way to assess students' emotional responses to learning and testing in mathematics. Developed by Schukajlow et al. (2023), the AEQ-M evaluates a wide range of emotions—including enjoyment, pride, anger, anxiety, hopelessness, and boredom—experienced during class, while learning, or during assessments. By distinguishing between these contexts, the instrument helps identify specific emotional patterns that may influence different aspects of learning behavior. For instance, a student might enjoy math lessons but still experience high anxiety during tests, suggesting the need for test-specific interventions. The AEQ-M's validated structure also allows educators to track emotional development over time and evaluate the effectiveness of emotional support strategies in the classroom.

Incorporating emotional awareness into teaching practices is increasingly viewed as essential for fostering a supportive learning environment. Teachers who recognize and respond to students' emotional cues—such as frustration, confusion, or enthusiasm—can more effectively guide them toward positive learning experiences. Research shows that emotionally supportive classrooms, where students feel safe to make mistakes and receive constructive feedback, can reduce the impact of negative emotions and promote resilience (Meyer & Turner, 2006). Practical strategies may include encouraging growth mindset language (e.g., praising effort over results), integrating collaborative problem-solving to reduce isolation, and using humor or storytelling to make math more engaging.

Furthermore, emotional competence is not only important for students—it is equally relevant for teachers. Teachers who exhibit emotional regulation, empathy, and positive affect create atmospheres where students are more likely to engage emotionally. A study by Frenzel et al. (2009) found that students were more likely to enjoy math when their teachers showed genuine enthusiasm for the subject. This

emotional contagion demonstrates how teacher affect can shape classroom mood and, by extension, student motivation and performance. In contexts where students already face cultural or psychological pressures related to mathematics, a teacher's emotional presence may serve as a buffer against fear and anxiety.

The integration of technology in mathematics instruction has also opened new pathways for managing emotions. Tools like Desmos and GeoGebra offer students an interactive and exploratory learning experience, reducing the pressure associated with traditional problem-solving. By allowing students to visualize abstract concepts and experiment freely without fear of making permanent mistakes, these tools can alleviate anxiety and build confidence. As noted in the findings of this research, the 7L class that used Desmos showed increased levels of motivation and a more positive emotional response to math tasks compared to the traditionally taught 7K class. This suggests that digital tools, when thoughtfully integrated, may help address the emotional needs of students alongside their cognitive ones.

Another key consideration is how emotional experiences differ across student populations. For example, studies have shown that girls often report higher levels of math anxiety than boys, despite similar levels of ability (Else-Quest et al., 2010). Similarly, students from marginalized or underrepresented groups may experience emotional barriers due to stereotype threat or lack of representation in math-related fields. Addressing these disparities requires a holistic approach that combines culturally responsive teaching, emotional validation, and targeted academic support.

In conclusion, emotions are not peripheral to mathematics education—they are central to it. Students' emotional experiences in math class influence how they approach tasks, how long they persist, and how they define themselves as learners. While positive emotions can empower and energize students, negative emotions can inhibit learning and create long-lasting aversions to the subject. Tools like the AEQ-M offer valuable insights into these emotional patterns, enabling educators to design more emotionally intelligent instruction. By acknowledging and addressing the emotional dimensions of mathematics learning, educators can create classrooms that are not only intellectually stimulating but also psychologically safe and motivating.

### **1.14 Students' Perspectives on Key Motivational Factors**

Understanding what students themselves view as the most influential factors on their motivation in mathematics offers valuable insights for educators and policymakers. Several recent studies have explored these perspectives through surveys, case studies, and experimental designs, revealing a complex interplay of internal, social, and environmental influences.

#### **1. Teaching Practices and Classroom Environment**

A study of over 2,000 secondary students in Spain found that students with higher motivation consistently rated their teachers' instructional practices more

positively. Specifically, clarity of instruction, teacher enthusiasm, and constructive feedback were strongly correlated with increased engagement (Frontiers in Psychology, 2022). Students emphasized that well-structured lessons, interactive explanations, and emotional support from teachers helped them feel more confident and willing to participate in mathematics tasks.

## **2. Use of Learning Resources and Study Habits**

The same study also highlighted that access to quality study materials and disciplined study routines significantly influenced student motivation and performance. Students reported that using tools such as videos, practice sets, and collaborative study sessions helped them take control of their learning and increased their intrinsic interest in mathematics.

## **3. Sense of Competence and Intrinsic Motivation**

A person-centered study of 863 students aged 9–13 identified distinct motivational profiles based on differences in perceived competence and intrinsic motivation. Students who believed they were good at math and genuinely enjoyed it reported significantly fewer negative emotions and performed better academically. These findings reinforce the notion that developing students' self-perceptions and interest is critical for sustained motivation.

## **4. Peer Support and Classroom Climate**

Survey data from middle and high school contexts indicate that positive peer relationships and a collaborative classroom climate are closely associated with higher motivation. In contrast, classrooms characterized by competition, isolation, or bullying negatively impacted students' emotional well-being and inclination to engage (Hughes & Cao, 2017; Totura et al., 2014).

## **5. Social and Family Influences**

In a case study of Grade 10 students in Namibia, learners reported that family encouragement, teacher support, and role models in their community were key motivational drivers. When family members valued mathematics and discussed its applications, participants felt more motivated to see practical relevance in their studies. Conversely, many admitted their engagement was driven primarily by the requirement to pass exams rather than genuine interest.

*Table 1.14.1 Summary of Student-Reported Motivational Factors in Mathematics*

Reported Factor	Description
Teaching quality & feedback	Clarity, enthusiasm, and constructive correction by teachers
Study resources & routines	Access to materials and disciplined study habits
Perceived competence & intrinsic enjoyment	Belief in ability and genuine interest in mathematics
Peer support & classroom climate	Collaborative, non-threatening peer interactions
Family encouragement & real-world relevance	Parental support and subject relevance to daily life

### **Implications and Synthesis**

These findings underscore that students' motivation is not driven by a single factor but by the synergistic interaction of internal beliefs, teacher behaviors, peer climate, and family environment. Students consistently highlight:

- The importance of teacher-student relationships, where clarity and emotional support foster confidence and engagement.
- The role of external resources and structured study habits in maintaining persistence.
- The significance of seeing themselves as competent and genuinely interested in the subject.
- The impact of supportive peer environments that encourage collaboration and well-being.
- The value of family involvement and real-world connections which anchor learning in everyday relevance.

For educators, these insights suggest that to enhance student motivation, interventions should be holistic, combining strategies such as effective teaching, resource provision, peer collaboration, and family engagement. A singular focus (e.g., only improving resources) may be insufficient unless reinforced by positive social and environmental support.

Despite the wealth of information available, several knowledge gaps persist in understanding the demotivation of middle school math students. For instance, while psychological and social factors have been extensively studied, there is a lack of longitudinal research that explores how these factors interact over time. Future studies could focus on longitudinal designs that track changes in motivation throughout the middle school years.

Moreover, the impact of emerging technologies on student motivation remains underexplored. As digital learning tools become more prevalent, understanding how these tools can either contribute to or alleviate demotivation in mathematics is essential. Research could investigate the effectiveness of gamified learning environments or interactive apps in promoting sustained engagement in math.

According to the analysis of recent literature, demotivation of teaching mathematics is an important process to study. An effective response to opposition requires a psychological knowledge of the affective condition of students as well as innovations in pedagogy, including active use of modern technologies such as GeoGebra and Desmos.

### **1.15 About Teaching Strategies to increase Motivation and Engagement**

It is well known that good teaching methods and strategies boost student engagement, which in return makes learning for students easier, important and more enjoyable. Children and adolescents will thrive academically in classrooms where they feel connected to their teacher and their peers (Ryan, Connell and Deci, 1985; Connell and Wellborn, 1991). According to Vickery (2014), most of the teaching methods push for the idea that children have to take interest in subjects which in return makes them develop their thinking, which then leads to the rich engagement in the classroom: "All children regardless of age and attainment will benefit from an education that focuses on the development of thinking skills. This approach will provide opportunities for children to be involved in the planning of their work and be creative and reflective".

There are a lot of teaching methods, but most of the times teachers tend to use methods during which teachers often provide answers instead of giving opportunities for students to find the answer themselves (Astuti & Lammers, 2017). Doing so often gives students another reason to not be motivated enough to solve problems themselves. Depending on the subject being studied, there are requirements for assignments that students must submit. There are findings that most of these students can't cope with their tasks given (Krawitz & Schukajlow, 2018). These findings also suggest that this is one of the reasons which lead to student demotivation (Tanaka, 2017). If the amount of work given by a teacher exceeds the amount student can do, it often demotivates them.

Effective teaching strategies can significantly boost student engagement and motivation, making the learning process more enjoyable and meaningful for students. High levels of engagement not only enhance students' academic performance but also contribute to a positive attitude toward learning. Research has shown that children and adolescents thrive academically when they feel a sense of connection and belonging in the classroom. In fact, students tend to perform better in environments where they

feel personally connected to their teacher and peers (Ryan, Connell, & Deci, 1985; Connell & Wellborn, 1991). Fostering such positive relationships and a supportive classroom climate is therefore a fundamental strategy for increasing motivation and engagement.

### **Building a Supportive and Connected Classroom Environment**

One key factor in student motivation is the teacher–student relationship. When teachers cultivate a warm, respectful, and supportive rapport with students, it satisfies learners’ need for relatedness and encourages greater engagement in class activities (Connell & Wellborn, 1991). Simple practices such as showing genuine interest in students’ lives, listening to their opinions, and maintaining an inclusive atmosphere can make students feel valued. This sense of belonging and emotional safety in turn motivates them to participate actively and take risks in learning. Additionally, peer connections are important – designing opportunities for students to collaborate and learn from each other helps build a community of learners where everyone feels accountable and supported. By nurturing trust and positive relationships in the classroom, teachers lay the groundwork for students to be more invested in their learning.

### **Promoting Active Learning and Participation**

Beyond relationships, the method of instruction plays a critical role in engagement. Studies have identified that excessive teacher lecturing can be demotivating for students. In one study, the most frequently cited demotivating factor was that teachers “*lecture too much*,” leading students to disengage. Many students prefer teaching strategies that require them to participate actively in class and work with their classmates, rather than passively listening to lectures. This suggests that shifting toward active learning approaches can greatly increase motivation.

Active learning strategies include class discussions, hands-on activities, problem-solving tasks, group work, and other methods where students are actively involved in the learning process. For example, rather than simply providing answers, teachers can pose thought-provoking questions, facilitate small group problem-solving, or use the Socratic method to guide students to discover answers themselves. Research emphasizes that learners should be given opportunities to find or produce answers on their own, instead of being told solutions directly (Astuti & Lammers, 2017). This kind of student-centered approach encourages deeper cognitive engagement and gives students a sense of accomplishment, thereby boosting their intrinsic motivation. In practice, a teacher might present a real-world problem and allow students to brainstorm solutions in teams or use project-based learning so that students actively explore and apply concepts. Such interactive techniques not only make lessons more engaging but also improve understanding and retention of material.

Another aspect of active learning is incorporating collaboration and discussion. Allowing students to work together on assignments or discuss ideas enables peer learning and keeps them engaged. Cooperative learning techniques (e.g. jigsaw activities, group projects) with individual accountability ensure that every student participates meaningfully (Astuti & Lammers, 2017). These methods tap into students' social nature and can make learning more enjoyable. Overall, by minimizing one-way lecturing and maximizing student participation, teachers can create a more dynamic classroom where students are motivated to be involved.

### **Encouraging Student Autonomy and Interest**

Motivation flourishes when students feel a sense of ownership over their learning. Autonomy-supportive teaching — giving students choices and a voice in their learning — is a powerful strategy to increase engagement. Decades of research conclude that providing students with choices increases their autonomy and, in turn, their motivation and engagement. Students are more motivated to complete a task, and often perform better, when they have some control over how they learn or how they demonstrate their learning. For instance, teachers can let students choose from several project topics or decide which book to read for an assignment. Even small choices, like selecting which problems to solve or which role to take in a group activity, can enhance students' interest and investment in the task. By offering structured choices, teachers foster a sense of agency in students, which leads to greater enthusiasm and persistence in learning.

Involving students in planning and decision-making not only boosts motivation but also cultivates important thinking skills. According to Vickery (2014), all children – regardless of age or ability – benefit from an education that focuses on developing thinking skills and invites them to be active participants in the learning process. This approach means providing opportunities for students to help plan aspects of their work, and to be creative and reflective in their studies. For example, a teacher might involve the class in co-creating a project rubric or brainstorming topics they want to explore in a unit. Such involvement gives students a stake in the process and makes learning more relevant to them. Vickery notes that when students are involved in planning and encouraged to think critically and reflect on their own learning, they become more focused and develop traits like curiosity and confidence.

Teachers can also boost engagement by connecting lessons to students' interests and real-life experiences. If students see the personal relevance or importance of what they are learning, they are more likely to be intrinsically motivated. For instance, incorporating examples, projects, or readings that relate to students' cultural backgrounds or current hobbies can spark interest. The key is to tap into what students care about and show how the subject matter connects to the real world. This relevance, combined with autonomy, creates a powerful motivator:

students feel that they are pursuing learning for their own purposes, not just because the teacher said so.

### **Ensuring Optimal Challenge and Support**

Another crucial strategy is to tailor the difficulty and amount of work to the right level – what educational psychology often calls the optimal challenge. Students are most motivated when tasks are neither too easy (boring) nor overwhelmingly difficult. If the amount or difficulty of work given exceeds what students can handle, it can demotivate them. There is evidence that many students become discouraged when they “*can hardly cope with their assigned tasks*” (Krawitz & Schukajlow, 2018). In such cases, students may feel helpless or develop a low sense of competence, which reduces their motivation to continue. Tanaka (2017) likewise found that students’ perceived competence plays a decisive role in motivation – when learners continually feel incapable of meeting task demands, they are likely to disengage. For this reason, teachers should be mindful of balancing high expectations with adequate support.

Differentiating instruction is one way to achieve this balance. This means adjusting tasks to different ability levels or providing scaffolding (such as hints, guided practice, or step-by-step support) so that all students can experience success. When students are challenged just beyond their current ability – a level that stretches them but is still attainable with effort – they often enter a state of engagement and productive struggle that promotes learning. On the other hand, consistently overwhelming students with excessive homework or overly complex projects without support will likely cause frustration and apathy. Teachers can increase motivation by breaking large tasks into manageable steps, offering feedback and help when needed, and celebrating incremental progress. Each small success builds students’ confidence in their abilities. Over time, as students feel more competent, their intrinsic motivation to tackle new challenges grows.

In addition, it’s important for teachers to monitor the workload and pacing of the class. Checking in frequently on how students are handling the assignments can provide clues if many are feeling overloaded or bored. With this information, teachers can adjust deadlines, modify the quantity of work, or incorporate lighter, engaging activities when needed. The goal is to keep students in that optimal zone where they are working hard but not giving up. By ensuring that learning activities are appropriately challenging and providing support for students to meet those challenges, teachers help sustain students’ motivation and engagement throughout the course.

### **Making Learning Stimulating and Relevant**

Finally, effective teaching strategies strive to make learning stimulating, varied, and relevant. Even a well-intentioned method can fall flat if it does not capture students’ interest. Research on demotivation has pointed out that uninteresting or

monotonous classroom activities can lead students to disengage. In the earlier-mentioned study, another top complaint was that classroom instruction and activities were not motivative enough to hold students' attention. To combat this, teachers should incorporate a variety of activities and interactive techniques that arouse curiosity. This could include educational games, multimedia resources, debates, experiments, or field trips – anything that adds novelty and breaks the routine in a productive way. When students are curious or excited about a lesson, they are naturally more motivated to participate.

Moreover, aligning lessons with real-world applications can make learning feel more meaningful. For example, a math teacher might show how a concept applies to everyday life or future careers, or a literature teacher might connect themes from a novel to current social issues. If students understand why the material matters, they are more likely to engage with it. Teachers can explicitly discuss the purpose of a lesson or ask students to reflect on how what they learned could be useful outside of school. Relevance energizes learners by giving them a sense of purpose.

It's also beneficial for teachers to be responsive to student feedback about what is working or not. If certain activities consistently fail to engage, a teacher can try a different approach. On the other hand, if something really captivates students (say, a particular project or discussion format), then finding ways to do more of that can maintain high motivation. Good teachers are flexible and ready to adjust their strategies to keep students interested. As noted by educational researchers, instructors should monitor students' motivation levels and be willing to modify their methods to re-engage learners when attention fades. This might mean infusing a bit of fun, offering a brain break, or connecting the topic to a student's question.

In summary, increasing student motivation and engagement involves a combination of supportive relationships, active learning, autonomy, appropriate challenge, and stimulating content. Teachers who build trusting relationships and foster a sense of belonging set the stage for engagement. By using active, student-centered teaching methods and giving students more autonomy, teachers tap into students' natural curiosity and drive to learn. Ensuring that tasks are challenging but achievable helps maintain students' confidence and willingness to put in effort. And by keeping learning activities varied, relevant, and interesting, teachers can capture students' attention and sustain their enthusiasm. Implementing these strategies creates a positive feedback loop: motivated, engaged students are more likely to succeed, and their success further fuels their motivation. In such classrooms, learning becomes not just easier for students, but also more important and enjoyable – exactly the outcome that effective teaching aims to achieve.

## 1.16 Impact on Achievement and Understanding

Many studies have reported that students taught with the aid of digital tools perform better on assessments than those taught by traditional methods. For example, an experimental study by Zulnaldi and Zakaria (2012) found that the use of GeoGebra software led to significantly higher conceptual and procedural knowledge scores in a high school algebra class (focused on functions) compared to a control group without GeoGebra. In a follow-up study, Zulnaldi et al. (2020) observed a similar positive effect of GeoGebra on students' mathematics achievement, noting that the GeoGebra group outperformed the traditional teaching group on post-test scores. These improvements are often attributed to the visual and interactive nature of the software – students can see the immediate impact of changing a variable or moving a point on a graph, which helps to solidify their understanding of relationships and correct misconceptions. Research by Bakar et al. (2015) further supports these findings: their work showed that instruction with GeoGebra improved Malaysian students' performance on quadratic function problems, regardless of the students' initial levels of spatial visualization ability. The dynamic representation of functions in GeoGebra helped students grasp concepts that might remain abstract in a textbook-only approach.

Digital tools have also proven effective in teaching specific mathematical concepts through exploration. Abadi and Fardah (2018) analyzed how students learn the concept of function transformations (shifting graphs) using GeoGebra. They found that students engaged in trial-and-error with the software, formulating and testing conjectures about how graphs shift when parameters change. This exploratory process allowed students to learn from mistakes and gradually deduce the general rules of transformations, leading to a robust understanding that they could articulate and support with examples. Similarly, King (2017) reported that high school students who used Desmos in learning about algebraic functions developed a deeper conceptual understanding of functions' domains and ranges and how parameter changes affect graph shapes. King's study noted that with Desmos, students could investigate families of functions interactively – for instance, by manipulating a slider to see how the graph of  $y = mx + c$  changes – which made abstract concepts more concrete. The students in the Desmos-supported class showed higher achievement on function topics and were able to explain concepts like slope and intercept more clearly than those in a traditional class. These findings echo earlier research on graphing calculators which suggested that technology can help build a “versatile

understanding” of algebraic concepts by linking multiple representations (graphical and algebraic).

It should be noted that not all studies found uniform benefits to all students. For instance, Ocak (2008) examined university students using graphing calculators for complex function problems and discovered that merely providing technology did not guarantee improved performance. Students with prior experience and positive attitudes toward technology benefited the most, while those less experienced sometimes struggled to use the tools effectively. In Ocak’s study, some students used the graphing tool to manually check graphs but without fully understanding the underlying concepts, resulting in no significant performance gains over non-technology users. This suggests that the effectiveness of digital tools can depend on how they are implemented and on students’ familiarity with them. When well-implemented, however, the consensus from numerous studies is that technology-enhanced teaching can address common learning difficulties in mathematics. Indeed, a systematic review by Hoyles (2018) concluded that digital technology, when combined with good pedagogy, has the potential to transform mathematical learning by allowing learners to visualize and experiment with mathematical objects in ways that improve understanding.

### **1.17 Impact on Motivation and Engagement**

Beyond test scores, researchers have explored how digital tools affect students’ motivation, interest, and attitudes toward mathematics. The evidence here is largely positive. Selçik and Bilgici (2011) reported that teaching a geometry unit (polygons) with GeoGebra increased students’ enthusiasm for learning and made it easier for them to grasp basic geometric concepts. Students in that study found the lessons more engaging than usual, which the authors attributed to the immediate visual feedback and interactive nature of the software – instead of passively listening to a lecture, students were actively constructing and measuring shapes themselves. Another study on teaching the Pythagorean theorem with GeoGebra (İçel, 2011) found not only improved test performance but also better retention of knowledge over time. Students remembered the material longer, presumably because the interactive learning experience was more memorable and helped them form stronger cognitive connections. Research has also shown that technology-enhanced math classes can be more enjoyable and participatory. Bagcivan (2005) observed that when students used dynamic software, the classroom atmosphere became livelier – students were eager to

try things out on the computer, share their discoveries, and even engage in friendly competition on who could solve a problem faster or in a novel way. Similarly, Topuz and Birgin (2020) documented that 7th graders working with GeoGebra on a circles topic were more involved in discussions and demonstrated a positive competitive spirit that spurred learning. These studies suggest that digital tools can reduce the boredom and fear often associated with math by making learning more game-like and exploratory.

The use of Desmos has also been linked to improved student attitudes. Teachers surveyed by McCulloch et al. (2018) indicated that students found Desmos-based activities “fun” and that the platform’s ease of use encouraged students to experiment more with math problems. In those classrooms, students often worked at their own pace with Desmos, which helped to personalize learning – a factor that can increase both confidence and interest. Additionally, Fabian et al. (2016), in their study of mobile technology in math, found significant gains in student engagement: students using apps and software were more likely to participate actively and spent more time on-task during lessons than those in conventional settings. The interactive nature of technology (immediate feedback, multimedia elements, etc.) caters to diverse learning styles and often makes mathematical exploration feel like solving a puzzle or playing a game, which can be intrinsically motivating.

Importantly, increased motivation is not only a feel-good outcome; it can translate into better learning. When students are motivated and engaged, they tend to put forth more effort, persist through challenges, and employ deeper learning strategies. By making lessons more engaging, tools like GeoGebra and Desmos may indirectly boost achievement as well. In fact, the experimental study by Taukebayeva and Bakirova (2024) provides a compelling example: they introduced interactive digital game elements into math lessons and observed that the experimental group’s higher engagement levels coincided with significantly better test performance (half again as much as the control group’s scores). This aligns with the broader literature that sees engagement as a mediator between instructional innovation and learning outcomes.

## 2. METHODOLOGY

### 2.1 Theoretical Rationale and Validity of the Questionnaire

Measuring emotions in mathematics: the Achievement Emotions Questionnaire—Mathematics (AEQ-M from now on). The development of the AEQ-M is grounded in control-value theory, which posits that achievement emotions are determined by students' perceptions of control over learning activities and the value they assign to these activities (Pekrun, 2006). According to this theory, emotions arise from appraisals of whether students believe they can succeed (control) and whether they consider the task important or interesting (value).

The items in the AEQ-M, and by extension in the translated questionnaire used in the current study, are designed to capture these appraisals and the resulting emotional states. By aligning the items with control-value theory, the questionnaire ensures that it measures the constructs that are theoretically linked to motivation and achievement outcomes in mathematics.

The Achievement Emotions Questionnaire—Mathematics (AEQ-M) is grounded in control-value theory of achievement emotions, which posits that students' emotional experiences depend on two central appraisals: their perceived control over academic tasks (such as competence) and the value they attach to those activities (Pekrun, 2006). In this framework, emotions such as enjoyment, anxiety, pride, hopelessness, and boredom arise from specific combinations of control and value. High perceived control and value promote positive emotions, while low control and low value foster negative emotions (Pekrun & Perry, 2014).

The AEQ-M was developed specifically to assess emotions in mathematics, and it is an adaptation of the domain-general AEQ. The instrument consists of 60 self-report items that measure seven discrete emotions—enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom—across three academic contexts: class, learning, and test situations (Schukajlow, Rakoczy, & Pekrun, 2023). For example, a class-related enjoyment item reads, “I enjoy my math class,” while a test-related anxiety item states, “When I have an upcoming math test, I get sick to my stomach.” By evaluating emotions in different contexts, the AEQ-M captures the assumption that academic emotions are context-dependent and vary based on whether the student is in class, learning independently, or preparing for an exam.

In addition to context specificity, the AEQ-M uses a multicomponent structure for each emotion in accordance with the theory's view that emotions involve affective, cognitive, motivational, and physiological/expressive dimensions. For instance, anxiety items might assess worry (cognitive), urge to escape (motivational), tension (affective), and somatic symptoms (physiological). This design allows researchers to capture the complex nature of students' emotional experiences in mathematics.

About construct validity, validation studies conducted with middle- and high-school students (Study 1:  $N = 781$ ; Study 2:  $N = 699$ ) showed that the AEQ-M's seven emotions are statistically distinguishable across contexts. The pattern of correlations observed between emotions and control-value appraisals followed theoretical predictions. Confirmatory factor analyses supported the model structure, with a seven-emotion by three-context model showing excellent fit indices ( $CFI = .978$ ,  $RMSEA = .057$ ), which were superior to simpler models. Internal consistency was also high across all scales (Cronbach's alpha ranging from .84 to .96), confirming the reliability of the questionnaire.

Furthermore, studies confirmed that control and value appraisals are significant predictors of emotional responses. Students with high perceived control and value were more likely to report positive emotions such as enjoyment and pride, while those with low control and value were more likely to experience emotions like anxiety and hopelessness. These emotional states, in turn, have shown strong associations with motivational variables such as interest, goal orientation, learning strategies, and mathematics performance.

In summary, the AEQ-M is a well-established, theory-based instrument for measuring students' emotional experiences in mathematics. It is directly aligned with control-value theory, covers seven distinct emotions across three educational contexts, and employs a multidimensional structure that reflects the complexity of emotional experience. Its psychometric validation supports both its reliability and its theoretical integrity.

In the current study, a translated version of the AEQ-M was used. Based on the original version, this translation preserved the context-specific structure and multicomponent format of the items, ensuring theoretical alignment and comparability. As such, the instrument offers a valid and reliable means to examine the emotional side of mathematics learning and its connection to motivation and achievement.

## **2.2 Structure and Content Validity of the AEQ-M**

The AEQ-M covers a range of emotions relevant to mathematics, including enjoyment, pride, anger, hopelessness, and boredom. These categories represent both positive and negative emotions, as well as activating and deactivating emotions, providing a comprehensive picture of students' affective experiences.

Each set of items was carefully developed and validated to reflect the specific characteristics of these emotions. For example:

- **Enjoyment items** assess students' positive feelings during math learning, such as enthusiasm and fun.
- **Pride items** target students' satisfaction with their performance and sense of accomplishment.

- **Anger items** focus on frustration and irritation experienced during math tasks.
- **Hopelessness items** reflect feelings of resignation and perceived inability to succeed.
- **Boredom items** capture disengagement and lack of interest.

The questionnaire was subjected to extensive psychometric evaluation, including factor analysis, to ensure that each item loads appropriately onto the intended factor (Schukajlow et al., 2023). The high internal consistency reported in the validation studies supports the reliability of these scales.

### **2.3 Questions' validity**

The translated items in the current study preserve the essential structure and wording of the original AEQ-M items. This alignment ensures that the questions validly measure the emotional constructs they are intended to capture. Since the AEQ-M was developed through rigorous empirical testing, including exploratory and confirmatory factor analyses, the translated version inherits this robustness, provided that the translation was done carefully and contextually adapted (Schukajlow et al., 2023).

Moreover, each question reflects specific components of emotional experience: affective, cognitive, motivational, and physiological. For instance, items addressing hopelessness not only tap into emotional states but also capture related cognitions (e.g., thoughts of failure) and motivational consequences (e.g., giving up). This multidimensionality ensures that the questionnaire captures the complexity of students' emotional responses.

### **2.4 Practical Significance and Applications**

By measuring these emotions, educators and researchers can identify patterns that influence students' motivation and academic outcomes. For example, high levels of boredom and hopelessness may signal the need for interventions aimed at increasing engagement or modifying instructional practices. Similarly, recognizing students who experience pride and enjoyment can help reinforce positive learning strategies and environments.

The AEQ-M and its adaptations provide valuable tools for both research and practice, enabling targeted support that goes beyond cognitive assessments to address the emotional dimensions of learning.

Prior to the development of the AEQ-M, most instruments measuring emotions in academic contexts were either too general or lacked focus on specific subjects like mathematics. The AEQ-M filled this gap by offering a domain-specific tool with clear theoretical grounding. Its validation across different age groups and cultural contexts further supports its generalizability and utility (Pekrun & Perry, 2014).

### **Limitations and Considerations**

While the AEQ-M is a well-established tool, certain limitations must be considered in translation and adaptation. Cultural differences may influence how students interpret certain items or express emotions. Therefore, it is important that any translated version, such as the one used in the current study, undergo additional validation in the target population to ensure that the items function as intended (Schukajlow et al., 2023).

## **2.5 Organization of the survey**

The survey was conducted in an offline format in a middle school setting and targeted 49 students in grades 7, 9, and 10. The aim was to explore factors contributing to demotivation in mathematics lessons. The data collection took place during regular school hours, with the permission of school administration. Students were gathered in their respective classrooms, and the survey was administered in a quiet environment to ensure focus and minimize distractions.

Participation was voluntary and anonymous. 2 students from 10<sup>th</sup> grades did not want to participate in the survey and 3 students from 7K could not be included in the survey due to health issues. Before the survey began, students were informed about the purpose of the study and assured that their responses would remain confidential. They were encouraged to answer honestly, as there were no right or wrong answers, and their input would help improve teaching strategies and learning conditions.

The questionnaire consisted of 89 Likert-scale questions, where students rated statements on a scale from 1 (strongly disagree) to 5 (strongly agree). The survey measured various factors influencing motivation, including enjoyment, pride, anger, hopelessness, boredom, and attitudes toward the future importance of mathematics. The distribution of questions was as follows:

- Questions 1–28 focused on enjoyment;
- Questions 29–34 on pride;
- Questions 35–59 on anger;
- Questions 60–67 on hopelessness;
- Questions 68–88 on boredom;
- Question 89 asked about students' beliefs regarding the future importance of mathematics in their lives.

The questions themselves can be found in the Appendix 1 section.

Each class completed the survey within approximately 30 to 40 minutes. After data collection, responses were reviewed, and missing values marked as "null" were later filled using the mean value for that question within the respective class. This ensured that the dataset was complete for subsequent statistical analyses, including correlation analysis and factor analysis.

A further element of the survey organization involved a small experimental intervention: the 7K class used Desmos technology as part of their mathematics

lessons, while the 7L class continued with traditional instruction. This allowed for a comparative analysis of the impact of dynamic technology on student motivation.

## 2.6 Reliability Analysis (Cronbach's Alpha)

The internal consistency of the questionnaire was assessed using Cronbach's alpha for each of the five factors identified in the study: Enjoyment, Pride, Anger, Hopelessness, and Boredom. The results indicate excellent reliability across all scales (see Table 1). Specifically, the Enjoyment scale demonstrated a Cronbach's alpha of .95, suggesting that the items measuring enjoyment are highly consistent with each other. Similarly, the Pride scale had a Cronbach's alpha of .87, which is considered very good. The Anger (.97), Hopelessness (.96), and Boredom (.97) scales also exhibited excellent internal consistency. These results support the validity of the questionnaire in measuring the intended motivational constructs in the context of mathematics education (Nunnally & Bernstein, 1994).

*Table 2.6.1 Cronbach's Alpha Values for Each Factor*

Factor	Cronbach's Alpha
Enjoyment	0.95
Pride	0.87
Anger	0.97
Hopelessness	0.96
Boredom	0.97

## 2.7 Correlational Analysis

Pearson correlation coefficients were computed to examine the relationship between students' average scores for each motivational factor and their response to the item measuring perceived importance of mathematics in the near future (Q89). The results revealed significant correlations across all factors (see Table 2).

A moderate negative correlation was found between Enjoyment and perceived importance of mathematics ( $r = -.47, p < .001$ ), suggesting that students who reported greater enjoyment were more likely to view mathematics as important. Similarly, Pride was negatively correlated with perceived importance ( $r = -.43, p < .01$ ). Conversely, positive correlations were observed for Anger ( $r = .45, p < .001$ ), Hopelessness ( $r = .55, p < .001$ ), and Boredom ( $r = .51, p < .001$ ), indicating that students experiencing these negative emotions tended to associate mathematics with higher importance, perhaps reflecting external pressures or perceived necessity.

The high internal consistency observed across all scales aligns with previous findings in educational psychology, where emotional responses to mathematics have been shown to be multidimensional yet internally cohesive (Pekrun et al., 2002). The Enjoyment scale's alpha of .95 suggests that students' positive emotional experiences in mathematics (e.g., fun, enthusiasm) are measured with high precision. Similarly, the Anger, Hopelessness, and Boredom scales, with alphas above .95, reflect robust measurement of negative affective responses.

*Table 2.7.1 Pearson Correlations Between Motivational Factors and Perceived Importance of Mathematics*

Factor	r	p-value
Enjoyment	-0.47	.0004
Pride	-0.43	.0018
Anger	0.45	.0008
Hopelessness	0.55	.00003
Boredom	0.51	.0001

Interestingly, the Pride scale, while slightly lower at .87, still demonstrates strong reliability. This could suggest that pride is a somewhat more complex emotion, potentially influenced by both intrinsic factors (e.g., mastery) and extrinsic validation (e.g., recognition from teachers or parents).

The correlational findings present a nuanced view of how emotional factors relate to perceived importance of mathematics. The negative correlation between Enjoyment and perceived importance may seem counterintuitive at first glance. However, it could reflect that students who find genuine enjoyment in mathematics do not base their sense of its value on external utility but rather on intrinsic satisfaction. In contrast, students reporting high levels of Anger, Hopelessness, or Boredom may feel that mathematics is important because of external demands, societal expectations, or a sense of obligation, rather than personal interest or enjoyment (Eccles & Wigfield, 2002).

### Correlation Between Emotional-Motivational Factors

The correlation matrix between the five major emotional-motivational factors (Enjoyment, Pride, Anger, Hopelessness, and Boredom) revealed several noteworthy patterns that are consistent with the control-value theory of achievement emotions (Pekrun, 2006). These results highlight how students' emotional experiences in mathematics are interconnected, with positive emotions tending to align and negative emotions forming clusters.

### Correlation Matrix

Table 2.7.2 Pearson correlation coefficients between emotional-motivational factors

Factor	Enjoyment	Pride	Anger	Hopelessness	Boredom
Enjoyment	1.00	0.81	-0.68	-0.68	-0.69
Pride	0.81	1.00	-0.54	-0.59	-0.54
Anger	-0.68	-0.54	1.00	0.87	0.84
Hopelessness	-0.68	-0.59	0.87	1.00	0.84
Boredom	-0.69	-0.54	0.84	0.84	1.00

A particularly strong positive linear relationship was observed between Enjoyment and Pride ( $r = .81$ ). This finding suggests that students who report higher levels of enjoyment during mathematics lessons are also likely to experience a greater sense of pride in their achievements. Both enjoyment and pride are associated with perceptions of high control and positive value attributed to mathematics tasks. This result aligns with prior studies demonstrating that positive emotions co-occur when students feel competent and see the subject matter as meaningful or personally relevant (Pekrun & Perry, 2014).

Similarly, strong positive correlations were found among the negative emotional factors:

- Anger and Hopelessness ( $r = .87$ )
- Anger and Boredom ( $r = .84$ )
- Hopelessness and Boredom ( $r = .84$ )

These strong positive linear relationships indicate that students who experience one form of negative emotion (e.g., anger) are highly likely to report other negative emotions (e.g., hopelessness and boredom). This clustering of negative emotions suggests that interventions designed to address a single negative emotion could potentially have broader effects, reducing multiple negative emotional states simultaneously.

In contrast, Enjoyment demonstrated strong negative linear relationships with all three negative emotions:

- Anger ( $r = -.68$ )
- Hopelessness ( $r = -.68$ )
- Boredom ( $r = -.69$ )

These negative correlations indicate that as students' enjoyment of mathematics increases, their experiences of anger, hopelessness, and boredom tend to decrease. While these are not inverse proportional relationships in a strict mathematical sense, they reflect a consistent trend where higher positive emotional engagement is associated with lower levels of negative affect. Similarly, Pride showed moderate negative linear relationships with negative emotional factors:

- Anger ( $r = -.54$ )
- Hopelessness ( $r = -.59$ )
- Boredom ( $r = -.54$ )

This suggests that pride in one's mathematics performance may act as a buffer against negative emotional states, although the relationships are slightly weaker than those observed for enjoyment.

It is important to note that correlation coefficients should be interpreted as indicators of the degree and direction of linear association rather than evidence of direct causality or proportional dependency. In scientific writing, it would not be accurate to describe these relationships as directly proportional or inversely proportional. Instead, terms such as strong positive linear relationship or strong negative linear relationship are more appropriate and scientifically accurate.

## **2.8 Educational Implications**

The identified relationships between emotional factors highlight the importance of addressing the emotional climate in mathematics classrooms. Strategies aimed at enhancing enjoyment—such as incorporating engaging activities, offering meaningful feedback, and providing opportunities for student autonomy—may not only increase positive emotional experiences but also help reduce negative emotions. Similarly, efforts to reduce boredom (e.g., through differentiated instruction or real-world applications of mathematics) may simultaneously decrease anger and hopelessness, leading to more adaptive motivational profiles.

Overall, the correlation matrix offers valuable insights into the dynamics of students' emotional experiences in mathematics. These findings provide empirical support for the theoretical assumptions of the control-value theory and underscore the need for educational practices that nurture positive emotions while mitigating negative ones.

These results have important implications for mathematics education. Teachers should be aware that high perceived importance of mathematics does not necessarily

indicate positive motivation. As the data suggest, students who feel bored, hopeless, or angry may still regard mathematics as important, but their engagement is likely driven by external pressures rather than intrinsic motivation. Therefore, fostering positive emotions in the classroom — such as enjoyment and pride — is crucial for supporting authentic, self-determined motivation (Ryan & Deci, 2000).

Practical strategies could include designing lessons that are both challenging and accessible, providing timely and supportive feedback, and creating opportunities for students to experience mastery and success. Additionally, incorporating collaborative activities and real-world applications may help reduce feelings of boredom and hopelessness.

## **2.9 Limitations**

While the findings of this study provide valuable insights, certain limitations should be acknowledged. First, the cross-sectional nature of the data prevents causal interpretations. The observed correlations do not indicate whether emotions influence perceived importance of mathematics or vice versa. Longitudinal studies are needed to explore these dynamics over time.

Second, the reliance on self-report measures may introduce bias, as students may respond in socially desirable ways or misinterpret items. Although the high internal consistency supports the reliability of the scales, future research could incorporate observational data or teacher reports to triangulate findings.

Finally, the study was conducted within a specific cultural and educational context (Kazakhstan), which may limit the generalizability of results to other settings. Cultural values and educational practices could influence both the experience and expression of emotions related to mathematics.

## **2.10 Instructional Content Delivered via Desmos**

During the intervention phase, class 7L received instruction on linear functions through the use of the Desmos online graphing calculator. The lessons were aligned with specific curriculum objectives, including:

- Constructing the graph of a linear function in the form  $y = kx$  and predicting its position based on the value of  $k$ , including with the use of software tools (Objective 7.5.1.8);
- Constructing the graph of a linear function in the form  $y = kx + b$  and predicting its position based on the values of  $k$  and  $b$  (Objective 7.5.1.9);
- Finding the intersection points of a linear function graph with the coordinate axes without actual graph construction (Objective 7.5.1.10);

- Identifying the values and signs of coefficients  $k$  and  $b$  based on the graph of the linear function (Objective 7.5.1.13).
- Students described and justified the mutual placement of graphs of linear functions depending on the values of coefficients  $k$  and  $b$  in functions of the form  $y = kx + b$  (Objective 7.5.1.11). They also formulated linear functions whose graphs were either parallel or intersecting relative to a given function's graph (Objective 7.5.1.12).
- Learners practiced solving systems of two linear equations using graphical methods, thereby strengthening their visual and analytical understanding of intersection points and solution strategies (Objective 7.2.2.7).
- Students analyzed and graphed a variety of nonlinear functions, including  $y = ax^2$ ,  $y = ax^3$ ,  $y = k/x$ , and  $y = |x|$ . They examined how the parameters  $a$  and  $k$  affected the shape and position of graphs and identified their properties (Objectives 7.5.1.14, 7.5.1.15, 7.5.1.16, 7.5.1.6). The interactive manipulation in Desmos facilitated an intuitive grasp of symmetry, vertex behavior, and asymptotic tendencies.
- Finally, students were introduced to graphing functions that represent real-world data. They investigated trends using both continuous graphs and tabulated numerical values (Objectives 7.5.1.4, 7.5.1.6), which helped contextualize mathematical concepts in everyday scenarios such as motion and temperature change.

Table 2.10.1 Curriculum of 7L during the experiment period

4 четверть			
7.4А – Функция. График функции. (17 часов)			
131	Функция График функции	7.5.1.1 решать задачи с использованием различных способов задания функции;  7.5.1.3 распознавать функциональную и нефункциональную зависимости;  7.5.1.2 находить область определения и множество значения функции;	1
132-136	Линейная функция и её график	7.5.1.8 строить график функции $y = kx$ и прогнозировать его расположение в зависимости от $k$ , в том числе с использованием программного обеспечения;	2
		7.5.1.9 строить график линейной функции $y = kx + b$ и прогнозировать его расположение в зависимости от значений $k$ и $b$ ;	
		7.5.1.7 собирать информацию и анализировать ее с помощью графиков (графика движения или графика изменения температуры);	1
		7.5.1.10 находить точки пересечения графика линейной функции с осями координат (без построения графика);	2
		7.5.1.13 находить по графику функции $y = kx + b$ , знаки и значения коэффициентов $k$ и $b$ ;	

137-139	Взаимное расположение графиков <u>линейных функций</u>	7.5.1.11 описывать и обосновывать в зависимости от значений $k$ и $b$ взаимное расположение графиков <u>линейных функций</u> вида $y = kx + b$ ;  7.5.1.12 задавать <u>линейную функцию</u> , график которой параллелен графику <u>данной функции</u> или пересекает его;	3
140-141	Решение систем <u>линейных уравнений</u> с двумя неизвестными графическим методом	7.2.2.7 решать системы уравнений графическим способом;	2
142-145	Функции видов $y = ax^2$ , $y = ax^3$ , $y = \frac{k}{x}$ ( $k \neq 0$ ), $y =  x $	7.5.1.15 определять в зависимости от $a$ расположение графиков функций $y = ax^2$ , $y = ax^3$ и строить их;  7.5.1.16 определять в зависимости от $k$ расположение графика функции $y = \frac{k}{x}$ ( $k \neq 0$ ) и строить его график;  7.5.1.14 определять свойства функций видов $y = ax^2$ , $y = ax^3$ , $y = \frac{k}{x}$ ( $k \neq 0$ );  7.5.1.6 строить график функции $y =  x $ ;	4
146	Чтение и интерпретация графиков реальных процессов	7.5.1.4 исследовать графики функций, описывающих реальные процессы;  7.5.1.5 строить графики с помощью табличных данных реальных процессов;	1

By leveraging Desmos for these varied objectives, students engaged with both algebraic and applied mathematics in a visually dynamic and interactive format. This supported the development of conceptual understanding and promoted a deeper appreciation for the utility of mathematics beyond the classroom.

Additionally, students engaged with graphical representations of real-life data (e.g., movement or temperature graphs) to collect and interpret information (Objective 7.5.1.7). The dynamic and interactive features of Desmos facilitated exploration and manipulation of parameters  $k$  and  $b$ , allowing students to visually understand the effects of changes on the graph's shape and position. This visual and exploratory approach aimed to deepen conceptual understanding and support student engagement with abstract algebraic concepts. Overall, 16 lessons were dedicated to using Desmos in a span of 3 weeks. 7K was using the traditional teaching method such as drawing graphs by hand and was limited in using technology overall.

## 3. RESULTS

### 3.1 Comparative Analysis of Motivation: Grade 9 vs. Grade 10

A detailed comparison of the motivational and emotional profiles of Grade 9 and Grade 10 students reveals important distinctions that provide insight into how motivation in mathematics may evolve across educational stages. The data demonstrate that Grade 9 students consistently report higher levels of positive emotions and lower levels of negative emotions in relation to mathematics learning compared to their Grade 10 counterparts.

Specifically, the average enjoyment score for Grade 9 was 3.93, notably higher than the 3.69 reported by Grade 10 students. This suggests that Grade 9 students generally experience greater satisfaction and engagement during mathematics lessons. Enjoyment is a critical emotional factor as it has been linked to sustained interest, persistence in problem solving, and a greater likelihood of adopting adaptive learning strategies (Pekrun, 2006). Similarly, Grade 9 students reported higher levels of pride (3.75) relative to Grade 10 students (3.43). Pride in mathematical achievements reflects students' recognition of their competence and can reinforce positive academic behaviors, including persistence in the face of challenges.

In contrast, Grade 10 students exhibited higher mean levels of negative emotional experiences. Their anger score averaged 2.24 compared to 2.01 in Grade 9, suggesting that frustration or irritation during mathematics learning is more prevalent among older students. This could be due to increased academic demands, higher stakes associated with assessments, or perceived difficulty of the material at the Grade 10 level. Similarly, hopelessness was reported at a higher level in Grade 10 (2.68) versus Grade 9 (2.15). Feelings of hopelessness are particularly concerning as they may signal that students believe they have little control over their success in mathematics, a belief that undermines motivation and effort. The boredom score further highlights this trend: Grade 10 students reported greater boredom (2.44) compared to their Grade 9 peers (2.13). Boredom in the classroom is associated with disengagement, reduced effort, and lower academic achievement (Pekrun & Perry, 2014).

These differences may reflect a combination of developmental, curricular, and contextual factors. For example, the transition from middle to upper secondary education often introduces more complex content, a faster instructional pace, and heightened pressure related to examinations and future academic pathways. Such changes can contribute to increased stress and reduced positive engagement if not accompanied by appropriate support systems. It is also possible that students' motivational profiles shift as their interests and priorities evolve during adolescence.

The results highlight the importance of targeted interventions at the Grade 10 level aimed at sustaining students' enjoyment and pride in mathematics while

addressing sources of negative emotions. Strategies might include differentiated instruction, the integration of technology to increase engagement, and the provision of emotional and academic support to help students navigate the increasing demands of the curriculum. Further research could explore the specific classroom or school-level factors that contribute to these emotional differences between grades, as well as the role of teacher-student relationships, peer dynamics, and assessment practices in shaping motivation.

### **3.2 Analysis of Motivation: Grade 7 (Combined) vs. Grade 10**

A comparative analysis between the combined Grade 7 classes (7K and 7L) and Grade 10 reveals important trends in the emotional and motivational experiences of students at different educational stages. These findings provide insight into how motivation and related emotional states may evolve as students progress through school and face increasing academic demands.

#### **Positive Emotional Factors**

One of the most striking outcomes of this comparison is that Grade 10 students report slightly higher levels of enjoyment (mean = 3.69) compared to the combined Grade 7 group (mean = 3.48). This suggests that despite the increased difficulty and complexity of mathematics at higher grade levels, many Grade 10 students continue to find satisfaction and positive engagement in learning the subject. This may be attributed to a more developed sense of competence, an appreciation of the relevance of mathematics to future academic and career goals, or instructional practices that succeed in capturing student interest at this level.

Similarly, pride scores were marginally higher in Grade 10 (mean = 3.43) compared to Grade 7 (mean = 3.39). This could reflect the greater emphasis on individual achievement and mastery at higher educational stages. Older students may feel a deeper sense of accomplishment from overcoming more challenging material, contributing to their sense of pride.

#### **Negative Emotional Factors**

In contrast to these modest differences in positive emotions, a more pronounced divergence emerges in negative emotional experiences. The mean level of hopelessness reported by Grade 10 students (2.68) was significantly higher than that of Grade 7 students (2.31). This suggests that as students advance in grade level, some may begin to feel overwhelmed by the increasing complexity of mathematical tasks or the heightened pressure associated with assessments and future academic expectations. Hopelessness is particularly concerning because it reflects a belief that effort will not lead to success, which undermines motivation and persistence (Pekrun, 2006).

Anger levels were relatively close across groups, with Grade 10 students reporting a mean of 2.24 and Grade 7 students a slightly lower mean of 2.18. This small difference suggests that frustration with mathematics is present across both age groups, albeit slightly more pronounced in Grade 10, possibly due to the more demanding nature of the curriculum. Interestingly, boredom scores were nearly identical between the groups (2.44 in Grade 10 vs. 2.49 in Grade 7). This indicates that disengagement through lack of interest is a common challenge at both levels, underscoring the need for engaging instructional strategies at all stages of mathematics education.

### **Interpretation and Educational Implications**

These findings highlight a complex emotional landscape in mathematics learning that evolves with educational progression. While Grade 10 students appear to sustain or even slightly increase their positive emotional engagement compared to younger peers, this is counterbalanced by a notable rise in feelings of hopelessness. This juxtaposition suggests that while older students may value their accomplishments and take pride in their work, they may simultaneously feel burdened by the increased demands and pressures of their academic environment.

Several factors may contribute to this emotional profile. The transition to higher grades often entails more abstract and demanding mathematical content, greater emphasis on standardized testing, and an increased focus on academic outcomes tied to future educational and career pathways. These factors can heighten students' stress levels and contribute to emotional fatigue, even as they continue to experience moments of enjoyment and pride in their learning.

For educators and school leaders, these results point to the importance of supporting students not only cognitively but also emotionally, particularly as they progress to higher grade levels. Strategies might include:

- **Differentiated instruction** that balances challenge with support, ensuring tasks are neither too easy nor overwhelming. A big topic in education, not only in mathematics.
- **Opportunities for collaborative learning** to reduce isolation and provide emotional and academic scaffolding. Also helps with boredom.
- **Integration of real-world applications and technology** to sustain engagement and reduce boredom. Gives them a good reason to learn.
- **Emotional literacy and resilience programs** that help students develop coping strategies for managing stress and negative emotions associated with learning challenges.

Additionally, interventions could focus on helping students reframe their perceptions of difficulty and failure. For example, promoting a growth mindset can encourage students to see challenges as opportunities for learning rather than as threats to self-worth (Dweck, 2006).

### 3.3 Analysis of Motivation Levels in 7K and 7L Classes

This section presents an analysis of motivation levels among two seventh-grade classes—7K and 7L—based on student responses to an 88-item Likert-scale questionnaire. The survey was designed to measure multiple emotional and cognitive dimensions of motivation in mathematics, using a five-point scale (1 = strongly disagree to 5 = strongly agree). Each student completed both a pretest and a posttest to evaluate changes in motivation over the course of instruction.

#### Descriptive Statistics

*Table 3.3.1 Average student motivation scores for 7K and 7L across pretest and posttest phases.*

Class	Pretest Mean Score	Posttest Mean Score	Percent Change
7K	2.66	2.78	+4.5%
7L	2.92	3.08	+5.6%

#### Findings and Interpretation

The analysis shows that both 7K and 7L classes experienced an increase in motivation levels between the pretest and posttest administrations. The 7K class exhibited a modest improvement of 4.5%, while the 7L class demonstrated a slightly larger gain of 5.6%. Importantly, both classes improved, suggesting that instructional methods and the passage of time contributed to enhanced student attitudes toward mathematics.

However, the 7L class received instruction with the integration of Desmos, a dynamic graphing and visualization tool, during the posttest instructional period. The slightly greater increase in 7L's motivation scores may be associated with the enhanced interactivity and engagement fostered using technology. Students in 7L were observed to participate more actively during lessons, and their posttest responses reflect a generally more positive orientation toward mathematical tasks.

While the differences in improvement percentages are not dramatic, they provide preliminary evidence that technology-supported instruction may support increased motivation, especially when tools are aligned with curriculum goals and student interests. The fact that 7L began with higher baseline motivation scores and still managed to improve further suggests that Desmos may have played a supportive role in sustaining engagement.

### **Educational Implications**

These findings underline the importance of considering digital tools in mathematics instruction, particularly for younger students. Incorporating interactive platforms such as Desmos can support not only comprehension but also students' emotional responses toward the subject. While further research is needed to draw firm conclusions, the current data support the idea that thoughtful integration of technology may contribute to more motivated and engaged learners.

## CONCLUSION

This research explored the underlying reasons behind demotivation in mathematics among middle school students, with a particular focus on psychological, social, and pedagogical factors. Through a combination of literature review and quantitative data analysis based on survey results, the study aimed to uncover which elements most significantly impact student motivation, and how technological interventions such as Desmos might support engagement and academic performance.

The results indicate that psychological barriers—particularly math anxiety and low self-efficacy—remain critical impediments to student motivation. These findings are consistent with prior research highlighting the role of emotions and belief systems in shaping attitudes toward mathematics. Moreover, social factors such as peer relationships and teacher-student dynamics were found to influence engagement levels, especially during the transitional middle school years.

A comparative analysis of two seventh-grade classes, one of which used Desmos for studying functions, revealed a noticeable increase in motivation and post-test scores in the class that benefited from the digital tool. This suggests that interactive, student-centered technology can enhance motivation, especially when aligned with well-structured pedagogical practices. The 7L class, which received instruction via Desmos, demonstrated both improved enthusiasm during lessons and a higher increase in post-test survey scores compared to the 7K class.

These findings carry important implications for educators, curriculum developers, and policymakers. Integrating digital tools into mathematics education can serve as a meaningful strategy to counteract demotivation, particularly when combined with an understanding of the emotional and social context of learning. Additionally, the research underscores the importance of assessing student motivation not only as an outcome but as a dynamic factor that evolves with teaching approaches and classroom environments.

Future studies may benefit from longitudinal designs and larger sample sizes to further validate the relationship between technological interventions and student motivation. However, the current research offers actionable insights that can inform immediate classroom practice, including the value of differentiated instruction, emotional support, and the integration of engaging technologies such as Desmos.

This research internship has provided a comprehensive exploration into the complex factors contributing to middle school students' demotivation in mathematics, and offered a practical examination of how technology-enhanced instruction can serve as an effective response. From planning and conducting the experiment to analyzing pre- and post-test results, the project allowed for a multifaceted investigation into students' psychological, social, and instructional experiences. One of the key takeaways is that motivation in mathematics is not merely a cognitive issue, but a

deeply emotional and contextual one—shaped by anxiety, confidence, relationships, and the methods used in instruction.

Throughout the internship, the implementation of Desmos as a digital learning tool stood out as a transformative teaching strategy. Unlike traditional methods, Desmos enabled students to engage visually and interactively with mathematical concepts, particularly functions and graphs. The 7L class's improved motivation levels and test scores compared to the 7K class illustrate how even short-term integration of meaningful technology can enhance classroom dynamics and learning outcomes. These results echo broader findings from the literature, reinforcing that student-centered digital tools—when supported by effective teaching—can increase both understanding and enjoyment of math.

The structured diary of the internship further reflected the systematic planning and progressive integration of digital methods, beginning with diagnostic pre-assessments, followed by targeted lessons using Desmos and GeoGebra, and ending with post-assessment and reflection. This process not only improved student outcomes but also contributed to professional growth by deepening the researcher's understanding of evidence-based pedagogical practices. It became clear that technology should not be an add-on, but rather an integrated component of a responsive and inclusive learning environment.

Importantly, this study also demonstrated the role of teachers in recognizing and responding to emotional cues such as disengagement or anxiety. By aligning instructional methods with students' developmental and psychological needs, and by creating lessons that foster agency, curiosity, and collaboration, educators can better support sustainable engagement in mathematics. As schools and policymakers continue to emphasize digital transformation in education, findings from this internship provide timely, actionable insights.

Going forward, this research can serve as a foundation for continued innovation in mathematics teaching—where differentiated instruction, emotional support, and engaging tools like Desmos and GeoGebra are not exceptions, but essential features of the modern classroom. In conclusion, the research reaffirms that when students feel supported, challenged appropriately, and allowed to explore concepts actively, their motivation and achievement can flourish—a goal that should be at the center of all educational efforts in mathematics.

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# APPENDIX

## Appendix 1. Questionnaire

### 1. Я с нетерпением жду урок математики

Оцените по шкале: 1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 2. Мне нравится урок математики

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 3. Материал, который мы изучаем на уроках математики, так захватывает, что я действительно наслаждаюсь уроком

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 4. Мне так нравится урок, что я сильно мотивирован участвовать

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 5. Мне весело на уроке математики

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 6. Я с нетерпением жду новых знаний на уроке математики

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 7. Я рад\-а, что понял материал

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 8. Я мог\-ла бы слушать часами с воодушевлением темы про математику

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 9. На уроке математики у меня стучит сердце от радости

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 10. Я с радостью улыбаюсь своему учителю на уроке математики

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 11. Когда я делаю домашнее задание по математике, у меня хорошее настроение

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 12. Я рад\-а, что понимаю материал

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 13. Мне так нравится делать домашнее задание по математике, что я мотивирован\-а делать дополнительные задания

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 14. В математике я с нетерпением жду выполнения домашнего задания

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 15. Мне нравится домашнее задание по математике

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 16. Я рад\-а, что задания такие интересные

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 17. Я рад\-а, что домашнее задание по математике не вызвало у меня никаких проблем

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 18. Потому что мне нравится математика, я занимаюсь ею больше, чем мне нужно

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 19. Когда по математике все получается, мое сердце наполняется радостью

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 20. Когда домашнее задание по математике проходит хорошо, я сияю от радости

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

### 21. Мне нравится сдавать тесты по математике

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**22. Потому что я хочу получить хорошую оценку, я усердно готовлюсь к тесту**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**23. Я думаю, что все идет отлично**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**24. Тесты по математике — это тесты, которые мне по душе**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**25. Я рад\а, что могу сразу показать, что я выучил\понял**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**26. Я думаю, что хорошо справился\ась с тестом по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**27. Когда я замечаю, что у меня все получается, я стараюсь еще больше**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**28. Когда тест по математике проходит хорошо, я улыбаюсь от радости**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**29. Я думаю, что могу гордиться своими знаниями по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**30. Я горжусь своими вкладами в урок математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**31. После выполнения домашнего задания по математике я горжусь собой**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**32. Я очень мотивирован\а, потому что хочу гордиться своими достижениями в математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**33. После теста по математике я горжусь собой**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**34. Я горжусь тем, как хорошо я справился\ась с тестом по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**35. Меня раздражает урок математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**36. Я так злюсь на уроке математики, что мне хочется уйти**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**37. Я злюсь, потому что материал по математике такой сложный**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**38. Меня раздражает урок математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**39. Я расстроен\а во время математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**40. Меня действительно злит урок математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**41. Меня раздражает учитель математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**42. Я хотел\а бы выплеснуть свою злость на одноклассников**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**43. Меня охватывает жар от злости**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**44. На уроке математики я раздражен\а**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**45. Мое домашнее задание по математике меня злит**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**46. Я злюсь, потому что домашнее задание по математике занимает так много времени**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**47. Я так зол\зла, что хотел\-а бы выбросить домашнее задание в мусорку**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**48. Я злюсь, когда делаю домашнее задание по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**49. Я злюсь, что мне нужно делать так много домашнего задания по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**50. Из-за злости на домашнее задание по математике я предпочел\-ла бы вообще не начинать ее делать**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**51. Домашнее задание по математике так меня злит, что мне хочется прекратить его делать**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**52. Еще до того, как я начинаю делать домашнее задание по математике, я злюсь**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**53. Когда мне приходится долго сидеть и делать домашнее задание по математике, я становлюсь беспокойным\-ой от злости**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**54. После долгого выполнения домашнего задания по математике я весь\-вся напряжен\-а от злости**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**55. Я так зол\-зла, что хотел бы разорвать экзаменационный лист на куски**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**56. Меня раздражает, что учитель задает сложные вопросы**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**57. После теста по математике я чувствую гнев**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**58. Я злюсь на то, как прошел тест по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**59. Я замечаю, как сжимаю кулаки от злости во время теста по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**60. Я чувствую себя подавленным\-ой во время математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**61. Во время теста по математике я чувствую безнадежность**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**62. Я постоянно думаю, что не понимаю материал**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**63. Я постоянно думаю, что никогда не получу хороших оценок по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**64. Я предпочел\-ла бы сдать когда решаю задачи**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**65. Из-за чувства безнадежности я больше не прикладываю усилий**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**66. Я чувствую себя парализованным\-ой во время математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**67. Я почти начинаю плакать, потому что не знаю, что делать**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**68. Я думаю, что урок математики скучный**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**69. Я не могу сосредоточиться, потому что мне скучно**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**70. Мне так скучно, что я не могу оставаться бодрым на уроке**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**71. На уроке математики мои мысли часто витают в облаках**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**72. Из-за скуки я думаю, что мне все равно на материал**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**73. Когда мне скучно, я думаю: если бы только урок математики уже закончился!**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**74. На уроке математики я мечтаю**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**75. Я постоянно смотрю на часы, потому что время идет слишком медленно**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**76. Я стараюсь отвлечь себя от скуки**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**77. Я становлюсь беспокойным\-ой, потому что просто жду окончания урока**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**78. Я замечаю, как опускаюсь в кресле\студе от скуки**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**79. Просто думая о домашнем задании по математике, мне становится скучно**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**80. Мое домашнее задание по математике убивает меня от скуки**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**81. Мне так скучно, что я не хочу больше учиться**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**82. Я снова думаю о том, насколько скучное домашнее задание по математике**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**83. Мои мысли полностью где-то в другом месте**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**84. Я скучаю, думая о том, что выполнение этих заданий бессмысленно**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**85. Задания по математике такие скучные**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**86. От скуки я бы лучше занялся\-ась чем-то другим интересным**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**87. Когда я делаю домашнее задание по математике, я быстро устаю от скуки**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 — Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**88. Я начинаю зевать от скуки во время математики**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 —  
Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен

**89. Я считаю что урок математики лично для  
меня не нужен**

1 — Совершенно не согласен | 2 — Скорее не согласен | 3 —  
Нейтрально | 4 — Скорее согласен | 5 — Полностью согласен