FACTORS INFLUENCING STUDENT INITIATIVE IN EFFECTIVE MATHEMATICS STUDIES AT UNIVERSITIES

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Abstract
One of the most important problems of modern education is low achievement in STEM (Science, Technology, Engineering and Mathematics) subjects. Poor performance in mathematics is a serious problem in many countries. In order to improve the effectiveness of mathematics studies, it is more important to improve such key factors as students' learning self–efficacy and learning initiative. This study is devoted to students' learning initiative and the factors influencing it. It is the insufficiency of students' regular learning initiative in the study process that is the basis of the fact that students are not sufficiently prepared for the final exam. Based on the research results of the scientific literature, a questionnaire was created that investigated the students' learning initiative and factors that could improve it – attitude towards mathematics studies, motivation, as well as emotional factors that are often related to Causal attributions. The research was conducted at Latvia University of Life Sciences and Technologies, surveying students of various specialties and various courses. Fisher's exact test of independence is used to determine whether there is a significant relationship between two categorical variables – the respective factors and performance on the math completion test. The results show that one of the main causes is a low self–assessment of mathematics competence, which in turn affects motivation and attitude towards mathematics studies and slows down learning initiative.
Key words: effective mathematics studies, students' learning initiative, attitude, motivation.

Introduction

Mathematics studies in universities play an increasingly important role not only in engineering, but also in social science education, such as in such interdisciplinary fields as mathematical linguistics, quantitative sociology, etc. (Xiang, Wan, & Zhou, 2019). At the same time, it is no secret that mathematics studies are becoming more and more difficult both in secondary schools and universities. For example, the average grade in mathematics in Latvian secondary education centralized exams is improving (2019 – 32.7%, 2020 – 35.4%, 2021 – 36.3%, and 2022 – 37.6%) (State test, 2022, State test, 2020); however, it is insufficient. At universities, especially engineering study programs, student dropout is critical – around 40% in the United States (Hanson, 2022), in Latin America – around 50% (Ferreyra *et al.*, 2017), in the European Union – around 30% (Grove, 2014), including Latvia – as much as 48% (OECD, 2022). One of the reasons is the low success in exact subjects.

The results show that learning mathematics is not particularly effective. How to evaluate **learning effectiveness**? One of the most popular is The Kirkpatrick model, which consists of four levels (Kirkpatrick Model, 2022):

- **Reaction** (have the learners found the training relevant, engaging, useful);
- **Learning** (has knowledge, skills, attitude improved, according to the program);
- **Behavior** (whether behavioral changes can be observed, whether the learners have applied what they have learned);
- **Results** (whether objectives were achieved).

Not less important is the question: how to improve learning efficiency? The most important factors that would improve learning efficiency are learning self–efficacy, learning cognition, learning initiative. At the same time, we cannot ignore such factors as students' attitude towards learning, learning environment and teacher's support. **Self–efficacy** has developed since A. Bandura's work in 1977. Self–efficacy refers to an individual's belief in his capacity to perform the relevant behavior necessary to achieve a certain goal (Bandura, 1988; 1994) and has a great importance in the learning process, which was especially relevant during the COVID–19 period, when distance learning took place (Ahmadipour, 2022). Self–efficacy is influenced by: emotions, attitudes, digital literacy, expected result, previous experience, motivation, satisfaction (Backs, 2017). **Cognitive learning** is an active type of learning and is characterized by the ability of the brain's mental processes to absorb and retain information through experiences, feelings and thoughts (Learning Theories, 2022). A very important factor in improving learning efficiency is the student's learning initiative, which in turn depends on the students' attitude towards learning, motivation, the learning environment and the teacher's support.

The above referred to effective learning in general. Mathematics studies at the university are influenced not only by factors acquired in secondary education (basic knowledge, general competence, ability to learn in general, attitude towards school in general), but also by the emotional attitude towards these factors. These factors could be improved if there was more student learning initiative. Experience shows that success in mathematics could be much better if:

- students showed more **initiative** during the study

process than at the end of the semester;
- students changed their passive **attitude** towards learning mathematics, which is largely dependent on **motivation**;
- students were aware of the influence of the **learning environment**;
- made **efforts** to eliminate obstacles that hinder an effective study process.

The aim of this study is to identify factors that could increase students' **initiative** in learning, which in turn would improve the effectiveness of learning mathematics at universities.

Objectives of the study are:
1) to find out the students' **attitude, goal** and **involvement** in the mathematics study process and its relationship with the results in mathematics;
2) to investigate the influence of the **emotional factor** on learning **initiative** and **attitude** towards learning mathematics;
3) to investigate the relationship between students' learning performance motivation and **emotional factor** and **attitude** towards learning mathematics.

Many studies were and are being conducted on the factors that influence the attitude towards learning various subjects, especially towards those subjects which are difficult to learn. As an example, the main factors influencing **the attitude** towards foreign language learning are often mentioned: (i) The learner's personality context (self–confidence, risk–taking, anxiety), (ii) The educational context (learning situation, teacher, learning materials); (iii) Social context (students' parents, students' peer groups, community), as well as other factors, such as the students' gender, age, etc. (Gettie, 2020).

As the determining factors for students' attitude towards learning, studies also mention: ways of thinking about learning, awareness of the goal of learning (Anghelache, 2013), which would stimulate personal involvement in the learning process (initiative) and the development of personal performance.

However, Wenden (Wenden, 1991) offered a broad definition of the concept of attitudes. He states that the concept of attitude includes three components:
- the cognitive component, which consists of beliefs and ideas or opinions about the object of attitude;
- the affective component, which refers to feelings and emotions towards the object, 'like' or 'dislike', 'with' or 'against';
- the behavioral component, which refers to human actions or behavioral intentions towards an object.

But the most important thing is that attitude is learned, not innate or genetically endowed (Gardner, 1985). Although attitudes tend to persist, experience can change them.

The **emotional factor** plays a relatively large role in the attitude towards learning mathematics. It is essential for students to be aware of their emotions and build emotional skills. The promotion of emotional skills is essential (Mayer, Salovey, & Caruso, 2020): (i) emotional perception; (ii) emotional integration; (iii) emotional understanding and (iiii) emotional management.

The emotional factor often correlates with **achievement motivation** and attitude toward learning mathematics. Achievement motivation can be defined as an individual's ability to work to achieve the highest level of performance (Jankielewicz, 2022). It includes both thoughts and feelings related to motivated behavior. The desire to understand the causes of one's performance, to attribute responsibility to something, forms the causal attributions. **Causal attributions** have emotional consequences that lead to our subsequent feelings – whether we feel good, bad, or indifferent about our success or failure. The type of causal attribution made will affect the student's reaction to the situation (Sytsma, 2019). Internal and external factors also play an important role in motivation (Ornelas, 2023).

Causal attributions can be classified according to three criteria (Weiner, 1985; Graham & Weiner, 1996) (Figure 1):
- Locus of control – which can be internal (ability or motivation) or external (success or task difficulty).
- Stability – which can be stable (ability or task difficulty) or unstable (motivation or luck).
- Controllability – whether successes and failures are controllable or not.

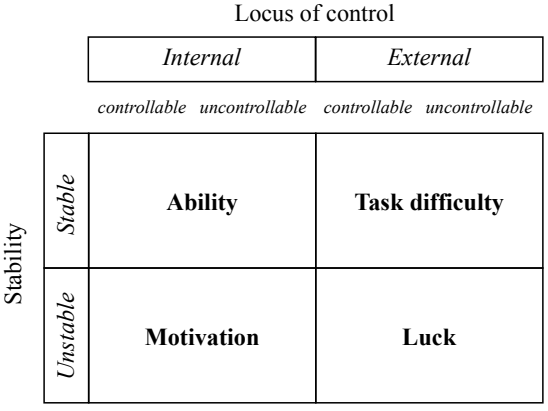

Figure 1. Attributions for Success and Failure.

Materials and Methods

In order to develop a research methodology on factors that would promote student initiative in the learning process, a study of scientific literature and documents was carried out. Based on the obtained results, a questionnaire with closed questions was created. The survey was conducted at the Latvia

University of Life Sciences and Technologies (LBTU), inviting students from various specialties to fill out an electronic questionnaire 'Factors Affecting Mathematics Studies' online. It consisted of questions about the respondents and their competences in mathematics. Study sample is 116 LBTU students from Faculty of Information Technologies, Faculty of Engineering and Faculty of Food Technology. 52% of them were first year students, 39% second year students and 9% third year students. By gender, 67% were male and 33% female, which is related to the work of the authors of the study mostly with engineering students, where most students are male. The questionnaire included questions related to the student's goal to study at LBTU, the goal to study mathematics, the evaluation of his/her competence in mathematics, as well as the evaluation of his/her attitude and involvement in mathematics studies. Based on the above, an emotional factor plays a huge role in students' involvement in mathematics studies, as well as motivation, so questions about students' emotional attitude and related attributions for success and failure were developed.

Tests of independence are used to determine whether there is a significant relationship between two categorical variables. Since some values in the contingency table in the case of obtained data are less than 5, Fisher's exact test was used in this study. Statistical analysis of results was performed using R Statistical Software (version 4.2.2, R Foundation for Statistical Computing, Vienna, Austria).

Results and Discussion

As the results of the final exams of mathematics courses show that the results in mathematics are not high enough, especially for students of engineering specialties. The involvement of students in the learning process, regular work during the semester, and the ability to manage time are very important in the process of studying mathematics. If the homework is not handed in on time, the last night is spent trying to prepare for tests, then the results are often poor.

In order to characterize students' **learning initiative** – regular involvement in the process of learning mathematics, the questionnaire includes questions about how the student solves problems when faced with difficult tasks in homework (Figure 2).

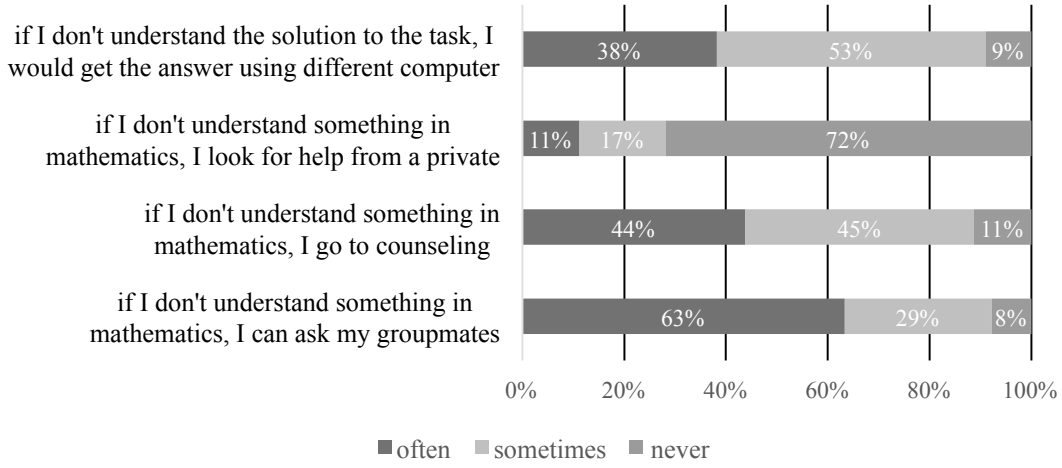

Figure 2. Student initiative in independently solving difficult tasks in mathematics.

Studies show that students more often use the 'easiest way' to solve their problems – to ask for advice from groupmates (63% – 'often'), instead of attending consultations (44% – 'often'), where the help of better quality from the teacher is possible. It is surprising that small percentage of the surveyed students use various mathematics computer programs (38%– 'often'), which are of high quality and where the solution is even explained in some of them (such as 'Symbolab Math Solver – Step by Step calculator', available https://www.symbolab.com). Students' initiative in the regular learning process is also manifested in the ability to **systematize** their knowledge, to create their own formula list in time, so that they can more fully engage in practical work in the audience. In response to the question 'When calculating homework in mathematics, do you systematize your own knowledge?', 62% of respondents answered 'often' and only 4% chose the answer 'never'. On the other hand, when answering the question 'Do you create your own list of formulas?', the majority of students (63%) chose the option 'created before the test', while 21% of students noted that they do not create their own list of formulas at all.

Of course, learning mathematics is not easy for everyone, and one of the reasons is insufficient prior

knowledge, which was not acquired in secondary educational institutions. Therefore, learning requires **effort** and **takes time.**

Evaluating the time required for learning mathematics, more than half of the survey participants (52%) chose the option 'I spend an average amount of time solving tasks', only 10% believe that 'mathematics is easy, so I don't need much time to learn subjects', but 38% chose the answer option 'when solving tasks, I make a lot of effort, devote a lot of time to them' (Figure 3).

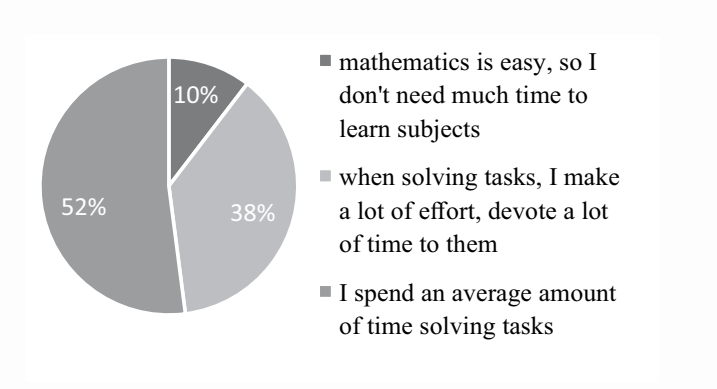

Figure 3. Time required for learning mathematics.

48% of survey participants often feel helpless when solving math problems, 42% find solving math problems interesting, and 10% feel confident.

In order to increase students' learning initiative, first of all, students' attitude towards the study process, or **motivation** to study at LBTU, should be assessed (Figure 4).

When answering the question about what motivates them to study, students had the opportunity to choose one of seven answers and the possibility to write another option. 18% of respondents chose 'it was my own choice' as the only option from the options offered, 10% chose 'career and good salary opportunities in the future' as the only option, 4% chose 'like the chosen specialty', 3% 'recommended by parents' and 2% 'recommended by friends', the rest of the respondents mentioned several reasons for studying the chosen specialty at LBTU. From the results of the survey, it can be concluded that the respondents' motivation to study was more often 'it was their own choice' and 'career and good salary opportunities in the future', so a reasonable question arises, why the student with a weak basic knowledge of mathematics chose the relevant specialty knowing

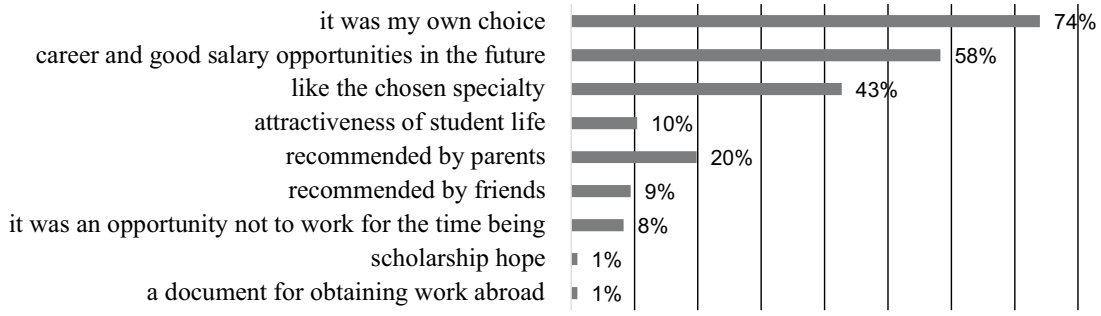

Figure 4. Motivation of students to study at LBTU.

that the program contains higher mathematics.

When starting to study mathematics, students begin to question the necessity of studying this subject even at the first failure. Students often do not see where they will use calculations in higher mathematics, because mathematics is in the first years and students have not mastered special subjects yet.

The survey participants were asked to answer which **mathematics learning goal** is most important personally to them. Three answer options were offered ('get a passing grade', 'get the best possible result', 'get knowledge that can be used in learning other study courses') and students could write other option themselves (Figure 5).

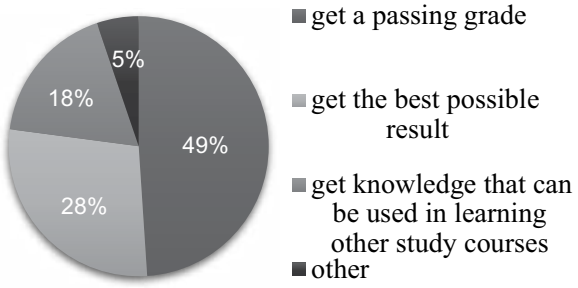

Figure 5. Students' motivation to study mathematics.

As other option, students wrote, for example, the following 'to improve thinking skills', 'to gain knowledge and understand the application for further life', 'I like solving math problems and thinking along'. Using Fisher's exact test, the hypothesis about the relationship between students' study goals and average grades was tested. Let's define the null hypothesis H0: there is no relationship between the student study goal and the student grade and the following alternative hypothesis H1: the student study goal and student grade are related variables. The result of test is $p= 0.0005<0.05$, which proves that there is a relationship between the student's study goal and the student's average grade in mathematics. 82% of students with the goal of 'getting a passing grade' have an average grade between 4 and 6. 85% of students with the goal of 'getting the best possible grade' are between grades 7 and 10.

The study also looked at the relationships between students' goals to study mathematics, attendance at counselling and the final grade in mathematics.

Applying the Fisher's exact test, it was found that for students whose main goal of learning mathematics is to get a passing grade, there is a relationship between the average grade and the attendance of counselling ($p=0.046$). Survey data shows that 86% of these students attend counselling.

For the students with the main goal of teaching mathematics 'to get knowledge that can be used in learning other study courses', there is also a relationship between the average grade and attendance at counselling ($p=0.039$). Survey data shows that only 5% of these students never attend counselling.

Using Fisher's exact test, a relationship between student's evaluation and counselling attendance was not demonstrated for students with a goal 'get the best possible result', but survey results show that 90% of these students attend counselling.

Being aware of your motivation to study mathematics, you should have a positive attitude towards the usefulness of studies. Evaluating their **attitude** towards mathematics studies, 64% of students evaluated it positively, 4% evaluated it negatively. The remaining 38% are problematic – for whom the **attitude** is neutral, but apparently not enough to increase the study initiative.

On the other hand, the attitude towards mathematics studies is also influenced by the students' self–assessment of competence. The results show that the **self–assessment** of mathematics **competence** is relatively low. Only 31% agreed with the statement 'I also understand more difficult tasks in mathematics class and tests do not cause me problems'. 26% of students admit that they simply do not understand how to solve math problems, 59% – admitted that they sometimes do not understand. The last statement is a too low self–assessment, because students have just passed the final exam in mathematics in secondary educational institutions.

Fisher's exact test of independence was performed to assess the relationship between student's attitude towards the mathematics study process at LBTU and his or her average grade in mathematics at university. Let's define the null hypothesis H0: there is no relationship between student's attitude towards the mathematics study process at LBTU and the student's average grade in mathematics, the alternative hypothesis H1: student's attitude towards the mathematics study process at LBTU and the obtained average grade are related variables. The result of Fisher's exact test is $p= 0.726>0.05$. In this case a high p–value indicates that our evidence is not strong enough to indicate the existence of a relationship between these two quantitative variables. But if the same null hypothesis is considered for students whose motivation factor for studies was a career and good salary opportunities in the future, it turns out that $p=0.0015<0.05$. It can be concluded that for this group of students, the attitude towards the mathematics study process at LBTU depends on the obtained average grade. Similarly, for students whose motivation factor for studies was their parents' recommendation where $p=0.007<0.05$.

Often the emotional factor, such as anxiety, affects the study process and test results. The participants

of the survey evaluated the emotional factors in the process of studying mathematics, choosing 'often', 'sometimes' and 'never' to evaluate the following statements: 'I worry that math lessons will be difficult', 'I worry that the test will be difficult', 'excitement during the test reduces my task–solving abilities' (Figure 6). Almost half of the surveyed students admit that they often worry that the test will be difficult. The relationship between the statement 'I worry that math lessons will be difficult' and the average grade and between the statement 'I worry that the test will be difficult' and the average grade was not found using Fisher's exact test of independence ($p=0.104>0.05$ and $p=0.500>0.05$ respectively).

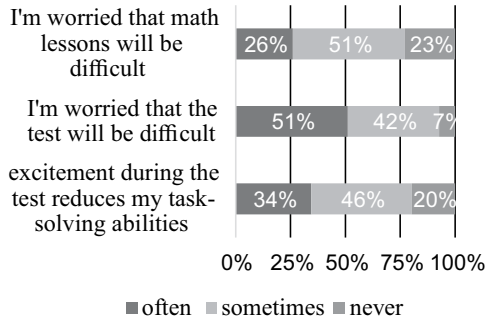

Figure 6. Emotional factors in the process of studying mathematics.

Students' answers to the questions, which were created based on the three criteria of Causal Attributes (Weiner, 1986; Graham & Weiner, 1996), are shown in Figure 7. Respondents were asked to rate with 'disagree', 'partially agree' and 'agree' several reasons why the mathematics test was not written as well as expected (Figure 7 for options and answer choices).

According to Causal attributions theory, the statement 'I haven't had time to study at all lately' ('agree' and 'partly agree' 56%) indicates controllable luck, while the statement 'I was just unlucky this time' ('agree' and 'partly agree' 67% of students), and indicates uncontrollable luck. In both cases, where the success factor dominates, there is minimal expectation of success and little desire to engage in the further learning process.

The statement 'There was an event the day before and I was too tired' ('agree' and 'partly agree' 28%) indicates a controllable effort, while the statement 'I have to study late at night and I can't learn the course well' ('agree' and 'partly agree' 73%) – already to uncontrollable effort. Deliberate lack of effort can increase guilt and heighten expectations of success when engaging in achievement–prone tasks.

It is worse when failures are attributed to lack of ability. The statement 'My head simply does not accept numbers and calculations' ('agree' and 'partly agree' 61%) indicates an uncontrollable lack of ability although the statement 'I am too lazy to properly prepare for test' ('agree' and 'partly agree' 64%) indicates a lack of controllable abilities. Practice shows that it is difficult to overcome laziness, and if it does succeed, it often turns out that it is no longer capable. In this case, there is shame, the expectation of success is reduced, and there is a reluctance to engage in tasks in which achievement is even possible.

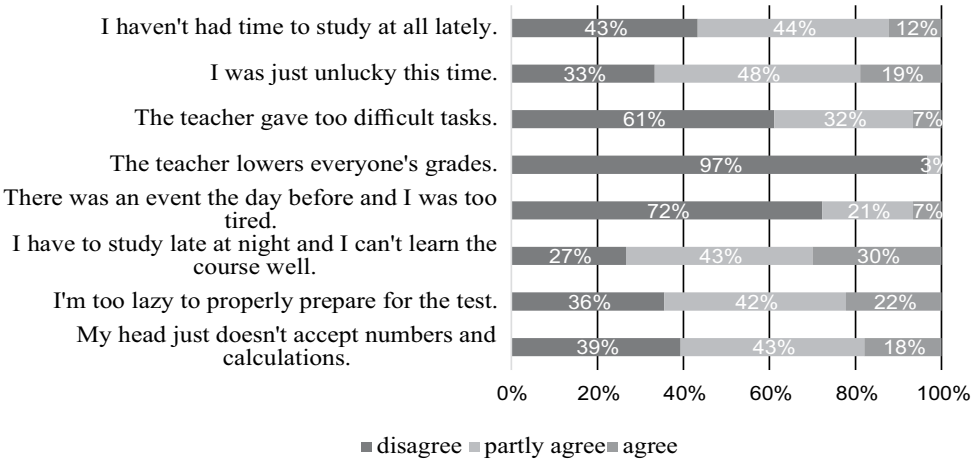

Figure 7. Attributions for Success and Failure.

One of the objectives of our study is to investigate the relationship between emotional factor and attitude towards learning mathematics. Using Fisher's exact test, the relationship between the student's attitude towards mathematics studies and the emotional factor was found in two cases: between 'how a student feels when solving math tasks' and the student's attitude towards mathematics studies ($p=0.012<0.05$) and between 'I worry that the test will be difficult' and the student's attitude ($p=0.007<0.05$).

Analysing the obtained data on the motivation of the students' learning performance and attitude towards mathematics studies, as well as on the motivation of the performance and the emotional factor, in seven cases the relationship of two qualitative variables was found using Fisher's exact test (Table 1).

Table 1

Cases when a relationship was found using Fisher's exact test

There is a relationship between	p–value
1. attitudes towards mathematics studies and 'the teacher gave too difficult tasks in the test', so it was not possible to write it as intended	0.004
2. how a student feels when solving math problems and 'my head just doesn't accept numbers and calculations', so it was not possible to write it as intended	0.008
3. how students feel when they solve math problems and 'the teacher gave too difficult task', so it was not possible to write it as intended	0.020
4. how students feel about solving math problems and 'I'm worried that math lessons will be difficult'	0.013
5. 'the teacher gave too difficult tasks in the test, so it was not possible to write it as intended, and 'I'm worried that math lessons will be difficult'	0.028
6. 'I haven't had time for studies at all lately, so I didn't manage to write the test as planned' and 'I'm worried that math lessons will be difficult'	0.027
7. 'I haven't had time for studies at all lately, so I didn't manage to write the test as planned' and 'I'm worried that the test will be difficult'	0.039

Conclusions

1. The results show that students' initiative and involvement in the study process and regular work during the semester increase the effectiveness of mathematics studies.
2. Students initiative in mathematics studies is influenced by such factors as study goals and attitude towards the learning process, understanding of the necessity of mathematics both in being able to perform calculations of various processes and in the development of cognitive processes.
3. Although almost half of the surveyed students admitted that they often worry that the test will be difficult, the relationship between the anxiety in studying mathematics and the average grade was not found.
4. Applying Causal attribution theory to research on student failure in mathematics studies, a disturbing fact is that 61% of students underestimate their ability in mathematics, while 64% admit that they are too lazy to prepare properly. Unfortunately, even unwritten several tests are not enough incentive to overcome your laziness.
5. The relationship between students' learning performance motivation and emotional factor and attitude towards learning mathematics was found in several cases using Fisher's exact test.
6. In order to improve students' attitude towards mathematics studies and motivation, to increase students' self–assessment of mathematics competence:
   – a major role must be taken by the lecturer who chooses not only optimal teaching methods and the organization of the study process, but also provides effective support.
   – the social learning environment in the student group should be improved, helping to form group work even when learning outside of the classroom.

References

Ahmadipour, H. (2022). Online learning self-efficacy: A necessity for virtual education. *Journal of education and health promotion,* 11, 113. DOI: 10.4103/jehp.jehp_848_21.

Anghelache, V. (2013). Determinant factors of students' attitudes toward learning. In 3rd World Conference on Learning, Teaching and Educational Leadership (WCLTA-20212), 25–28. October 2012 (pp. 478–482). Brussels, Belgium: Elsevier Science BV. DOI: 10.1016/j.sbspro.2013.09.223.

Backs, A. (2017). *Promoting Online Learner Self–Efficacy Through Instructional Strategies and Course Supports.* Thesis, Capella University, United States. DOI: 10.13140/RG.2.2.31657.65120.

Bandura, A. (1988). Self–efficacy conception of anxiety. Anxiety Research, 1(2), 77–98. DOI: 10.1080/10615808808248222.

Bandura, A. (1994). Self–Efficacy. In V. S. Ramachaudran (Ed.), Encyclopedia of Human Behavior (Vol. 4, pp. 71–81). New York: Academic Press.

Ferreyra, M.M., Avitabile, C., Alvarez, J.B., Paz, F.H., & Urzua, S. (2017). At a Crossroads: Higher Education in Latin America and the Caribbean. Washington, D.C.: World Bank Group.

Gardner, R.C. (1985). Social Psychology and Second Language Learning: The Role of Attitudes and Motivation. London: Edward Arnold.

Getie, A.S. (2020). Factors affecting the attitudes of students towards learning English as a foreign language. *Cogent Education,* Vol. 7, 2020, Issue 17(1), 1–37. DOI: 10.1080/2331186X.2020.1738184.

Graham, S., & Weiner, B. (1996). Theories and principles of motivation. In D.C. Berliner & R.C. Calfee (Eds.). Handbook of educational psychology (pp. 63–84). New York: Macmillan.

Grove, D. (2014, April). *UK has 'lowest drop–out rate in Europe*'. Times Higher Education. Retrieved February 25, 2023, from https://rb.gy/paeiot.

Hanson, M. (2022, June). *College Dropout Rates.* EducationData.org, Retrieved February 25, 2023, from https://educationdata.org/college–dropout–rates.

Jankielewicz, R. (2022, April). *Achievement Motivation Theory and Examples*. Retrieved February 18, 2023, from https://study.com/learn/lesson/achievement–motivation–theory–examples.html.

Kirkpatrick Model (2022, February). *The Kirkpatrick Model.* Retrieved February 25, 2023, from https://www.valamis.com/hub/kirkpatrick–model.

Learning Theories (2022, February). *Learning Theories Cognitive Learning*. Retrieved February 25, 2023, from https://www.valamis.com/hub/cognitive–learning.

Mayer, J., Salovey, P., & Caruso, D. (2000). Models of Emotional Intelligence. In R. Sternberg (Ed.), Handbook of Intelligence (pp. 396–420). Cambridge: Cambridge University Press.

OECD (2022, October). *OECD: Students in Latvia often do not finish university.* Retrieved February 25, 2023, from https://www.lsm.lv/raksts/zinas/latvija/oecd-studenti-latvija-biezi-nepabeidz-augstskolu.a476744/.

Ornelas, R. (2023, March). *What Is Achievement Motivation And How To Use It*. Retrieved March 10, 2023, from https://www.lifehack.org/909492/achievement–motivation.

State test (2020, October). S*tate tests 2019/2020 study year.* Retrieved February 28, 2023, from https://www.visc.gov.lv/lv/valsts–parbaudes–darbi–20192020–mg.

State test (2022, October). *State tests 2021/2022 study year.* Statistics. Retrieved February 28, 2023, from https://www.visc.gov.lv/lv/valsts–parbaudes–darbi–20212022–mg–statistika.

Sytsma, J. (2019). The Character of Causation: Investigating the Impact of Character, Knowledge, and Desire on Causal Attributions. Retrieved March 8, 2023, from http://philsci–archive.pitt.edu/id/eprint/16739.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. Psychological Review, 92(4), 548–573. DOI: 10.1037/0033–295X.92.4.548.

Wenden, A. (1991). *Learner strategies for learner autonomy.* New York: Prentice-Hall.

Xiang, J., Wan, Y., & Zhou, J. (2019). Factors Affecting the Learning Effect of Advanced Mathematics among Chinese College Students in Social Science Majors. *Eurasia Journal of Mathematics, Science and Technology Education*, 15(11), em1770. DOI: 10.29333/ejmste/109607.