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PROVIDING PROFESSIONAL TRAINING TO STUDENTS MAJORING IN CONSTRUCTION THROUGH TEACHING MATHEMATICS

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Abstract. Construction specialists need to have a deep understanding of mathematics to perform essential tasks such as design, structural calculations, engineering analysis, quality control, and other critical responsibilities. From this perspective, teaching mathematics to students in construction-related fields is an essential component of their professional training. The relevance of this issue is associated with the need to enhance the effectiveness of mathematical education for construction majors. The aim is to determine effective methods for teaching mathematics and integrate them into the educational process to develop the professional competencies of construction students. Adapting mathematical subjects to the specific features of construction specialties ensures that students acquire knowledge at an applied level. The study employed several research methods to identify effective teaching strategies for improving the professional training of construction students. Theoretical analysis methods were used to examine the key concepts of the study. Empirical research methods, including surveys and interviews, were also applied. To objectively assess the experimental results, the collected data underwent statistical processing. The study highlighted the importance of teaching mathematics in an applied context for construction students. Specifically, compared to traditional mathematical education methods, incorporating construction-oriented mathematical problems into the learning process demonstrated significant outcomes. The statistical significance of the test results after the study confirmed this: $t(98) = 7.6024$, $p < 0.05$, indicating sufficient evidence to reject the null hypothesis.

Keywords: construction specialties, mathematical education, professional training, applied mathematics, engineering calculations, teaching methods, construction industry, students

Introduction

The construction industry is a crucial sector of the economy and engineering that focuses on designing, building, renovating, and reconstructing buildings and infrastructure. This field encompasses the construction of residential, commercial, industrial, transportation, energy, and engineering infrastructure facilities [1].

The construction industry is one of the key sectors of modern economy and technology. Professionals in this field are responsible for solving complex engineering problems, conducting design and construction work, ensuring quality control, and efficiently managing construction processes. Consequently,

the mathematical education provided to students in construction-related fields plays a significant role in their professional training.

A study conducted by Zhou, Z. and other researchers confirms the necessity of teaching mathematics to construction specialists. The application of probability theory, mathematical analysis, and numerical methods is essential for making engineering decisions, assessing structural strength, and determining the life cycle of construction projects. Thus, mathematical knowledge is a fundamental component of professional competence in the construction sector, and its effective teaching can improve the quality of engineering education [2].

The article by Çelik, İ. E. demonstrates the significance of mathematical modeling and analytical calculations for enterprises in the construction sector. The author's research highlights the need for applied mathematical knowledge and confirms the importance of learning mathematics for effective decision-making in business and engineering fields [3].

In another study, Zhou, Z. and colleagues used a multidisciplinary linkage model to assess the long-term sustainability of the regional construction industry. The study applied life cycle assessment and social impact assessment methods to evaluate the sustainability of the construction industry. These methods are based on mathematical models that allow for a quantitative assessment of the environmental and social impacts throughout the entire life cycle of a product or service. Mathematics facilitates scientifically grounded decision-making through data analysis, modeling, and forecasting, which in turn contributes to the sustainable development of the construction sector [4].

Lu, W. article highlights the application of mathematical methods to enhance the accuracy of strategic planning. Mathematical calculations, fuzzy logic, and probability models integrated into traditional SWOT analysis have enabled decision-making based on the construction industry's specifics. Thus, applying mathematics improves the efficiency of strategic management and enhances companies' adaptability in the market [5].

The limitations of PERT and CPM methods in construction management planning emphasize the necessity of strengthening mathematical education in architecture and construction programs. While these methods are widely used in project planning and management, they do not fully address issues such as resource constraints, reduced efficiency under uncertainty, and adaptation challenges for complex projects. Therefore, deeper integration of mathematical methods and modeling into construction education programs is crucial. By mastering mathematical tools such as probability theory, statistical analysis, linear programming, optimization, and system modeling, students can be better prepared to tackle real-world challenges in project management [6].

Professionally oriented mathematics education fosters students' logical thinking and computational skills. For a construction professional, understanding projects correctly and implementing them through precise calculations is of utmost importance. Additionally, performing mathematical computations helps students develop accuracy, responsibility, and attentiveness—qualities that are essential for professional work in the construction industry.

The research conducted by Lee, N., Lee, L. W., & Kovel, J. focuses on identifying effective pedagogical methods for teaching mathematical content in construction management education. Since the construction industry requires a high level of mathematical proficiency, it is essential to develop future construction managers' numerical skills, analytical thinking, and engineering decision-making capabilities. The study results contribute to improving educational programs in construction, ensuring that future professionals acquire the mathematical knowledge necessary to meet market demands. Therefore, curricula for construction management students should focus on integrating theory with practice, ensuring that mathematical education is delivered in an applied context [7].

Currently, the U.S. construction industry faces a shortage of skilled labor, which negatively impacts project timelines, industry stability, and economic growth. Hoshizaki, N. T. research examines the relationship between STEM (Science, Technology, Engineering, and Mathematics) education and the shortage of qualified professionals in the construction sector. The findings suggest that revitalizing vocational education programs is necessary to address workforce shortages in the U.S. construction industry. By adapting STEM education to construction, it is possible to increase young people's interest in this field. Hoshizaki, N. T. recommendations include technological modernization of the construction sector, the introduction of incentive programs for young professionals, and the development of new educational programs that integrate STEM and vocational training. These strategies will help ensure a steady supply of qualified professionals and contribute to the long-term sustainability of the construction industry [8].

Mathematical models and algorithms enhance efficiency in construction process management, optimize resource utilization, and mitigate risks. Therefore, the application of mathematics in construction management systems is a key tool for improving modern engineering projects [9].

Song, Y. research highlights the significance of BIM-GIS integration in architecture, engineering, and construction. This integration provides substantial opportunities for managing construction projects, urban planning, and ensuring environmental sustainability. However, technical challenges and standardization issues need to be addressed. Future research in this area will play a crucial role in the development of smart cities and digital infrastructure [10].

This study aims to identify effective methodologies for teaching mathematics to enhance the professional competencies of construction students and integrate these methodologies into the educational process. By adapting mathematical subjects to the specific features of construction disciplines, students can acquire knowledge at an applied level, ensuring their readiness for real-world engineering tasks.

Materials and methods

The research was conducted through a review of scientific articles published in the Mendeley database over the last 10 years. The literature review analyzed

the process of identifying effective methods for teaching mathematics to enhance the professional competencies of construction students. Various keywords such as “construction specialties,” “mathematical education,” “professional training,” “applied mathematics,” “engineering calculations,” “teaching methods,” and “construction industry” were used. A systematic review was also conducted on research studies and academic works by both domestic and international scholars on the topic of mathematics education.

To determine effective teaching methods for mathematics in developing the professional competencies of construction students, the study utilized scientific research methods. These methods comprised theoretical and empirical approaches aimed at ensuring the reliability and accuracy of the obtained results.

Initially, theoretical research methods were employed. This phase involved an analysis of scientific literature to examine the significance of teaching mathematics in training construction specialists. Studies by international and domestic researchers were reviewed to identify the content and teaching methodologies necessary for mathematical education in the construction sector. Additionally, pedagogical practices were analyzed, educational programs and methodological guidelines were examined, and the characteristics of mathematics education tailored to construction were explored.

The next stage of the research involved empirical methods, aimed at assessing the practical impact of mathematics education on construction professionals. A survey was conducted to evaluate students' interest in the subject and their ability to apply mathematical knowledge. Additionally, interviews were held with experienced professionals and instructors in the construction field. The interview results helped define the mathematical requirements in construction and systematize the essential mathematical tools for solving real engineering problems.

An essential part of the study was the experimental research method. The goal of the experiment was to evaluate the effectiveness of applied teaching methods for mathematics in construction education. A total of 100 students participated in the experiment, divided into two groups:

- Experimental group (50 students): received instruction using construction-related mathematical problems.
- Control group (50 students): followed a traditional mathematics curriculum.

The experiment consisted of three main stages:

1. Pre-test stage: Both groups took an initial test to assess their baseline mathematical proficiency.
2. Instructional phase: The experimental group was taught using construction-specific mathematical applications, while the control group continued with standard methods.
3. Post-test stage: A final assessment was conducted to measure changes in the mathematical proficiency of both groups.

For an objective evaluation of the collected data, statistical analysis methods were used. The independent t-test was applied to compare the results

of the experimental and control groups. The G*Power software was utilized for statistical data processing, enhancing the accuracy of results and allowing for hypothesis verification.

Results

Effective methods of teaching mathematics to develop professional competence of students in the construction field

Mathematical knowledge is of great importance for specialists working in the construction industry, as they perform engineering calculations, structural analysis, material durability, cost calculations and design. Therefore, teaching mathematics adapted to the specifics of the construction industry improves the professional preparation of students.

It is important to adhere to the principles of teaching mathematics to students in the construction industry.

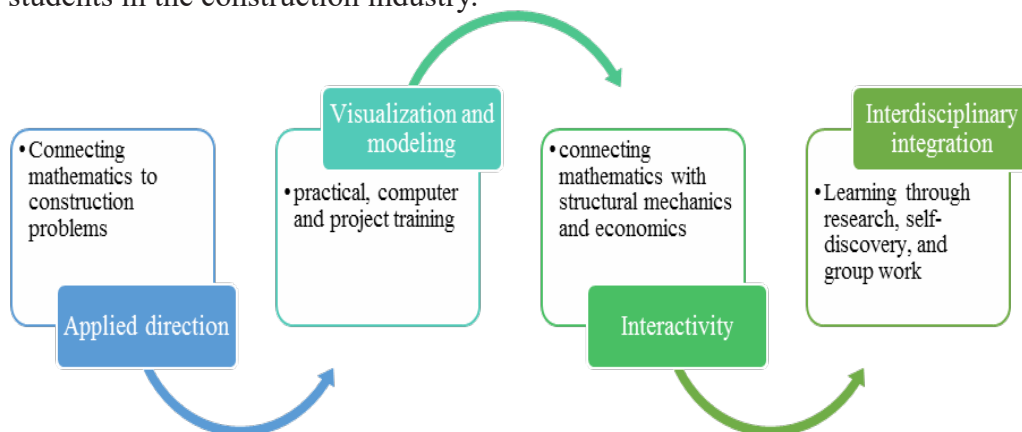


Figure 1 - Principles for teaching mathematics to students in the construction field

The purpose of the methodology for teaching mathematics to students in the construction field is to teach students in the construction field mathematical knowledge, adapting it to professional tasks, to develop their skills in calculation, analysis, engineering decision-making, as well as to form the ability to apply theoretical knowledge in real construction situations.

For effective teaching of mathematics to students studying in the construction field, it is important to introduce teaching methods based on applied, interactive and interdisciplinary connections. This methodology is aimed at developing students' skills in applying mathematical knowledge in the professional field.

1. Theoretical Lessons

The goal of theoretical lessons is to help students understand the significance of mathematics in the construction industry and prepare them for engineering calculations. The lessons cover mathematical concepts relevant to construction, including:

- Vector and matrix calculations – Static analysis of construction structures.
- Differential equations – Structural strength calculations.

–Probability theory and statistical methods – Assessment of construction material quality.

–Optimization methods – Calculation of construction costs and cost-saving strategies.

2. Practical Lessons

The purpose of practical lessons is to enhance students' ability to apply mathematical knowledge to real-world construction problems.

–Practical exercises include:

–Calculating the load-bearing capacity of a building.

–Determining the required quantity of construction materials (concrete, steel, bricks).

–Estimating project costs (materials, labor, transportation expenses).

3. Project-Based Learning

The objective of project-based learning is to develop students' ability to independently conduct mathematical calculations related to construction.

Project tasks include:

–Mathematical assessment of the structural integrity of a multi-story building.

–Calculating and optimizing expenses at a construction site.

–Group project – Developing a mathematical model for bridge construction and performing engineering calculations.

The effectiveness of teaching mathematics to construction students is improved by incorporating applied problems, utilizing computer technologies, implementing project-based learning, and establishing interdisciplinary connections. The use of interactive teaching methods increases student engagement in the subject and helps develop their professional skills. Consistently applying these methods enhances the competitiveness of future construction professionals and contributes to their demand in the labor market.

Evaluating the effectiveness of teaching mathematics to develop professional competence of construction students

To determine the effectiveness of teaching mathematics to construction students, it is essential to conduct a statistical study. This research examines students' academic performance, their ability to apply mathematical knowledge, and changes in their professional competencies. The study involved 100 construction students, who were divided into two groups: Experimental group (50 students): Taught using construction-oriented mathematical methods. Control group (50 students): Taught using traditional methods. The study was conducted over one academic semester (15 weeks). Before implementing the construction-adapted mathematics curriculum, a preliminary test was conducted to assess differences between the two groups. The pre-test results of both groups before the experiment are presented in Table 1.

Table 1. Students' results before the experiment

Group	n	X	Sd	df	t	p
Control group	50	61,25	13,45	98	0,7289	0,4678
Experimental group	50	63,45	16,57			

* *n* - number of elements in the sample, *X* - arithmetic mean, *Sd* - standard deviation, *df* - degrees of freedom, *t* - independent *t* test, Mean difference is significant at $p \leq 0.05$;

When comparing the results of the two groups before the experiment, the statistical data obtained were: $t(98) = 0.7289$, $p > .05$. This result indicates that there was no significant difference in the initial knowledge levels of the students, meaning the null hypothesis was accepted. The acceptance of the null hypothesis confirms that both groups were initially at an equal level, ensuring that their knowledge levels were similar before the experiment began. To enhance the reliability of the results, the G*Power software was used (Figure 2). This program is a widely used and reliable statistical tool for hypothesis testing. During the analysis of the pre-experiment survey results, a *t*-test for two groups was conducted using G*Power. After inputting each group's mean scores and standard deviations, the software generated two distribution curves, representing the distribution of the groups before and after the study. The program's results confirmed that the difference before the experiment was not statistically significant.

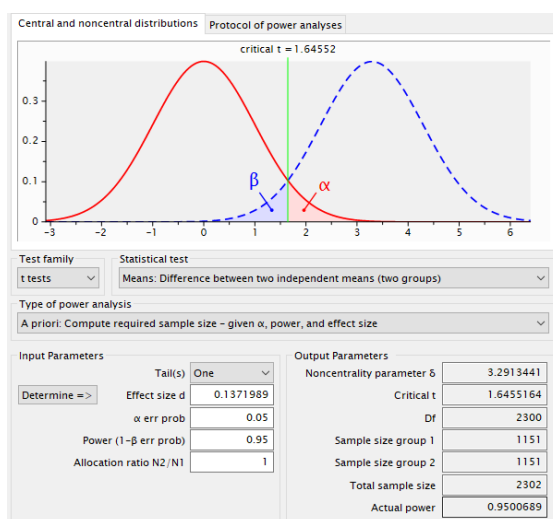


Figure 2 - G*Power critical value result

The red curve shown in the figure represents the null hypothesis, and the blue curve represents the alternative hypothesis. In addition, the green vertical line represents the critical value. Here α is considered as a type I error, and β is considered as a type II error. As a result of the analysis, the *t*-critical value was

equal to 1.64552. During the study, the initial data from the survey showed that there was no significant difference in the level of education of students. Since $t_{cr}(1.64552) > t_s(0,7289)$, the null hypothesis was accepted. This means that the use of the traditional teaching method does not cause a statistically significant difference in the academic achievements of students.

The results obtained contributed to the conduct of research to assess the effectiveness of teaching mathematics in order to develop the professional competence of students in the construction field. The impact of teaching mathematics in order to develop the professional competence of students in the construction field on the results of students was determined by the test results. The results of students are shown in Table 2.

Table 2. Student results after the experiment

Group	Топ (кейін)	n	X	Sd	df	t	p
Control group	БТ	50	69,85	12,4	98	7,6024	0,0001
Experimental group	ЭТ	50	87,65	10,97			

* *n*-number of elements in the sample, *X*-arithmetic mean, *Sd* – standard deviation, *df* – degrees of freedom, *t* – independent *t* test, Mean difference is significant at $p \leq 0.05$;

After the experiment, the statistical significance of the test results was confirmed: $t(98) = 7.6024$, $p < 0.05$, indicating sufficient evidence to reject the null hypothesis.

Using G*Power software, we can confidently interpret these results. The impact of mathematics education on the professional competencies of construction students was assessed based on their test performance. By inputting the test results into the software, hypothesis testing was conducted, confirming the statistical significance of the findings. The results are presented in Figure 3.

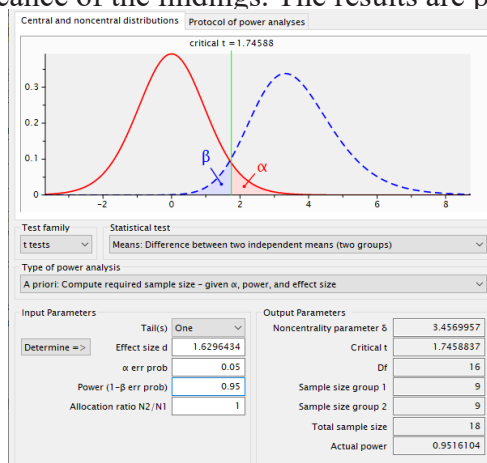


Figure 3 - Conclusion of hypotheses using the G*Power program

As mentioned earlier, the critical value and the statistical value were compared. The critical t-value was 1.74588, while the statistical t-value obtained from the survey results was 7.6024. This comparison shows that $t_{cr}(1.74588) < t_s(7.6024)$, providing sufficient evidence to reject the null hypothesis.

Discussion

The research results demonstrated that teaching mathematics to construction students using applied methods is highly effective in enhancing professional competencies. Students showed improvements in speed and accuracy when solving construction-related mathematical problems, enhanced analytical thinking skills, and significantly increased readiness for future professional work. Thus, integrating applied mathematics into construction education programs positively impacts students' professional competencies and enhances their competitiveness in the job market.

Conclusion

The study confirmed that mathematical education plays a crucial role in developing the professional competencies of construction students. It was determined that incorporating applied problem-solving methods instead of traditional teaching approaches enhances students' analytical thinking skills and improves their ability to efficiently perform professional tasks.

The research findings indicate that applied mathematics education for construction students significantly improves their ability to perform engineering calculations quickly and accurately. When comparing academic performance, the experimental group demonstrated significantly higher results than the control group, proving that integrating construction-specific mathematical methods* into the curriculum enhances professional training quality.

This study further validates the importance of mathematical education in training construction professionals and highlights its role as a key factor in improving professional competencies. Therefore, the widespread integration of applied mathematics into construction education programs will contribute to providing the construction industry with highly qualified specialists and increasing their competitiveness in the job market.

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ҚҰРЫЛЫС МАМАНДЫҒЫ СТУДЕНТТЕРІНІҢ КӘСІБИ ДАЯРЛЫҒЫН МАТЕМАТИКАНЫ ОҚЫТУ НЕГІЗІНДЕ АРТТЫРУ

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Аңдатпа. Құрылыс мамандары жобалау, құрылымдық есептеулер, инженерлік талдау, сапаны бақылау және басқа да маңызды міндеттер сияқты маңызды тапсырмаларды орындау үшін математиканы терең түсінуі керек. Осы тұрғыдан алғанда, студенттерге құрылысқа байланысты салаларда математиканы оқыту олардың кәсіби дайындығының маңызды құрамдас бөлігі болып табылады. Бұл мәселенің өзектілігі құрылыс мамандықтары бойынша математикалық білім берудің тиімділігін арттыру қажеттілігімен байланысты. Мақсаты-құрылысшы студенттердің кәсіби құзыреттіліктерін дамыту үшін математиканы оқытудың тиімді әдістерін анықтау және оларды оқу процесіне енгізу. Математикалық пәндерді құрылыс

мамандықтарының ерекшеліктеріне бейімдеу студенттердің қолданбалы деңгейде білім алуын қамтамасыз етеді. Зерттеу барысында құрылысшы студенттердің кәсіби дайындығын арттырудың тиімді оқыту стратегияларын анықтау үшін бірнеше зерттеу әдістері қолданылды. Зерттеудің негізгі тұжырымдамаларын зерттеу үшін теориялық талдау әдістері қолданылды. Сондай-ақ эмпирикалық зерттеу әдістері, соның ішінде сауалнамалар мен сұхбаттар қолданылды. Эксперимент нәтижелерін объективті бағалау үшін жиналған мәліметтер статистикалық өңдеуден өтті. Зерттеу құрылыс студенттері үшін қолданбалы контексте математиканы оқытудың маңыздылығын атап өтті. Нақтырақ айтсақ, дәстүрлі математикалық білім беру әдістерімен салыстырғанда, құрылысқа бағытталған математикалық есептерді оқу процесіне енгізу айтарлықтай нәтижелер көрсетті. Зерттеуден кейінгі тест нәтижелерінің статистикалық маңыздылығы мынаны растады: $t(98) = 7.6024$, $p < 0.05$, нөлдік гипотезаны қабылдамау үшін жеткілікті дәлелдерді көрсетеді.

Тірек сөздер: құрылыс мамандықтары, математикалық білім, кәсіптік оқыту, қолданбалы математика, инженерлік есептеулер, оқыту әдістері, құрылыс индустриясы, студенттер

ПОВЫШЕНИЕ ПРОФЕССИОНАЛЬНОЙ ПОДГОТОВКИ СТУДЕНТОВ СТРОИТЕЛЬНЫХ СПЕЦИАЛЬНОСТЕЙ НА ОСНОВЕ ОБУЧЕНИЯ МАТЕМАТИКЕ

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Аннотация. Специалисты в области строительства должны обладать глубокими знаниями математики для выполнения таких важных задач, как проектирование, структурные расчеты, инженерный анализ, контроль качества и другие важные обязанности. С этой точки зрения, преподавание математики студентам, работающим в областях, связанных со строительством, является важным компонентом их профессиональной подготовки. Актуальность данного вопроса связана с необходимостью повышения эффективности математического образования для студентов строительных специальностей. Цель исследования - определить эффективные методы преподавания математики и интегрировать их в образовательный процесс для развития профессиональных компетенций студентов-строителей. Адаптация математических дисциплин к специфике строительных специальностей гарантирует получение студентами знаний на прикладном уровне. В ходе исследования было использовано несколько исследовательских методов для определения эффективных стратегий обучения, направленных на улучшение профессиональной подготовки студентов-строителей. Для изучения ключевых концепций исследования были использованы методы теоретического анализа. Также были применены эмпирические методы исследования, включая опросы и

интервью. Чтобы объективно оценить результаты эксперимента, собранные данные были подвергнуты статистической обработке. Исследование подчеркнуло важность преподавания математики в прикладном контексте для студентов-строителей. В частности, по сравнению с традиционными методами математического образования включение в учебный процесс математических задач, ориентированных на построение, продемонстрировало значительные результаты. Статистическая значимость результатов теста после исследования подтвердила это: $t(98) = 7,6024$, $p < 0,05$, что указывает на достаточные доказательства для отклонения нулевой гипотезы.

Ключевые слова: строительные специальности, математическое образование, профессиональная подготовка, прикладная математика, инженерные расчеты, методика преподавания, строительная отрасль, студенты

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