

PAPER

Implementation of Professionally Oriented Tasks with Interactive Cloud Environment Google Colab

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ABSTRACT

The purpose of the paper is to analyze the necessity of implementing professionally oriented tasks in higher mathematics courses for technical students during practical classes using the interactive cloud environment Google Colab. The results are as follows. The main mathematical concepts are analyzed; the indicators of professionally oriented mathematical tasks are characterized; the aspects of solving professionally oriented tasks are considered. The students' survey as a pilot study has shown that students do not have very high self-esteem, have little problem-solving skills, it affects students' motivation, academic performance. The examples of solving professionally oriented tasks with the interactive cloud environment Google Colab are shown. The conclusion is that a balance between the fundamental mathematical knowledge and the practical value is needed; Google Colab helps a lot. The prospect for further research is to monitor the success of students' learning in other courses using Google Colab.

KEYWORDS

mathematical knowledge, professionally oriented training, practice training, solve math tasks, Google Colab

1 INTRODUCTION

The increasing importance of online and blended teaching and learning demonstrates the transformation of mathematics education. It is a need to rethink and redesign teaching to make it more student-centered. This involves not only adopting new digital technologies but also challenging traditional notions of educational success. Emerging technologies are also influencing the nature of mathematics itself. For example, the emphasis on procedural application is diminishing, while new approaches to validation, practice, and visualization are being developed.

As digital technology evolves rapidly, its characteristics and applications in education continue to change. Collaborative learning is becoming more feasible and popular with the rise of web-based teaching and learning through interactive cloud

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environments. Such approaches are not yet widespread in mathematics education. New trends in mathematics education with digital technologies are likely to accelerate these changes. The integration of digital technologies and collaborative practices may become even more important.

The capacity of modern knowledge has increased significantly, outstripping the ability to memorize and store it in an individual's cache memory. However, it is well known that knowledge only becomes valuable to an individual if it is acquired through personal effort, adopted, and consistent with one's own worldview. Therefore, more and more attention are being paid to the question of strengthening the pragmatism of knowledge, its practical orientation, and, in particular, the possibility of introducing integrative activities when knowledge is not transmitted but is learned and acquired in an interactive way.

Indeed, mathematical knowledge is a thorough basic knowledge for almost all future experts in technical professions, but it is the most difficult to learn and the most abstract. For this reason, the motivation to study, for example, theoretical mathematics is sometimes low, and there is a need to improve the quality of mathematics education; it forces mathematics educators to look for flexible and effective activities of encouragement, visibility, and practicality for students.

The scientific interest of researchers and developers, which began in the middle of the 20th century, is dictated by the importance of integrating basic theoretical knowledge with practical knowledge. Numerous changes emphasize the importance of such integration through the implementation of professionally oriented tasks in the educational process to train highly qualified students' ability to solve complex problems in modern production and technologically developed conditions.

Collaboration in solving professionally oriented mathematical and engineering tasks, integration of innovative learning tools such as collaborative platforms, simulation tools, and gamified learning environments can significantly increase students' engagement and productivity. Students need feedback and a sense of achievement, so tools and methodologies for organizing and implementing professional tasks are important, especially for future specialists in technical fields.

Undoubtedly, the confirmation of the practical usefulness of the learned abstract mathematical knowledge and the vivid visualization plays the most important role. Therefore, it is necessary to choose interactive cloud environments, which are quite a powerful tool in modern teaching and learning. Moreover, the need to create a visualized, visual workspace for future specialists in technical specialties helps to find a combination of solving mathematical problems and creating their models.

It can help engineering students tackle real-world problems more effectively, fostering teamwork, critical thinking, and creativity. Such environments can be Matlab, Wolfram Mathematica, Google Colab, GeoGebra, Desmos, Simulink, and others. These are interactive cloud environments that specialize in mathematical modelling, simulation, data visualization and analysis. With their help, solving mathematical problems of an applied nature becomes a collaborative creation of models, and the possibility of changing input data clearly demonstrates the importance of solving the problem of efficiency.

Among the variety of such interactive cloud environments for active students' collaboration and to achieve the goal of visualizing the practical value of mathematical knowledge, we chose Google Colab because it is free of charge.

High technology, such as Google Colab, provides an excellent solution for professionally oriented tasks in practical mathematics education. Using the capabilities of Google Colab, students, even at the elementary level, can visually represent complex mathematical tasks and solutions to enhance their understanding of concepts.

The interactive environment platform allows code to run in real time, helping to quickly demonstrate how professional mathematical tasks are solved step-by-step. It makes Google Colab technology clear, understandable, and accessible. It also allows students to collaborate, share their work, and receive immediate feedback, which promotes a deeper understanding of the content. It is clear that this technology integration not only supports more engaging and efficient learning but also extends students' knowledge and equips them with new tools to enhance their technical skills for future professional applications.

For us, authors in Ukraine, it is even more important. Now, in Ukraine, in times of war, it is essential to focus on the economic development of the country. The main thing after the destruction of the war is the reconstruction, the restoration of the destroyed national infrastructure, which requires qualified engineers and technical specialists. Post-war economic development contributes to the economic recovery and growth of the country, as technological progress is the driving force behind innovation and competitiveness in the world. Therefore, it is important to provide students with professionally oriented tasks in mathematical, engineering, and technical fields in technical education in general. It will help Ukraine to meet the current challenges of the war and lay the foundations for future development.

2 LITERATURE REVIEW

In order to understand the gap in previous investigations let's analyze the world's approaches to mathematical problem-solving, and different views on the implementation of career-oriented learning, points of using Google Colab as an environment, and finally, the interest of local researchers in the importance of technical education in Ukraine for the reconstruction of the country today.

In the world, the organization and methods of teaching mathematical problem-solving have been the focus of scientific attention for a long time, with ongoing research in this area. Solving a mathematical problem is seen not only as a process of finding an answer [1], but also as a process of dealing with uncertainty and using strategies to overcome it. It involves several cognitive processes, including the construction of mathematical models, the planning of solutions, and the execution of actions [2], [3], [4]. The nature of individual problem-solving also plays a critical role, as the process involves a series of mental actions, including awareness, analysis, synthesis, planning, implementation, and generalization [5]. The process is therefore complex but can be algorithmized by appropriate heuristics and guided by a teacher or planned in collaboration with students.

The implementation of work-based learning contribute to many skills and competencies, such as the development of critical thinking [6], [7], motivation of engineering students [8], [9], creative skills [10], academic performance and mathematical skills [11], effective adaptation to the rapidly changing demands of the future work environment [12].

The development of practical experience is also possible through the introduction of project-based learning [13] as well as changing the educational environment [14], in particular, changing classroom learning to participation in real collaborative projects, creating relevant engineering education projects [15], creating virtual laboratories and simulations [16], [17], as the environment is close to real-life conditions in wartime [18].

Using Google Colab as a research platform [19] designed for prototyping machine learning models [20], and providing access to powerful hardware options such as

GPUs and TPUs is explored [21]. It provides a serverless Jupyter notebook environment for interactive code development and execution [22].

In times of war in Ukraine, it is important for Ukrainian researchers to deepen the foundations of professional orientation in mathematical education for the economic development of the country, to restore the destroyed national infrastructure. Ukrainian researchers define the principle of vocational orientation in mathematical education as a systemic principle that integrates mathematical and vocational disciplines in higher education [23]. This integration combines general scientific and mathematical knowledge with professional skills and promotes the development of key qualities for future specialists [24]. Moreover, it is seen as a didactic principle aimed at adapting curricula and educational content to align with the needs of specific industries [25], especially in terms of the necessary level of mathematical knowledge, the choice of pedagogical methods and the development of mathematical readiness for professional activity [26].

In addition, Ukrainian researchers emphasize that vocational education is a process in which students deal with objective reality in order to master the basic knowledge and skills necessary for their chosen profession [27]. In particular, mathematical disciplines in technical education should focus on professional knowledge and skills, with an emphasis on the practical application of mathematics in professional contexts [28].

We agree with the views of Nantshev et al. [29] and Pasov et al. [19], who emphasize the leading role of mathematical disciplines. Based on the above, we argue that professionally oriented mathematics education is an effective blend of mathematical knowledge and professional expertise presented to future professionals through the lens of practical value and scientific validity.

In our view, the scientific validity and relevance of the integration of these areas of knowledge is crucial for future professional success. Neglecting this integration could lead to a distorted view of theoretical mathematical knowledge, relegating it to ancillary status or over emphasizing mathematical tools at the expense of broader professional competencies. Achieving a balance between the fundamental nature of mathematical knowledge and its practical application in an interactive cloud environment is essential for the development of well-rounded professionals.

Thus, after the literature review, we can highlight that there is a gap in mathematical knowledge in the implementation of professionally oriented tasks using interactive cloud environments such as Google Colab.

The purpose of the article is to analyze the need to implement professionally oriented tasks in higher mathematics courses for technical students during practical classes using the interactive cloud environment Google Colab. In order to achieve this goal, the following tasks have been set: 1) to critically review the main theoretical concepts, analyzing their definitions, scope, significance, differentiation criteria and relevance in different professional fields; 2) to conduct a pilot student study to understand the students' motivation and personal experience for offering the effective approaches for implementing professional tasks in higher mathematics teaching; and 3) to show the implementation of the interactive cloud environment Google Colab for visualizing the offered professional tasks.

3 METHODS

In order to achieve the stated purpose, the following methods were used: 1) general theoretical methods, including analysis and synthesis, aimed at understanding

the main principles and specific challenges of integrating vocational orientation in mathematics education; these theoretical methods were also used to identify the main requirements for improving effectiveness and incorporating the best practices from pedagogical experience; 2) empirical methods, such as interviews, observations, interpretation and systematization, which were used to collect first-hand data from students in order to study their motivation and necessary skills for solving mathematical tasks; and 3) methods of context-based learning and project-based learning for solving career-oriented tasks, and model-based learning when using the interactive cloud environment Google Colab for visualizing the offered career-oriented tasks.

The study involved students enrolled in technical and economic specialties of Ukrainian universities.

4 RESULTS AND DISCUSSION

4.1 Theoretical background

In order to understand the main theoretical concepts, let's examine the main definitions, differentiation criteria and relevance in different professional fields. Vocational education and training are widely regarded as one of the fundamental principles of modern higher education. Its implementation not only contributes to the development of a solid theoretical knowledge base, but also promotes the refinement of knowledge. This process enriches theoretical understanding by infusing it with practical content, creative skills and the tools needed to apply theoretical knowledge in real-world contexts. It also fosters an intrinsic motivation to learn and a cognitive interest in the future technical profession.

In addition, it is important to balance the organizational methods of teaching in order to broaden students' professional outlook and research experience. Since the system of mathematical tasks, especially professionally oriented tasks, offers opportunities for such development, the activities used to organize the solution are refined and studied.

Let's analyze the main concepts. The concept of "task" has different interpretations in different disciplines and continues to be the subject of scientific investigation. Broadly speaking, a "task" refers to a problem situation in which a goal is set to achieve a particular result. It is traditionally seen as an iconic model of a problem situation, where the difference between the problem and its representation defines a task. This view emphasizes a task as a complex system with relationships between its structural components: the subject of a task and the model of the required state. The concept of "task" is intrinsically linked to mathematical problems through the common cognitive processes involved.

The concept of "a professionally oriented task" can be understood as a mathematical task that deals with objects from professional activity and is focused on developing actions relevant to future professional roles. These tasks may be narrative based, with so-called "plots" derived from professional contexts, where solutions are found using mathematical methods. In this sense, professionally oriented tasks serve as models of professional situations and help students to develop competencies relevant to their future careers.

As outlined above, professionally oriented tasks are either mathematical models of professional activities or problem situations that can be solved using mathematical techniques. These tasks play an important role in shaping the personal and professional qualities of future professionals. Thus, a professionally oriented

mathematical task is one that simulates a future industrial or engineering scenario, the solution of which contributes to the development of mathematical knowledge and skills linked to professional competences, while also incorporating elements of research and problem-solving.

On the basis of this definition of “a professionally oriented mathematical task” and taking into account the role, functions, and conditions for the practical application of mathematical tasks, we propose the following indicators of effective task implementation: natural and scientific relevance, alignment with the level of acquired professional knowledge, logical formulation, challenge (presence of a problem situation to be solved), variability, and realism.

Professionally oriented tasks, in order to ensure their effective implementation in education, should be closely related to real professional situations. They must correspond to the students’ level of knowledge and contain anticipatory content necessary for solving the problem at hand. In addition, such tasks should encourage the search for new knowledge and broaden students’ general and professional horizons.

Indeed, the choice of tasks for teaching must be made carefully, guided by the principles of systematics, scientific coherence, practicality and relevance. The stages of developing the necessary techniques to promote students’ cognitive activity should also be carefully planned. A scientific approach based on advanced pedagogical methods can greatly enhance effectiveness.

The concept of “effectiveness” (from the Latin “effectivus,” meaning active or creative) is primarily linked to the outcome of solving a specific problem. It characterizes the relationship between the result achieved and the resources invested in creating the conditions for finding and implementing solutions. Effectiveness is determined by the quality and quantity of the resources involved, as well as by the specific context of a task.

4.2 Pilot students’ study

We find out about the students’ motivation to learn and the necessary skills for solving mathematical tasks, we conducted a short pilot study in the form of a survey with 180 students: 90 students of technical specializations, 58 students of engineering specializations and 32 students of economic specializations of the first year. It consisted of five questions. They were: 1) Do you like mathematics? Why? 2) Do you like solving mathematical tasks? Why? 3) What difficulties do you have when solving a task? 4) Do you want to learn how to solve tasks? 5) Is mathematical knowledge essential (necessary) for your future job? As a result, the following answers were obtained among students of economic, technical, engineering specialties at Ukrainian universities.

The results obtained among students of economic specialties are as follows: In response to the first question, 56.4% of students said that they mostly like mathematics, and 43.6% said that they sometimes dislike mathematics because it is incomprehensible and complicated. In response to the second question, 65.8% of the students were not sure whether they liked solving tasks; they said that sometimes they did not know how to do it; 13.5% knew how to solve tasks, but did not like solving them; 11.1% liked it when they succeeded in solving them; 9.6% knew how to solve tasks and liked them a lot.

Among the difficulties that the students encountered when solving mathematical problems were the following “I don’t understand why,” “I don’t know how,” “I have little experience.” When asked whether mathematics was worth studying,

the answers were almost evenly divided. 55.7% of respondents agreed that math's was worth studying, while 42.4% disagreed, citing boredom as the reason. A small proportion of respondents were undecided.

The survey results show that the number of students who want to learn how to solve problems exceeds the number of students who already know how to solve them. This suggests that there is a desire to learn how to solve problems not only among those who already have such knowledge, but also among those who have not acquired such knowledge and skills at school.

The results for engineering and technical students are almost identical to the previous results, with an average of 3–5% higher for students who could solve problems and 8% lower for those who could not. More students were willing to learn to solve problems (67.3%). An analysis of the answers to the questions posed shows that half of the students (48.3% on average) do not consider mathematical knowledge to be necessary for their future professional activities. The highest level is 77.8% among students majoring in theoretical economics. These students traditionally value only elementary mathematical knowledge: arithmetic operations, percentages and ratios; another knowledge is considered “superfluous.”

As we can see, the situation is complicated by the fact that students who have entered universities do not have very high self-esteem, unused mathematical tools and problem-solving skills. Undoubtedly, this has a significant impact on students' motivation to learn and, in the future, on their academic performance, including the acquisition of mathematical knowledge.

The origins of such low motivation and self-esteem in mathematics learning among university students, and the lack of formation of a positive relationship with mathematics [30] come from school. Undoubtedly, the lack of basic knowledge and experience contributes to feelings of inadequacy that reduce students' motivation to engage with the subject, leaving them demotivated. For many students, the subject is seen as a burden, exacerbated by the perception that it has little practical value for their careers; students do not see mathematics as essential for their future careers, and it also reduces student motivation. The low self-esteem also associated with the inability to solve mathematical tasks is also likely to reduce students' motivation. Addressing these gaps in understanding, experience, and relevance is therefore crucial to improving both motivation and self-esteem in mathematics learning and the professionally oriented tasks are one of a useful tools.

4.3 Practical implementation

From our point of view, for the implementation of professionally oriented tasks we need to define a framework for evaluating the effectiveness of solving professionally oriented tasks in higher mathematics practical classes, focusing on the areas of knowledge integration, practical application, and personal-professional growth, assessed through criteria such as purposefulness, relevance, personal significance, motivation, and practicality.

We can state, that the effectiveness of organizing the solution of professionally oriented tasks in higher mathematics practical classes should be evaluated across the following areas: 1) the acquisition of integrated knowledge (broadening the knowledge base by integrating professional knowledge and improving the quality of understanding); 2) the development of practical experience (the ability to apply theoretical knowledge in professional contexts); and 3) personal and professional development (including motivational, intellectual, communicative, and worldview growth).

The evaluation of effectiveness is based on the following criteria: organicity (the degree of purposefulness and clarity in the task design), value (the relevance and significance of the knowledge and experience gained), internalization (the personal significance of the learning process), motivation (the degree of conscious engagement and dependency relationships), relevance (the subjective importance and specificity), and rationality (the optimization and practicality of the knowledge and skills acquired).

The analysis only helps to adjust the foundations and to redistribute the emphasis on personally oriented professional learning. Indeed, the initial bases have an impact on the university studies in the chosen field. Nevertheless, with effective and correct training, positive changes should occur in students' motivation and successful mastery of higher mathematics course content.

However, it is important to recognize some of the challenges that both teachers and students face when working with professionally oriented tasks. Firstly, the transition to solving such problems should come after a full introduction to theoretical issues, in particular relevant definitions, theorems, properties, and solutions to simpler (formalized) problems to consolidate simple techniques against a background of well-practiced computational and transformational skills. It is the transformations of expressions (simplifications) that students struggle with.

Secondly, a lecturer has very limited time (a lesson lasts 90 minutes) and solving applied problems is always a labor-intensive process with additional explanations and derivations of equations or formulae. In addition, it requires additional knowledge from the teacher, which significantly increases the time needed to prepare such lessons, including the development and selection of such tasks.

In order to meet the challenge of limited time in a 90-minute class for work-related tasks, practical time management strategies such as homework and online consultations outside of class are offered. Homework helps students to summarize theory and to extend and improve practical skills such as calculations and graphic work. It allows students to engage with the material independently and frees up class time for more focused discussion. Providing online consultations helps students with any difficulties they may have in working independently. This approach maximizes class time for interaction while ensuring that students still have ample opportunity to practice and refine their skills. Thirdly, the potential readiness of students for such complex, career-oriented tasks requires a solution based on students' interdisciplinary knowledge.

Interdisciplinary links should be achieved through the integration of tasks that reflect the vocational orientation of the mathematics course, as well as through the integration of knowledge from different subject areas. The first strategy for integrating interdisciplinary links in higher education is to enrich mathematics teaching by incorporating profession-specific tasks from areas such as material resistance, theoretical mechanics, engineering hydraulics and risk assessment. This approach helps students to understand how abstract mathematical concepts are applied in their future careers. The second strategy is to promote closer collaboration between mathematics departments and specialist disciplines, in particular through joint lectures that emphasize the practical relevance of mathematical knowledge in these fields.

The third strategy is to improve mathematics curricula so that they provide the most effective mathematical tools for the specialist disciplines. This can be achieved through consultation with specialist departments, aligning curricula with the professional competencies required in specific fields, and promoting joint decision-making. Ultimately, the successful integration of students' technical skills for future

professional applications depends on a combination of basic mathematical knowledge, career-oriented learning and interdepartmental cooperation.

The lack of readiness of students to solve complex, career-oriented mathematical tasks requires the development of detailed strategies to address this gap at different levels of knowledge. The proposed systematic approach involves five key strategies. First, it is essential to adapt the curriculum by integrating occupation-specific tasks that reflect real-world applications in fields such as engineering, business and technology, and that are tailored to different levels of knowledge. Second, these tasks should progressively increase in complexity to match students' evolving understanding, ensuring that the challenges they face are in line with their academic development. To facilitate learning, a differentiated approach should be adopted, providing tasks of varying levels of difficulty that allow students to engage with material appropriate to their abilities, from basic problems for beginners to more advanced challenges for experienced learners.

Thirdly, pedagogical support must be tailored to the needs of students, providing structured support that encourages progress across different levels of knowledge. Collaborative learning, including group work and interdisciplinary projects using interactive tools such as Google Colab, allows students from different disciplines and levels to share their knowledge, thereby enhancing their understanding of how mathematical concepts apply in different contexts.

Fourth, regular formative assessments, such as tests, quizzes, colloquiums and discussions, are essential to monitor student progress and provide timely feedback, fostering self-awareness and continuous improvement. Fifth, inviting industry professionals to demonstrate real-world applications of mathematics contextualizes learning and motivates students by showing the practical relevance of their studies. By making these strategic adjustments – in particular, by implementing differentiated tasks, providing targeted pedagogical support, and ensuring continuous assessment – students will be better equipped to solve work-related tasks, effectively bridging the gap in their readiness.

As not all the topics of a course can be applied to professional tasks, the specific topics remain abstract knowledge, because they serve as a basis for more complex practical tasks related to mathematical modelling, which is not part of the mathematics course for engineering specializations in the first and second years.

Among the ways to reduce the gap between mathematical knowledge and professional knowledge in practical classes in higher mathematics, we see the implementation of professionally oriented tasks during lectures and practical classes, computational and graphical tasks as a solution to a complex problem in all topics of modules that have the context of a professionally oriented task with the interactive cloud environment Google Colab.

Google Colab is a free interactive cloud environment that allows students to work online on the Internet without having to install any software on their computers. It is a tool with a simplified start that does not require any additional effort to configure. Google Colab offers a non-programming way to make mathematics accessible and interactive by providing tools that simplify mathematical calculations and help visualize the results.

A great visualization tool, both for checking the correctness of the output and for performing a visual experiment to find the optimal solution, is to use a library such as “ipywidgets” in Google Colab. Thanks to the addition of “ipywidgets” sliders for entering parameters (data from the task, for example, changing the size of a construction site or the amount of construction materials, etc.), you can immediately visualize the results obtained. When analyzing the sliders as a testing tool, we can

add that a pre-prepared problem-solving program with customized sliders allows a lecturer to enter data and get correct answers.

Here are examples of tasks for the two proposed techniques. Some task solutions are offered in [31], [32]. Examples of professionally oriented content tasks to be solved in practical classes to consolidate the studied material or show practical application during lectures, the tasks are presented according to the topics in which they are solved. Some professional tasks for the course topics may be as follows:

Example of Task 1 (topic “Linear algebra”). A mixture of iron and zinc dissolved in acid gives 2.33 g of iron and 896 mL of hydrogen. How many grams of each metal were in the mixture?

Example of Task 2 (topic “Vector algebra”). During the installation of radio transmitters for mobile communication, the question of the stability of the masts arose. Write the equilibrium condition for the forces acting in a loaded radio mast.

Example of Task 3 (topic “Defined integral”). In an inspection shaft for laying an optical fiber cable, the lower part has the shape of a truncated cone, and the upper part (hatch) has the shape of a cylinder; it is made of concrete with a material density of 2.45 ton/m³. Find the volume of the manhole and the mass of concrete used to make it (the sizes of the object are given in the table for each variant).

Example of Task 4 (topic “Differential equations”). A brick wall 30 cm thick has a temperature of 20°C on the inside and 0°C on the outside. Find the relationship between the temperature inside the wall at the distance from its outer boundary and the amount of heat that 1 m² of the wall gives off to the outside during a day.

Example of Task 5 (topic “Differential calculus of a function of several variables”). In an electric circuit, when an electric current flows through a conductor with resistance R , heat is released according to the law $Q = 0.24I^2t$. At the end of this conductor, three other conductors are connected in parallel with resistances R_1, R_2, R_3 . The resistances R_1, R_2, R_3 must be chosen in such a way that the current flowing in this system causes a minimum loss of heat.

Undoubtedly, the solution of all these tasks requires various knowledge from other courses, which is studied by future engineering specialists, establishes interdisciplinary links, increases the applied value of the acquired knowledge, which is an important tool for professional training and ensures the professional orientation of education.

The other technique is a *complex* computational and graphic task, which is formulated in the same way for all students, but the data for the calculations are given to each student separately. This task can also be solved by groups of students (a kind of group work), sharing responsibilities as in a real design and construction company.

In fact, Google Colab is a powerful motivational tool not only for learning mathematics, but also for learning programming, in particular, the Python language. The gradual integration of programming into the study of mathematics, in particular by solving certain practical, construction and optimization problems, allows students not only to study the technical aspects of their future profession, but also to develop programming skills that will certainly be useful in their future professional careers. Students who use Google Colab to solve applied, work-related problems are given the opportunity to visualize the results of their solutions.

Examples of a complex task. The construction of an object $C(x_0, y_0)$ has started. The plant is located off the motorway. To carry out this project, you need to make certain calculations:

- For the delivery of materials, equipment and workers, an auxiliary road should be built under the following conditions: a warehouse for construction materials and a car park for construction equipment should be located at points $A(x_1, y_1)$

and $B(x_2, y_2)$ (marked on the map), which are respectively connected in a straight line to the existing motorway, respectively. The new building $C(x_0, y_0)$ in the same system must be connected to the motorway by the shortest route. Find the entry point of such a road to the motorway and its length, and draw a figure if the positions of the objects are given by their coordinates $A(x_1, y_1), B(x_2, y_2), C(x_0, y_0)$.

- At the preparatory stage of construction, when preparing the budget, the task is to approve the consumption rate of building materials for the production of building mixtures. For the production of 1 ton of construction mixtures of types A_1 and A_2 (given in the table), components B_1 and B_2 are required, for their production, in turn, some construction materials C_1, C_2 are required (the quantity is given in the corresponding table). Work out the number of production materials C_1, C_2 needed to produce one tone of A_1 and A_2 .
- For the production of building mixtures directly on site, it is necessary to prepare cylindrical metal tanks of a given volume V . What should be their sizes so that the least amount of material is used in their production? Determine the size of the tank and the amount of material consumed ($y\ m^2$), excluding cutting costs, assuming that the tanks are to be made with volume V .
- Calculate the wages to be paid to the workers at each stage of construction, given the following (table attached): a) working hours at each job (matrix P); b) production rates (matrix Q); c) hourly wages (in USD) at each job (matrix C).

The grading criteria for task completion are as follows. For a satisfactory grade (D, E: 60–74), a student demonstrates a basic understanding of key concepts, definitions, and terms, and has the minimum knowledge and skills required to complete simple tasks. However, errors and logical inconsistencies may occur in problem-solving. However, errors and logical inconsistencies may occur during problem-solving. A good grade (C: 75–89) indicates that a student has a solid understanding of theoretical concepts, definitions and terms, and can solve practical problems with minor errors that do not disrupt the logical flow of the solution. Knowledge of formulas, definitions and theorems is confidently and effectively applied.

For an excellent grade (A, B: 90–100), a student demonstrates a comprehensive understanding of all relevant concepts, definitions, and terms. A student is able to solve complex problems with clear explanations and justifications, demonstrating independent, confident theoretical knowledge. A student applies critical thinking, avoids errors, follows logical reasoning, and demonstrates creativity in solving increasingly complex tasks.

Let’s analyze the implementation of Google Colab for a task: At the preparatory stage of construction, when preparing the budget, the task is to approve the consumption rate of building materials for the production of building mixtures. For the production of 1 tone of construction mixtures of types A_1 and A_2 (refer to Table 1), components B_1 and B_2 are required, for their production, in turn, some construction materials C_1, C_2 are required (the quantity is given in the corresponding table (refer to Table 1). Determine the number of production materials C_1, C_2 required to produce one tone of A_1 and A_2 , using the following data: $a = 2, b = 3, c = 2, d = 1, m = 1, f = 1, n = 1, q = 0$.

Table 1. Table presentation of the task

Products	Ingredients		Building Materials	C_1	C_2
A_1	a	b	B_1	m	n
A_2	c	d	B_2	f	q

An interactive code has been prepared, in which each of the components (B_1, B_2 for A_1, A_2, C_1 and C_2 for B_1, B_2) has sliders (see Figure 1), allowing the student to change the cost value for each component and see this it affects the results (for example, how the amount of materials C_1, C_2 changes, when the cost for B_1, B_2 is changed).

```
# Interactive interface
interact(plot_results,
  a=FloatSlider(value=2, min=0, max=10, step=0.1, description='a'),
  b=FloatSlider(value=3, min=0, max=10, step=0.1, description='b'),
  c=FloatSlider(value=2, min=0, max=10, step=0.1, description='c'),
  d=FloatSlider(value=1, min=0, max=10, step=0.1, description='d'),
  m=FloatSlider(value=1, min=0, max=10, step=0.1, description='m'),
  n=FloatSlider(value=1, min=0, max=10, step=0.1, description='n'),
  f=FloatSlider(value=1, min=0, max=10, step=0.1, description='f'),
  q=FloatSlider(value=0, min=0, max=10, step=0.1, description='q')
)
```

Fig. 1. The screenshot of the part of the application where sliders are entered

This allows students to see the practical application of mathematical models and calculations. The graphs are built (a bar graph to visualize the consumption of materials C_1, C_2 for mixtures A_1, A_2), they provide an opportunity to visualize clearly the dependence of material consumption C_1, C_2 , on the number of components B_1, B_2 for A_1, A_2 and to analyze the mathematical model obtained (see Figure 2).

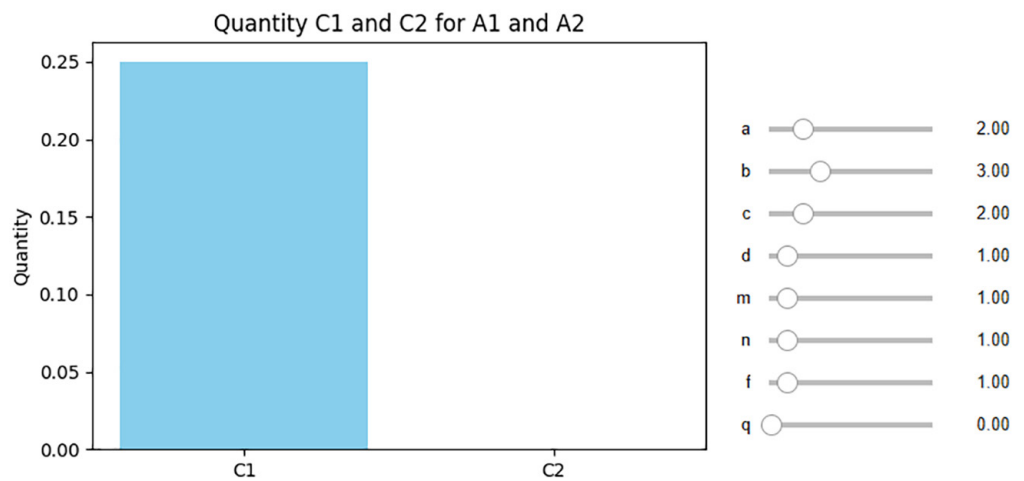


Fig. 2. The graphical visualization of results with selected slider parameters

The results of the calculation of the program with the given parameters (see Figure 3). The task can be carried out either individually by a student according to a specific variant for each, or in groups. With the help of a pre-developed software tool, the individual work of a student can be checked by entering predefined data for each student, which can be checked both by the students themselves and by the teacher. The teacher can deliberately present a wrong answer and ask the students to find the error in the algorithm implemented by a pre-prepared program. It is advisable to carry out an impromptu search in the form of a discussion with an experimental implementation (visualization in the Colab environment) of all the hypotheses put forward, or a brainstorming with leading questions.

```

det(A) = -4.0
A_inv =
[[-0.25  0.5 ]
 [ 0.75 -0.5 ]]
det(B) = -1.0
B_inv =
[[-0.  1.]
 [ 1. -1.]]
Result (B_inv * A_inv) =
[[ 0.75 -0.5 ]
 [-1.   1.  ]]
Solution C = [0.25 0.  ]
Solution for C1 i C2: C1 = 0.25, C2 = 0.0

```

Fig. 3. Results of the program calculation with the given parameters

Undoubtedly, the implementation of such tasks depends on the collaborative and careful efforts of two key players in the educational process: a teacher and a student. The effectiveness of this process depends on their mutual willingness to cooperate, the alignment of goals and the focus on achieving results. Overall, students tend to view the introduction of professionally oriented tasks positively, although their feedback varies according to individual factors and personal experience.

However, despite the strong potential and practical value of the Google Colab environment, there are certain difficulties in its implementation. First of all, it is the willingness of a lecturer to run such a course, it requires the lecturer's knowledge of the Python programming language and the skills to work in such interactive cloud environments.

It is clear that the use of interactive cloud environments, particularly for visualizing problem-solving and collective collaboration to solve them, allows real visualization of the real results of the task and increases students' motivation to learn. Thus, students understand that mathematics is not only an abstraction, but also a practical tool that directly helps them in their professional activities.

4.4 Discussion

To discuss the problem of effective implementation of professionally oriented tasks by university teachers, it is necessary to say that there is a notable gap in the research literature regarding the resources, training and support needed to use tools such as Google Colab. Despite the increasing use of different platforms and resources in educational contexts, many educators lack the necessary professional development to integrate them into their curricula in a meaningful way. This lack of training can prevent teachers from creating tasks that reflect industry standards and adequately prepare students for professional environments [33].

Furthermore, the lack of institutional support in the form of collaborative networks or continuous professional development opportunities exacerbates this challenge [34], [35]. To realize the full potential of tools such as Google Colab, it is essential to provide teachers with a comprehensive support system, including access to resources, targeted training and ongoing professional development [36].

In terms of discursive points, there are different challenges and limitations in implementing practical tasks. From the point of view of the students we interviewed, their main difficulties arise from two main factors: a sense of overload due to the considerable effort required to complete the tasks, and a lack of experience with non-standard (non-algorithmic) tasks. These tasks are complex because they require

the integration of several mathematical concepts. In addition, students faced with tasks that require a high cognitive load may struggle to process information effectively, which can negatively affect their learning experience and undermine their confidence in their mathematical abilities.

The research by Charalambides et al. [37] suggests that students with limited experience of practical tasks are likely to have greater difficulty with work-related tasks, especially in the early years of their studies. In such cases, the role of the lecturer becomes one of guidance and support.

According to López-Díaz [38], there is a significant correlation between the lecturer's attitude and students' performance in mathematics. One of the most important tools for teachers is their mastery of the subject. Providing clear explanations and relevant theoretical context helps students feel more confident and better able to solve complex problems. It is important to avoid making students feel helpless or unsupported. Therefore, the effectiveness of these tasks depends largely on how well they are integrated into the curriculum and how they are framed in relation to the students' future career paths.

Group work is discussed in terms of contextualized learning and project-based learning. As scholars [39], [40] have noted, group work serves as an exploratory phase prior to whole-class discussion where student-generated ideas can be tested. For discussions to be effective, students need to share, justify and refine their ideas towards consensus.

However, lecturers often find it challenging to manage these discussions, which raises the question of whether their interventions help students to understand the task better and encourage productive dialogue. For these reasons, lecturers should avoid content-specific questions and instead ask general, open-ended questions to stimulate student contributions and discussion. Hofmann & Mercer [39] argue that the differing views on effective lecture's interventions reflect the current limited understanding of these practices. Provided that individual intervention does not create dependency in thinking, while contextual feedback supports student thinking autonomy.

Thus, a consistent and comprehensive approach to implementing career-oriented mathematical tasks serves as a clear demonstration of the relevance of mathematical knowledge to students' future professional activities [41], especially using interactive cloud environments. This in turn acts as a strong motivation to master the learning material.

4.5 Limitations

While Google Colab is highlighted as a key tool, there are potential limitations such as internet accessibility, technical literacy and dependence on a single platform. Although Google Colab is a powerful tool for coding and machine learning, its reliance on a stable internet connection may limit access. Some users with low technical literacy may also find it difficult to use, especially its advanced features. Reliance on a single platform may introduce vulnerabilities, such as changes in platform policies or service interruptions, especially for free versions.

5 CONCLUSIONS

The need to include professionally oriented tasks in higher mathematics courses for technical students during practical classes with the interactive cloud environment Google Colab was explored.

The key concepts of the theory, including their definitions, scope in professional fields were critically analyzed. We can state that there is a need for a stable balance between the fundamentality of mathematical knowledge itself, its implementation by students and the practical value of the knowledge, especially for further professional activities.

We believe that it is impossible to reduce the level of fundamentality, especially the science of mathematical knowledge, by increasing the adaptation of studies, since its main role in the learning process is to create a scientific representation of the universe and to develop logical critical thinking for future specialists. We believe that if students are only provided with a large number of algorithms for the practical application of mathematical knowledge, they will have less need for research, analysis and independent generalization of theoretical knowledge, and the scientific search for new solutions will become impossible.

A pilot study was carried out to assess students' motivation and experience, and to provide insights for the development of effective techniques for the implementation of professionally oriented tasks in the teaching of higher mathematics. It was found that the situation for students is challenging as many students enter university with low self-esteem, underdeveloped mathematical skills in general and limited problem-solving skills in particular. This undoubtedly affects their motivation to learn and consequently their academic performance, including their ability to acquire and apply mathematical knowledge.

The use of Google Colab to visualize and integrate the specific vocational tasks we offer has been demonstrated. Vocational tasks are such an effective combination for cognitive activation, and it is the search for solutions to such tasks that gives students the opportunity to carry out their own practical research activities.

Google Colab helps with mathematical modelling, simulation, data visualization and analysis. It facilitates collaborative problem solving by enabling the creation and modification of models, where the adaptation of input data demonstrates the importance of addressing efficiency. It can be used to solve individual tasks as well as to develop programming skills, particularly in Python, to solve complex tasks. With Google Colab, students can visualize the results of their applied, career-oriented tasks, making the learning process both engaging and effective.

Prospects for further research on the identified scientific question include monitoring students' learning success in other courses through Google Colab, as well as examining their professional adaptation and career development in relation to future professional activities, using the additional opportunities provided by Google Colab. Future studies could provide a detailed framework for systematically exploring this process, proposing specific research questions that address key factors influencing success in different educational contexts. In addition, outlining appropriate methodologies for these investigations would provide a structured approach for subsequent research. A more focused articulation of research questions and methodologies could strengthen the basis for future studies and provide deeper insights into success in different courses.

This would provide valuable guidance for the further development of empirical research in this area. Furthermore, it is crucial to develop practical recommendations based on research findings that would help educators and institutions to improve teaching strategies and student support.

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