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Project based learning for the undergrads students

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Abstract. In this article we will present the results of a didactic research conducted over a period of one semester on a group of 23 students, to discover the advantages and limits of the project method at the level of university education. For comparison, we chose the portfolio method as the formative evaluation method, and the summative evaluation resulted in the project method. At the same time, using continuous evaluation techniques, we were able to determine the degree of involvement and receptivity of the methods used during the teaching-learning activity.

Keywords. learning by project, university level didactic research, formative evaluation methods

1. Short history and previous studies

The project-based learning method was first used by educator and philosopher John Dewey at the University of Chicago. He based his teaching method on an investigation process. Dewey argued that students will develop personal investment in the material if they engage in real, meaningful tasks and problems that shape real-life situations. A student of Dewey's, William Kilpatrick, writes, in 1918, an article about the method of the project as an educational process. (Dewey, 1958) (Kilpatrick, 1918)

In the U.S., in the early 1990s, science teachers realized that students were not motivated to learn the exact subjects, and even the best students showed a superficial understanding of the notions discussed in class. The researchers found that this state of affairs came from an ineffective manual composition and training methods. The textbooks covered many subjects at a superficial level, used only specialized vocabulary and did not rely on the students' previous knowledge. Moreover, they did not concretely explain the phenomena in everyday life and did not give students the opportunity to develop their own explanations of the phenomena. After these discoveries,

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American researchers together with high school and middle school teachers worked on the development of a set of instructions for designing projects in science. These projects involved the students in real problems, which had significance for them. The work of the students was similar to that of the researchers. (Kesidou & Roseman, 2002)

Project-based learning gives students the opportunity to explore phenomena, discuss personal ideas, debate others' ideas and apply their own ideas. It has been shown that project-based learning can help all students, regardless of culture, race or gender. (Karjcik & Blumenfeld, 2006) (Atwer, 1994) (Hernandez, 2016)

A well-known study comparing project-based learning to traditional methods of teaching mathematics focused on curriculum development known as The Adventures of Jasper Woodbury (http://jasper.vueinnovations.com). This research has shown that in middle school, students who use the approach by carrying out projects have not only developed greater skills in solving math problems expressed through words compared to other students, and have also demonstrated more positive attitudes towards mathematics . (Vanderbilt., 1998)

According to J. Mergendoller (p. 56) (Larmer, Mergendoller, & Boss, 2015), the most thorough study was conducted on the result that the project-based learning method can have on the learning of mathematics by Jo Boaler in two British global schools in classroom communities. One school, "Amber Hill", used the (Boaler, 1998) traditional way of approaching mathematics (centered on textbooks and exercises) to mathematics. A second school, Phoenix Park, involved students by having them work on open math projects and in heterogeneous groups. At the conclusion of the three-year study, all students completed the British Secondary School Certification Exam (GCSE). Overall, students in Phoenix Park scored higher than Amber Hill students. However, Boaler states at the end of the study that students at Pheonix Park do not know more math than those at Amber Hill, but that they are better able to apply the math they know.

2. Presentation of the method

A definition of the method is given by the Buck Institute for Education (BIE) in Novato, California, USA Project-based learning is a systematic teaching method that engages students in the process of skills formation and learning through a research process structured around authentic, complex questions and carefully designed tasks and products. (What is Project Based Learning (PBL)?, 2022)

The project is an interactive method of teaching-learning-evaluation, which involves a micro-research or a systematic investigation of a subject, with interest to students. The project method is based on the principle of learning through practical action, with real finality (learning by doing), which also gives it the necessary motivation. As opposed to verbal instruction, learning by carrying out projects is a more comprehensive way of organizing the educational process through which the requirements of a pragmatic education can be satisfied, in the spirit of action and independence in thinking.

The project has an extremely large role in intellectual development, and students need to be trained to work more in the projective phase (preparation of activities) than in the action phase.

The project is understood as a research theme oriented towards achieving a well-defined goal, by combining theoretical knowledge with practical activity. Thus, the student learns through research and practical activity and acquires the processualism of science and its content, applying them in practical activity. The subject is at the heart of an action that will be, reserving him an

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active, and main, role in the realization of the project, causing him not only to imagine, to build mentally, but to transpose into life, to find the means and resources of translating into real fact what he foreshadowed. (Cerghit, 2006)

The method of carrying out projects corresponds to the age at which fantasy and inclination to dream, the figments of projects are very strong. Applying the method gives adolescents or young people legitimate confidence in their ability to work independently and to highlight their creative strength. Moreover, the project has an interdisciplinary character, applying different notions from various, interconnected fields.

Stages of project realization

1. Specify project themes by displaying them in a visible place

The teacher proposes one or more project topics. Announce what it should contain. It is beneficial to let students choose their own homework from a variety of given topics or examples.

Here you can distinguish several approaches (Gaşiţoi & Zastînceanu, 2018)

- structured projects, in which the teacher establishes the activities within the project; the basic methods applied, etc.,
- guided projects, in which the teacher establishes the purpose of the project, and the students are actively involved and select themselves the methods to be used
- open projects, the student formulates the problem himself, studies it and proposes solutions.

2. Specification of documentation sources and conditions of realization

The teacher provides documentation sources to students or indicates a bibliography that can be consulted in the implementation of the project.

Moreover, it is explained exactly what the final product should look like, what it should encompass and what is pursued by the realization of the project.

3. Construction of groups of pupils/students

It is usually good for subjects to form their own groups, because they must interact with each other to teach and help each other. Therefore, they will be grouped by common affinities and interests.

4. Division of tasks

Within the group, each member assumes a task that they can carry out.

5. Making materials, communicating with the teacher on the content

This stage is very important. This is where the student's work and actual learning occurs, through communication with the teacher. The questions that the students ask the teacher are the difficulties they encounter in carrying out the project. Now they realize that something is not clear and they cannot move forward. The teacher's role is to make himself available to the student and help him overcome the obstacles he encounters. However, the teacher must only give directions, his role being outside the group and being the shadow coordinator of the project.

6. Realization of the final form

Finishing the product obtained by students for a final form, corresponding to all the requirements.

7. Presentation of the project

The presentation stage is as important as the realization of the project. The manner in which the product is presented and the information is delivered and the results obtained are crucial. Here the student presents his contribution to the project and proves that the learning took place.

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8. Monitoring and evaluation by the teacher

The teacher monitors the students' activity in the group card and provides support where needed. The assessment takes place at group level and at individual level. One grade is given to the project/product made and another grade, on the presentation of each student. The teacher decides the weighting of each in the final grade.

9. Feedback from the teacher and colleagues, self-evaluation

The last stage is the one in which the teacher and the students evaluate the product obtained, make comments on it and on the presentations. Also now, students can evaluate each other within the group and self-evaluate their own work and their own product. It is the stage when the student gets the merits for its work and thinks ways to perfect the realized project.

It is important to set a deadline for the realization of the project, to specify the bibliographic sources or to make it available to the subjects. It is preferable for students to choose their own working group and to be given enough time to investigate and carry out the project.

The evaluation of projects is made by presentations. The manner of realization, the accuracy of the product obtained, the materials and means used and the results obtained will be monitored. The degree of involvement of each member of the group and the way of presentation will be analyzed. Preferably recommended is the feedback type assessment from colleagues or staff, by those who have worked on the project. The teacher draws up a table with headings that he can point out if the submitted project meets the given requirements. Moreover, the comments must be positive, include statements such as: I like that...., I wonder if...., The best steps could be... (Hernandez, 2016)

The advantages and disadvantages of using the method of learning by carrying out projects in the specialized literature are formulated as follows: (Ionescu, 2003)

Advantages

- is an alternative method of evaluation that puts students in the situation of acting and solving group tasks, self-testing their cognitive and practical abilities;
- provides the chance to analyze to what extent the student is adequately using the knowledge, tools and materials available in achieving the proposed goals;
- develops cooperation and communication skills between students;
- restores the student's responsibility towards his own learning and towards the group;
- the subjects learn from each other

Limits

- solving tasks requires greater resources of time and material resources;
- facilities learning errors;
- the members of the group do not carry out their tasks, the members of the group taking them over to complete the project;
- professor does not fully evaluate the results.

3. Project-based learning in Romanian education

A study from the Republic of Moldova states that for most students, the experience in developing projects during pre-university studies is probably irrelevant, especially because most of the time the projects are elaborated in geography, chemistry, physics and very-very rarely in mathematics. (Gaşiţoi & Zastînceanu, 2018) The same conclusion can be drawn for the Romanian

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students, especially after many decades in which the school emphasized the mechanical reproduction of information that students rarely used in their daily activity.

For this reason, mathematics, as a subject of education, has suffered and still does. Students do not see the usefulness of increasingly elaborate and abstract mathematical constructions with the passage of time and advancement through the established national curriculum. There are many concepts that can be applied immediately and can therefore demonstrate their usefulness, but as concepts become more abstract, mathematics ends up being a philosophy that is difficult to understand for students who have not discovered the beauty of mathematics or who do not find joy in the intrinsic solution of some exercises or problems. Hence the disinterest in discipline manifested by many of the students of pre-university education.

About project-based learning, we found very few references to this method applied in pre-university education, applied to the subject of mathematics. Most of them are exercises as abstract as those in the textbooks, without a real applicability, which are solved by groups, so in collaboration. Although welcome even these attempts to apply the method, (Copăceanu, 2013), they do not come to reinforce the student's need to learn mathematics, making him understand its role and applicability in everyday life, but only to bring a novelty element to the conduct of mathematics classes.

Under the conditions of new educational trends, real problems are solved by applying the mathematics provided by the national curriculum. Some examples worth mentioning are the project entitled Household electricity consumption: what type of subscription is more efficient? which is a practical application of the theme "Functions of the form: $x \rightarrow ax + b$" (Singer & Voica, 2005) and the project entitled Pots and containers: which is the most advantageous shape? which is a practical application of areas and volumes of round geometrical shapes in everyday household objects (Recuperarea rămânerii în urmă la matematică). Other examples are mentioned in a handbook for professional development of teaching staff, page 53-55. (Singer & Voica, 2005)

Although in the university environment, in the two years of the pandemic, the method has been widely applied, in pre-university education it has not developed, teachers preferring traditional methods of evaluation even in the conditions of online education. One reason for this preference is that it requires a larger design, requires more application time, and the evaluation is also time-consuming, for individual evaluation, presentations and recommendations. As time is an extremely limited resource in pre-university education, this preference is understandable.

Therefore, the students participating in the didactic research start with a minimum of knowledge and without experience in carrying out a project.

4. Research hypotheses and objectives

We will analyse the following hypotheses, in comparison with other teaching-learning-evaluation methods:

H1. The realization of projects applying the notions learned improves the learning performance of the students.

H2. We expect students to be more involved in academic learning when learning on a project basis.

Research objectives:

O1. Highlighting the way of applying project-based learning in higher education;

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O2. Establishing the advantages and limits of the method through didactic experiment, both from the student's point of view and from the teacher's point of view;

O3. Improving teaching-learning-evaluation methods;

O4 Improving the assessment of the project-based learning method.

5. The research batch

We base our present results on the optional course "Simulation techniques" taught at the Faculty of Mathematics and Computer Science of the "Ovidius" University of Constanța, in the second semester of the academic year 2021-2022. The group has the specialization Mathematics-Computer Science and consists of 26 students, of whom 4 did not come to any class or seminary. A student only came to the presentation of projects. Therefore, the work group consists of 23 students, 15 girls and 8 boys.

The course and seminar are of applied mathematics in various fields, physics, chemistry, economics. That is why the idea that the evaluation through projects appeared naturally. The projects would be carried out by students applying everything they learned during the semester and, therefore, realizing that all the contents taught are necessary in performing computer simulations.

Some are more inclined to programming and computer science, and others are better at math. They chose their own groups in which to work and the problems to solve with the help of simulation techniques.

FIGURE1: RESEARCH BATCH

6. Experimental design

We will compare the traditional methods used in teaching mathematics, such as solving exercises without practical applications, with solving concrete problems and computer-assisted teaching. We will also compare online and physical teaching and highlight the particularities and limitations of online teaching as opposed to physical teaching.

Moreover, as evaluation methods, the method of portfolio realization and project realization were used. We will analyse the results obtained by the two methods.

7. Research methods

During the semester, the long-term, continuous and instantaneous observation, the didactic experiment and the questionnaire were used as teaching research methods.

The didactic experiment that I led with the students consisted of using the various teaching-learning-evaluation methods applied physically and the teaching methods applied during the period when the classes were held online (the first four courses and seminars).

During the period when we had to do the teaching activity online, due to the Covid-19 pandemic, the students were very little involved, not being noticed or observable. Most of them did not interact with the teacher and were not active in classes, did not answer questions or ask questions where they felt the need, because the human connection between the teacher and the student had not been realized. I felt like I was a simple presenter of information who didn't touch the audience. I didn't get real-time feedback from them, not being able to notice them. During the seminar, where it is assumed that the student, directed by the teacher, acquires, through his own

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effort, the techniques and procedures explained in the courses, only four students spoke, asked questions and demonstrated involvement.

The period when the courses returned with physical presence was beneficial for the teaching activity. The students made a connection with me, their teacher, that led to the understanding of the content taught. Most of them mobilized, began to work individually or in teams set up ad hoc in seminars. They went out to the whiteboard, understood the mathematical methods and procedures, worked very well, showed a desire to understand and asked questions about what they didn't understand during the online period. Thus, some content was resumed and was skilled by more than 70% of the students present, judging by their portfolios.

In addition to the traditional methods of teaching-learning, problem solving and exercises at the whiteboard, we applied, as a didactic experiment, computer-assisted teaching methods, which proved to be very useful. Students have learned to use Ms. Excel and for something other than creating lists or amounts. We discussed the simplex solving method applied to linear problems with real and discrete solutions, which were checked with the help of Ms. Excel. Although all the students were enthusiastic about solving problems with the help of solver in Ms. Excel, not all of them showed the same enthusiasm when it came to solving using traditional methods, since sometimes the calculations turned out to be complicated. Once they overcame the understanding part of the method, they worked well.

I add here that once the students acquired the method of solving, they had to solve real problems resulting from various fields. Those problems concerned the determination of a minimum or a maximum for a cost functional whose variables were subject to conditions resulting from practice (limited resources of time, space and raw materials).

In the second part of the course, the students regained their interest and enthusiasm for the subject we approached, because the theories of simulation were presented and, in the seminars, they used only computers. I noticed, from week to week, that computer-assisted teaching to the subject I taught was beneficial for the teaching-learning process. Each student worked at his own pace, following the instructions in the prepared materials. I had to offer them help many times, as they also encountered difficulties. It is worth mentioning that not all of them were asking for help. About 20% of them I had to find them at a standstill and offer to help them. My role as a teacher had diminished considerably, becoming a supervisor who made sure that all students got involved and worked. For technical reasons, the seminar was worked in groups and thus, the students learned through cooperation, explained within the group what needs to be done, found the mistakes of their colleagues and drew their attention to the correctness of the programs.

From the observation, it emerges that all students have evolved and mastered the techniques taught, but in each of them they have made a different progress that depends on several factors: interest in discipline, attention, ability to concentrate, their abilities and, finally, presence.

Moreover, they learned, also with the help of the computer, the Scilab program and computer-aided teaching to build mathematical models for various real problems. I have noticed that the practical part is much better received than a theoretical part that is not related to a real problem. The joy of running the program and getting the desired answer could be seen on the faces of most of them. Moreover, they gave their interest in solving the problems (mini projects) left for solving at the seminar and asked for advice when they needed it. We took care that in each seminar 70% of the applications were detailed in the materials distributed, but the rest were left to the students for solving during the seminars. Many times, the students encountered obstacles in

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carrying out these examples, however, they overcame them with the help of the teacher. If in the first parts of the course some students did not seem very interested, I noticed a note of enthusiasm towards the end, when they had to perform mini simulations. As an opinion, which that the multitude of examples has led to increased interest, various examples, from various fields, applied with the help of programs written either in code or in x-cos (the special application for simulations has the Scilab program). Moreover, it was also the first course where students wrote codes, which I learned when we started the code part of the seminars. Here I would mention that most of them hoped that this would happen from the first year and were therefore very glad that they now had this possibility.

Another didactic experiment was the formative evaluation by creating a hybrid portfolio, consisting of 22 problems, which had a traditional part – solving problems in writing – and a less used one – making mini-programs with the help of Ms. Excel to solve each problem separately. Almost 50% of the students submitted the portfolio on time. When it was a question of those who did not submit it to take a mandatory written exam at the end of the semester, in addition to supporting the final project, all the subjects wanted to submit the portfolio, so we extended the deadline for handing over the portfolios. This suggests that students prefer portfolio-based assessment, the traditional method, the written exam with the reproduction of demonstrations and the resolution of some exercises, which is very obvious. Moreover, they showed more interest when they understood that 40% of the final grade is the evaluation of the portfolio.

The last teaching experiment is, of course, the project, which is conceived as a summative assessment. The theme of the project was announced in the middle of the semester: The project consists of two simulations carried out using the methods to be discussed at the courses and seminars:

- the first project is of a deterministic nature – it involves fixed input data and simulates a natural phenomenon, inspired by physics or chemistry, such as a free fall of an object with elastic deformation in various environments or in various gravity, or simulating the fusion of some chemicals or nuclear fission.
- the second project is of a probabilistic nature – it involves input data calculated with the help of probabilistic distributions and simulates economic phenomena or the winning rate of some gambling.

For the first project, the courses of Differential Equations and Astronomy could also be applied, and for the second one, the Statistics and Probabilities course, which the students studied in parallel, could also be applied.

The strategy of the open projects was initially chosen – the student formulates the problem himself, studies it and proposes solutions. Where students couldn't handle choosing their problems, they were given suggestions from which they could choose.

In the realization of projects, a large part is based on the originality of the chosen theme. Subjects must choose for themselves the themes of interest to them, themes that inspire them something and that they want to work on. A good part in the realization of a project is the choice of a suitable and representative theme.

All the methods they must apply have been explained in courses and seminars and have been applied on various examples. Students have access to these materials produced during the semester. Moreover, we made available to the students all the books from which the examples and techniques discussed in the course were inspired.

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I provided guidance throughout the implementation of the projects, both in terms of content and in terms of editing and presentation. We also endorsed or disapproved of certain ideas coming from students, whether they fit into the proposed topics.

I noticed from discussions with students that many did not understand what the problems should look like and, when necessary, I offered suggestions from which they could choose.

The last method of applied research was that of the questionnaire, which will help me in the future to improve my methods and meet the expectations of the students.

At the end of the exam, we asked the students to fill in the questionnaire presented online in Table 1: Questionnaire on the Simulation Techniques course, designed specifically for the course we held. We chose the answers to be anonymous so that students did not feel timorous in honestly answering questions. Its results will be detailed in the next section.

TABLE 1: QUESTIONNAIRE ON THE SIMULATION TECHNIQUES COURSE

Question	**Possible answers**				
1. Why did you initially choose this course?	Learning to do simulations	To know how to perform a simulation	I liked the title of the course	I chose another optional	Others
2. Did the course meet initial expectations?	Very Little Much 1 2 3 4 5				Very
3. Did you like the applications from the seminar	Very Little Much 1 2 3 4 5				Very
Justify the answer	(Long answer)				
4. Was the course content accessible to you?	Very Little Much 1 2 3 4 5				Very
Justify the answer	(Long answer)				
5. Did you find the teaching-learning methods appropriate for the contents you have covered?	Very Little Much 1 2 3 4 5				Very
Justify the answer	(Long answer)				
6. Which evaluation method would you find more suitable for this course?	Written exam	Portfolio for all activity		Oral exam	Project	Others
7. Would you have needed additional help from the teacher?	Yes. I asked for and received help	No. I didn't need to.	Yes, I asked for help, but I did not	Yes, but I did not ask for help.	No, but I wouldn't have asked for	Others

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			receive any guidance.		help either.	
8. What difficulties did you encountered during the realization of the projects	I did not understand the theme well	I didn't understand what to do	I didn't find problems	I did not know how to solve the problems I thought of		Others
9. How did you overcome the difficulties you encountered				(Long answer)		
10. What would you change about this course? Do you argue the answer?				(Long answer)		
11. Would you recommend this course to first-year students?				Yes	No	
12. What justification would you give to a first-year student in your recommendation?				(Long answer)		

8. Results of the evaluation and analysis of the methods applied

Following the evaluation of the 21 portfolios the students received the grades shown in Table 2: Portfolio evaluation grades.

TABLE 2: PORTFOLIO EVALUATION GRADES

Grade	3	4	5	6	7	8	9	10
Frequency	1	7	3	2	3	2	2	2

The average is equal to 6.04, and the median value is 5.5. Half of the students got grades above 5 and only 36% failed to pass. Many of those who have taken low grades are those who have either been absent, have shown little interest in linear programming issues or have not compiled the full portfolio. This proves that either the content was not attractive to them, or traditional methods were not the right ones for them.

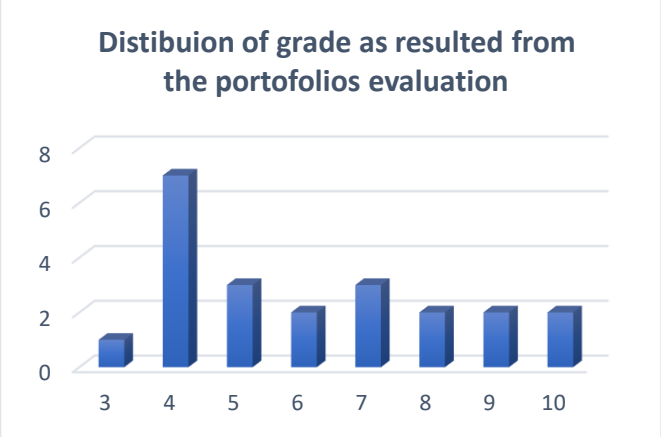

FIGURE2: THE BREAKDOWN OF THE NOTES OBTAINED FROM THE EVALUATION OF THE PORTFOLIOS

The evaluation of the students' projects was carried out according to the following grid:

- Note given to the project according to the following criteria (common to the project) — n_1
  1. Choosing the theme – complexity and originality 2 p

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2. Project requirements – two problems: one deterministic and one stochastic 2 p
3. Fairness of programs 2 p
4. Explanation of the simulation results 1 p
5. Presentation of problems 1 p
6. Bibliography 1 p

1 p

Office

- Note given to the presentation according to the following criteria (individual) – n_2
  1. Correctness of the information submitted 2 p
  2. Individual contribution to the project 4 p
  3. Answers to questions 3 p

Office 1 p

- The grade resulting from the average of the grades given by the project colleagues (collegiate evaluation) and self-evaluation – n_3

Method of computing the final grade = $50\%\ n_1 + 30\%\ n_2 + 20\%\ n_3$.

The evaluation of the projects took place before the exam, by subjecting the projects to the scoring grid, where each project received the grade n_1, and at the time of the exam, through presentations of the projects, where each presentation received the grade n_2 and each student the grade n_3. These resulted grades are in Table 3: Final notes by projects after presentation. This time the average of the group is 9.12. Average considerably higher than that obtained when evaluating portfolios.

TABLE 3: FINAL NOTES BY PROJECTS AFTER PRESENTATION

Grade	6 - 6,99	7 – 7,99	8 – 8,99	9 – 9,99
Number of students	3	0	4	16

Comparing the results in subjects, all students achieved better results when they carried out projects, than when they made portfolios. In Figure3: Grades obtained by students through the two forms of assessment we can see that many of the students obtained better marks in the evaluation through the project. The progress is remarkable. Some with the help of the teacher or teammates, others with the help of the materials made available or through their own documentation.

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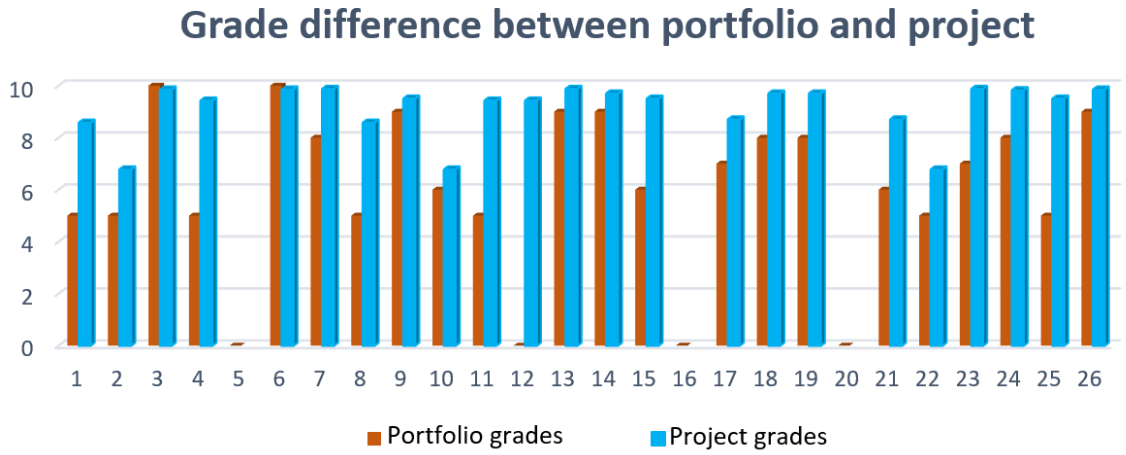

FIGURE3: GRADES OBTAINED BY STUDENTS THROUGH THE TWO FORMS OF ASSESSMENT[1]

These conclusions are highlighted not only by the analysis of the results, but also by the questionnaire that the subjects have completed.

16 students responded to the questionnaire. The results of the questionnaire are as follows:

- 56.3% of respondents chose the course to learn to do simulations, 43.8% wanted to know how to perform a simulation, and 12.5% chose the optional after the title.
- 81.2% of the subjects who completed the questionnaire consider that their expectations were met much and very much.
- The applications from the seminar were also as expected by 75% of the students who responded to the questionnaire. Their justifications are as follows:
    - I really liked the practical problems, the actual simulations of some physical phenomena that we encounter everyday / helped me to enrich my knowledge / were very interesting.
    - The teacher explained very clearly the courses and exercises of the seminar and answered our questions each time.
    - I was just expecting simulations / They weren't always explained in detail.

As can be seen not all students were satisfied with the applications, some wanted more simulations or more explanations.

- Relative to the accessibility of content, 68.8% of those who responded believe that they were very accessible, 18.8% have a neutral opinion, and 12.5% consider that they were accessible.

The justifications were:

- We were provided with all the necessary materials on the educational platform/ the course was very accessible because we had everything explained and at hand.
- I had no problems.

[1] A student, represented by no. 12, has not submitted a portfolio, so its grade is considered 0 in the chart of the Figure3: Grades obtained by students through the two forms of assessment.

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- Figure 4: STUDENTS' RESPONSES TO TEACHING METHODS shows the students' responses relative to the teaching-learning methods we have applied. Negative responses were not justified by respondents. Some students argued the answer:
  - The teacher-student relationship was very essential in terms of interaction from the courses.
  - The teacher knew how to teach for everyone's understanding.
- Regarding the evaluation method, 75% of the students consider that the project was the most appropriate evaluation methods, and 25% consider that a portfolio for the entire activity would have been more appropriate.

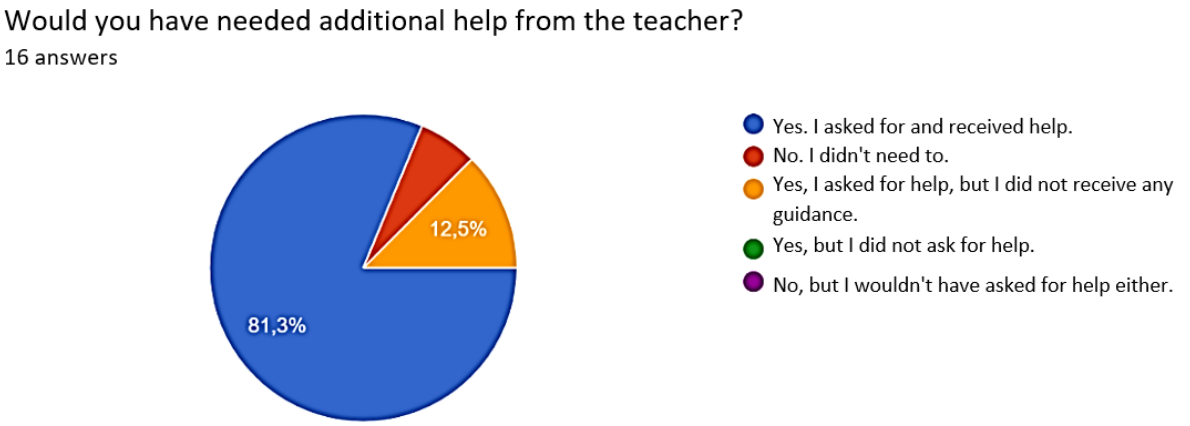

FIGURE5: ADDITIONAL HELP

- 80% of the students considered that they were offered help in designing and drafting projects 13.3% (2 students) consider that they had not received guidance from the teacher. It should be noted that the same two students considered that the teaching methods were not appropriate.
- Regarding the difficulties they encountered in carrying out the project, most of them needed help in finding problems to solve. (See Figure5: Additional help)
- In Figure6: Students' difficulties in carrying out projects Figure6: Students' difficulties in carrying out projects **Error! Reference source not found.**one can observe the difficulties that students have faced in carrying out the projects.

It emerges, the idea that to be successful the method of learning by carrying out projects, the teacher must provide a list of topics (problems) in this case. In this case, the students and offered themselves problem ideas or materials from which they had the freedom to extract what applications they wanted to do. The difficulties also aroused from the impossibility of carrying out the interdisciplinary transfer of the students, who failed to apply the notions learned to other subjects they study in the given context.

One can notice here an already well-known feature of the Romanian education: the inability to transfer the accumulated knowledge. Students and, here are the students, cannot make the interdisciplinary transfer and thus cannot correlate the information learned and the competences developed to solve various problems that do not fall into the pattern of a particular subject of education.

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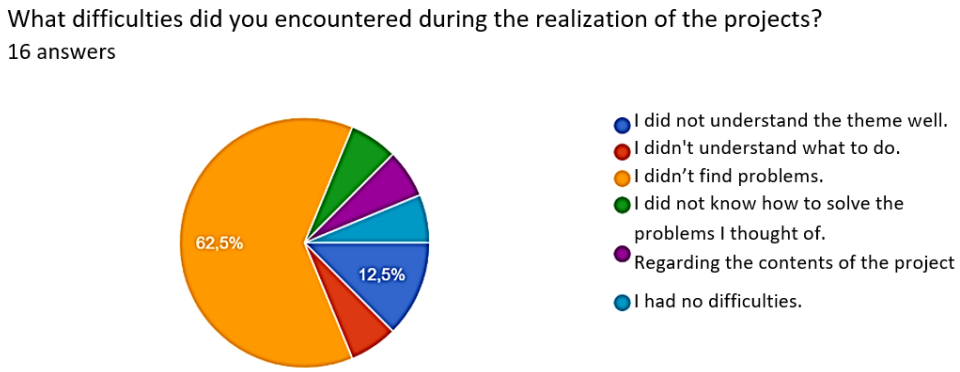
- On how they overcome the difficulties, the students gave several answers:



  - The teacher helped me to clarify/ I tried harder to understand what needed to be done and to remedy the mistakes mentioned by the teacher.
  - With the help of my teacher and teammate/I helped myself with my teammates
  - I searched the books and researched myself.
- When asked, what would change about this course, the students had various answers. Among them we mention
  - I wish there were more practical issues than theory/ I would do more than 2 programming seminars[2]. /As many simulations in Scilab as possible (those were the most interesting).
  - Nothing.
  - Teaching method. Some important notions should be deepened further.

FIGURE6: STUDENTS' DIFFICULTIES IN CARRYING OUT PROJECTS

- The two students who felt that they did not receive guidance, would not recommend the course to a first-year student. The rest would and argued that:
  - This discipline gives you an overview of the physical phenomena that we all encounter, helps you to form a deeper perspective regarding life with all its implications.
  - It is a very interesting discipline in which I learned new things.
  - It is an interesting course that can help you in the future.
  - It's good to know how to do simulations.

9. Conclusions and recommendations

Relative to the assumptions set out in Section 4, we can conclude that the project-based method improves the academic performance of students, as could be seen in Figure3: Grades obtained by students through the two forms of assessment, all students scored better in project evaluation than in portfolio evaluation.

However, even if they managed to carry out the projects, it does not mean that they will be able to solve any problem of this type that they will encounter, which is also proved by the answers within the questionnaire, where the students were not able to solve problems even if they were examples worked during the teaching activity. We can say that they have mastered certain

[2] There weren't just two of them, probably the student also missed some seminars.

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techniques, but not in the totality of the notions taught. Applying the techniques, however, they have at least an idea of what they need to do to solve the future problems they face and perhaps most importantly, they have formed a skill in looking for solutions, investigating on their own and researching on a problem they have to solve.

In terms of involvement, the students were motivated by their own choice, they wanted to get their good projects out and they asked for guidance throughout process. They helped each other, overcoming the difficulties on their own. Even so, encountering various obstacles in the realization of the project, some became more determined, and others could not cope with all the requirements, for example, one the groups did not realize two types of problems, because they said that they did not understand how to make a stochastic simulation. Two students, who formed a group together, said during the presentation that it was very difficult for them because they didn't attend to the seminars and, therefore, they did not understand how to solve the problems, but they managed using the indicated materials and the course support. Thus, we can state that hypothesis H2 is only partially verified, depending very much on the typology of the student, his nature and his motivation for learning or for the grades obtained.

The recommendations that emerge from the application of this didactic experiment are the following:

1. It is necessary for the teacher to give a varied list of topics from which students can choose, especially since the Romanian student has no experience with the projects carried out in mathematics.
2. The advantages of the method are already obvious: students help each other, get involved in learning, document themselves to better understand the topic they have to treat, learn to compose a scientific paper, which helps them to write their undergraduate thesis.
3. Regarding the limits of the method we can remember that it involves a lot of work on the part of the teacher who is forced to explain to each one, concretely what needs to be changed. Not all students will understand what they have to do, and some will not manage to apply the notions learned to different issues.
4. The number of students in the working groups must be a maximum of two. In groups of three students, one of them usually had the task of writing the project and therefore did not use the notions learned. Larger groups are justified when the project can be cut into several clear and well-determined parts. The teacher must be very careful to the number of pupils/students in groups. Everyone must have a significant part of the project and take responsibility within the group.
5. The teacher must provide clear deadlines for certain parts of the project, and the help must be given during the seminars and during the consultation period.
6. Collegial grade is not recommended, because very few students know how to self-evaluate and many easily give their teammates the maximum grade, not wanting to create animosities within their peers. But I asked the students what grade they would have given to the project and there I found a better self-assessment. They realized, after the discussion in the exam that they could produce a better project than the one presented, even those who got over 9.5.
7. Although we made a scheme with the project many did not understand exactly what needed to be done. From this I can extract that it would be beneficial to have a project model to guide themselves, but this could take away the uniqueness of the products obtained.

Therefore, this study brings to light the problems of past and present of learning mathematics. As of past, because the subjects of the study are students who took the Baccalaureate in 2020 but

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had 11 years of traditional school that attests that the problems didn't arise because of the pandemic but are rooted in public education. As of the present, because although the trend is towards change, the problems of the system cannot change in a year or two, but a whole generation of teachers is needed to be raised with new values and principles, who can implement effective methods of teaching-learning-evaluation, combining traditional methods, which we cannot abandon, with the modern ones, developing the formative sides of learning, in addition to the knowledge and competences required by the curriculum in force.

One of the biggest obstacles in learning mathematics is that it is not clear to students where and how to use the notions they learn in everyday life and therefore they cannot make the interdisciplinary transfer necessary for the full understanding of mathematics. As a measure to reduce this shortcoming, in recent years the need to formulate and solve problems that arise from the daily life has been brought up.

The project method can play a very large role here, as it necessarily involves interdisciplinarity. A project inspired by everyday life can not only be related to mathematics, only to calculations or to statics. It must come from a problem that humans face in everyday life, and it must be able to be mathematically modeled and solved by the methods known to the student.

The great challenge is to find these problems that are not so complex to require a mathematical apparatus that is too elaborate but are not so mundane as to turn into simple textbook problems, in the section of practical applications. To this end, it would be beneficial to develop guides with topics and project proposals, applicable to mathematics, to support teachers in school education.

I offer here two examples of projects based on sixth and seventh grade geometry that could be carried out by students over a period of two months:

1. We have a rectangular plot of land. On this land we want to build a zoo. The various animals to be accommodated within the perimeter must have a certain space.

a. Knowing the zoo animals (two lions, two giraffes, four hyenas, two lynxes, a variety of African snakes, three gazelles, two antelopes, six suricates, two lemurs, two ostriches and three zebras) determines the space and conditions necessary for each of them and their arrangement inside the perimeter to leave room for both the visiting alleys and the storage space of food and utensils necessary for cleaning.

b. Do not forget about the spaces dedicated to tourists such as a sufficient dining place for 50 tourists, a place for a bathroom, the entrance gate, where tourists pay for a viewing ticket, a place dedicated to the locker rooms of the employed staff and a parking lot that can accommodate at least 25 cars.

c. Once you have established all these spaces determine the optimal dimensions of the land. A large plot of land will cost too much, and a small one will not be able to include all the spaces thought out above, so you need to determine the best strategy of arranging the spaces so that the land is as small as possible but does not seem like anything cramped.

In carrying out the project, inform yourself what is the necessary space for the animals that we should purchase, what costs this purchase involves, what salaries the employed personnel should receive, what contracts should be concluded for the proper functioning of the zoo. Realize all these details and write them beautifully in a project with the title "My Zoo".

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In carrying out projects, keep in mind that you can get inspired from any source, but you have to understand everything you are reading in order to be able to realize this project. Group with other colleagues in the realization of the project because it will be easier for you to complete it.

2. Imagine that you want to build a house on a plot of 500 m². What would this house look like, what would the rooms be like, where would you position them, how would you have their furniture and how much would it all cost?

In the realization of the project, get informed about the costs of raising the house, about the materials used, about the best strategy by which the rooms are arranged and about the most useful furniture you can purchase.

a. It is also necessary to determine the geometric shape that the land you are building the house must have, so that you have space and garden left, and the house is enough for all the needs of a family. Be careful not to waste space and be able to find the best arrangement for the house and garden.

b. Make a layout or a blueprint of the house you imagined, ordering both the rooms and the furniture in this model. Include all of the above results and search and information results in a project titled "My Dream Home"."

In carrying out projects, keep in mind that you can get inspired from any source, but you must understand everything you are reading to be able to realize this project. Group with other colleagues in the realization of the project because it will be easier for you to complete it.

The two projects aim at the use of geometric figures, the calculation of areas and perimetes, the calculation of optimal costs and a strategy for solving real problems in everyday life, without offering the mathematical models, as we find them in the mathematic textbook. Thus, the student must start from the real situation, use mathematics to solve the problem and interpret the results obtained. Being complex, projects cannot be done individually and require a great analysis and a good strategy for solving, challenging, presenting and cooperating.

Another obstacle to learning, which does not necessarily relate to mathematics, that I discovered in students is that they cannot order their thoughts in a paper because they are not used to this type of project. Even if, it is assumed that they have carried out projects before, they do not know the exact stages of presentation of a topic or a scientific topic. This shortcoming derives from the fact that they are not required during formal education to read any kind of scientific document or to write one, and students will be put in this position in the third year of undergraduate studies.

In this regard, students should be encouraged to read and write scientific articles as early as pre-university education, in order to learn to express their thoughts clearly and following a logical sequence. This can be done within the training circles of students with scientific inclinations and besides, the formative valence of self-taught learning, a preparation for an academic life is developed. Thus it appears naturally, the method of the project for such activities, because the student is given a study theme that he must analyze, use his own thinking resources to understand the theme and solving, and can use his creativity in presenting the project or the techniques learned and applied in other conditions.

Finally, there is another observation on the difficulty of which students know/can self-evaluate their work, the product of the work and the effort made by each member of the group. They are not objective and don't desire performance, although everyone notices that they could more or better. But invariably, the mark for self-assessment was maximum. This denotes that they cannot appreciate their own capabilities because they are not used to doing it. They are not usually

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asked to grade themselves. This is the role of the teacher, who often does not motivate grading process. Thus, although they had the criteria pursued, although they could be guided by them in the elaboration of the projects, they were not able to assess them correctly, to draft them using the criteria pursued, nor to appreciate their work or that of their colleagues objectively, although almost certainly some worked harder than the others in carrying out the projects.

In order to gain the competence to self-evaluate, to be able to improve themselves on their own, at a young age students should be asked to self-evaluate, to evaluate their activity in the classroom, in carrying out homework, to be asked for an opinion about the results of the test they had or to be asked to evaluate their work according to a set of criteria imposed from the beginning of the activity. Although initially they will have an attitude like that of the students in the study, over time they will hold themselves accountable, correct their mistakes themselves, align themselves with the required standards and create a self-critical attitude. All this can add to their moral values that we hope to see in the future, values that they should adopt in everyday life and that formal education must develop in the adult of tomorrow.

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