Applying the STEM approach in studying Graph Theory from the perspective of technology-enhanced interactive learning concept

Liubomir CHIRIAC, Marina BOSTAN, Maria PAVEL,

Violeta BOGDANOVA, Natalia JOSU

"Ion Creangă" State Pedagogical University of Chișinău, Department of Informatics and Information Technologies, Chisinau, Republic of Moldova

chiriac.liubomir@upsc.md, bostan.marina@upsc.md, pavel.maria@upsc.md, bogdanova.violeta@upsc.md, josu.natalia@upsc.md

Abstract: *Graph theory (GT), as a branch of mathematics, can provide mathematical modeling of many real-world phenomena through fundamental notions, concepts, and theorems. Despite the fact that GT is an interdisciplinary science, in the process of studying the respective course, attention is not always paid to solving real-life problems that would involve developing a mathematical model and identifying solutions in the context of STEM education. In this sense, one of the central objectives of this research refers to the development of a methodology for capitalizing on information technologies and the Internet in the process of studying the GT course unit through the STEM approach from the perspective of the concept of interactive-technological learning. The concept of interactive-technological learning is defined as a means that targets 5 types of effective student interactions and interrelationships. The article examines the main benefits of implementing the concept of interactive-technological learning, such as creating a more dynamic learning environment, increasing student interest and motivation, stimulating cooperation and intercommunication between students, etc. Methodological recommendations are proposed regarding the stages in the implementation process of STEM activities/projects. The main advantages of approaching the STEM methodology from the perspective of the concept of interactive-technological learning when studying GT, through technologies, including MAPLE software and Internet platforms, are highlighted.*

Keywords: graph theory, information and Internet technologies, interactive didactic strategies, STEM, technology-enhanced interactive learning concept.

1. Introduction

The most significant benefits of STEM education lie in the direct involvement of students in the process of exploring phenomena through solving practical problems inspired by real life, which allows them to identify existing connections between theory and practice, as well as understand the need to develop specific skills in future professionals who will work in STEM fields. In this context, the use of interactive teaching strategies plays a primary role.

https://doi.org/10.58503/icvl-v21y202631

There are different approaches to defining learning strategies among researchers in this field. For example, researchers I. Albulescu, M. Albulescu (2000), claim that *„The teaching strategy represents the way of approaching and solving concrete training tasks"*. And interactive group teaching strategies (Oprea, 2006) represent „*the ways of organizing the activity that favor inter-relational exchanges between the participants in the activity through interpersonal processes of cooperation and constructive competition (learners - learners, learners - teachers, learners - group), stimulating the subject's activism in his interaction, not only with others, but also with the study material (learners - content), through the processes of action and the transformation of information"*".

In this context, the teacher, in the process of studying GT, constantly strives to find answers to the following questions: „In what situations and conditions is learning more effective: when students work in groups or when they study independently? Which teaching methods are most appropriate for each situation?" Based on our own observations and depending on the subjects being studied, we believe that the following **two didactic approaches** can be applied:

- *If the topics under consideration are of average complexity and do not require additional multilateral explanations, then, obviously, each student learns more effectively independently. The pace of learning and understanding of the subject studied by each student depends on his level of preparation and ability to assimilate new things. In this case, competition between students cannot be ruled out. Competition, in general, has positive aspects, but, at the same time, it can keep in the shade students with weaker academic preparation, who do not always manage to understand the essence of the studied material compared to their colleagues who are better prepared in this field;*
- *In situations where topics are highly complex, learning effectiveness is enhanced by organizing the learning process in a team. Under these conditions, the teacher's role consists, first of all, in good organization of the interactive relationship environment between students-students and students-teachers. It is precisely under these conditions that the application of interactive teaching strategies offers maximum efficiency, because it amplifies the active learning process (conducting an experiment, solving problems, discovering/reinterpreting new things and phenomena, etc.). In this way, the lesson becomes a dynamic process, stimulating students' creativity and involvement. Therefore, interactive teaching strategies (implemented through various methods, such as problematization, heuristic methods, experiments, etc.) contribute to the rethinking the relationships between student-teacher, student-student, student-subject of study, developing/promoting teamwork, dialogue, negotiation and effective cooperation.*

At the same time, in order to achieve educational goals, in our opinion, it is necessary to combine the teamwork rationally, which stimulates intergroup, interpersonal and intragroup competition, with individual work, which stimulates interpersonal competition. Thus, educational goals can be achieved efficiently. At the same time, we believe that carrying out STEM activities/projects also requires the successful implementation of interactive teaching strategies, by effectively combining group work with the individual effort of each student (Gremalschi, Chiriac, 2023), from the perspective of exploring information technologies, including the application of MAPLE software. All these approaches examined as a whole lead us to the need to introduce and develop a new concept regarding the efficiency of the study process – the concept of interactive-technological learning.

2. The concept of interactive-technological learning

The concept of interactive-technological learning is defined as a means aimed at: a) intermaterial interaction: student – subject of study and student – information technology; b) collegial interaction: horizontal – student – team and vertical – student – teacher; c) interpersonal interaction – student-student.

The concept of interactive-technological learning facilitates and contributes to the creation of a more dynamic learning environment, based on collaboration and communication, which generates the exchange of knowledge, opinions and experiences through the implementation of information technologies, creates learning situations centered on the willingness to cooperate and the active and direct involvement of students, mutually influenced by microgroups and moderated by the teacher.

In this regard, the respective paper studied the impact of applying the concept of interactive-technological learning on the process of studying GT through technologies, including MAPLE software and Internet platforms (www.campion.edu.ro, www.graphonline.ru, etc.).

1) Experience shows that a student will not be able to advance in understanding and applying information technology in the process of studying graph theory if he does not know the basic concepts and algorithms related to this discipline. In the MAPLE software, the with (GraphTheory) package version 18 contains 166 available commands. And the MAPLE 24 version already contains 220 commands, which relate to operating with undirected and directed graphs as well as implementing various algorithms. In addition to the basic instructions, the package also has subpackages: RandomGraphs in Maple 18 has 8 commands, and Maple 24 has 13 commands; SpecialGraphs: Maple 18 contains 46 commands, Maple 24 contains 138 commands; GeometricGraphs: only the Maple 24 version contains 11 commands, and Maple 18 does not have the respective subpackage. This comparison highlights the significant expansion of the graph library offered by this software.

In this sense, a student must have the necessary minimum of theoretical knowledge to be able to successfully use information technology to solve specific problems.

Thus, before applying MAPLE to solving concrete problems, students must be familiar with the basic algorithms in GT and clearly understand the purposes for which the corresponding algorithms are used. For example, without theoretical knowledge of GT, it would be difficult for the student to know in which situations the *MinimalSpaningTree(G1)* or *KruskalAlgorithm (G1, animated)* procedure could be applied. In this context, the minimum amount of theoretical knowledge that a student must possess to move on to a new stage of study is established by the teacher in accordance with the set goals.

2) On the other hand, even if a student has theoretical knowledge and is familiar with classical algorithms within GT, this still does not mean that he knows and can directly apply specialized software to solve various practical problems. From this perspective, it is necessary to change the paradigm of the didactic approach. In this context, it is proposed to organize work with students in small groups and conduct the didactic process in such a way that individual and team efforts, communication, collaboration, exchange of opinions and information are aimed at increasing the effectiveness of the five dimensions of interaction between the components of the process (Figure 1).

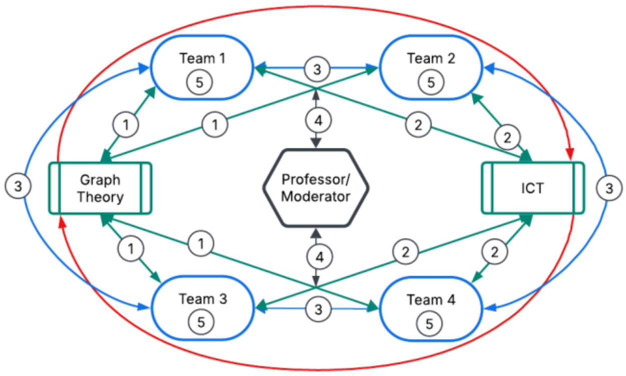

Figure 1. Interactions between components of the study process

(1) Inter-material interaction: student – subject of study;
(2) Inter-material interaction: student – information technology;
(3) Horizontal collegial interaction: student – team;
(4) Vertical collegial interaction: student – teacher;
(5) Interpersonal interaction: student – student.

Thus, interactivity is defined and produced through effective interaction and inter-relationship. Each of the 5 types of components (interactions mentioned) plays a significant role in the didactic approach.

3) In this sense, the application of the concept of interactive-technological learning from the perspective of studying information technology

encourages teamwork and cooperation among students in acquiring new knowledge, skills and competencies, which contributes to the effective achievement of learning goals.

The application of the concept of interactive-technological learning, according to the results of the pedagogical experiment, has a significant impact on the process of studying GT through technologies, including MAPLE software and Internet platforms. This concept is implemented in the context of 5 types of interactions *(student-student, student-team, student-teacher, student-subject, student-information technology)* and develops primarily due to team efforts, without diminishing the role of each student's individual efforts. In this context, we would like to highlight the following aspects:

- Any new technology generates great interest among young people (students) due to its potential for handling, application and use. In this situation, the interest of students increases for possible new impressions, perceptions and discoveries regarding the understanding of the functioning of the latest technology (Collins, Halverson, 2018);
- New technologies can be studied and mastered both individually and in small groups. Obviously the teacher facilitates the process, but, anyway, in the process of solving a problem through information technologies, many things remain, unexplained aspects that should be clarified through the direct involvement of students. In this sense, in the learning process, students can exchange opinions, information and impressions, discuss and come up with suggestions and recommendations within the work team or in the context of individual conversations. Thus, by discovering the possibilities and new technological advantages related to the MAPLE software, through exploration, analysis and deduction, it contributes significantly to the elucidation of the problem under examination (Couch, 2018);
- The efficient use of information technologies and the Internet stimulates increased confidence in one's own strengths, in the strengths of the team, generates desires and aspirations to get subsequently involved in the discovery and exploration of other high-performance technologies and attractive online platforms, thus demonstrating the creative potential of students and the strength of the group to overcome existing barriers (Hamilton, 2018; Miller 2014);
- Simulations of real phenomena reflected on the screen through applied technology can have convincing results and multiple effects on the team of students who generated this effect, thus contributing to a better understanding of the subject studied and, at the same time, highlighting situations and aspects that should be improved. In the case of applying the MAPLE software, the reflection on the screen of the graphs of the examined process demonstrates the efficiency and speed with which the mathematical model of the phenomenon under study can be built, allowing its study from multiple perspectives. (Reich, 2022; Robluer, 2018; Selwyn, 2022);
- MAPLE is a mathematics software with a friendly and accessible interface that allows the analysis, exploration, visualization and solution of practical

problems from almost any branch of mathematics. In this sense, in the context of the problem examined, in close collaboration with teammates and interaction with the relevant technology (exploring, discovering and reflecting), the student interactively participates in his own training as a specialist, while simultaneously being aware of his own shortcomings and gaps (Chiriac, Bostan, 2022**)**;

– The final results obtained from solving the practical problem in GT by applying information technologies generate feelings of satisfaction with the work done and strengthen confidence in the team and and one's own abilities. This increases the motivation and strengthens the desire to work together to complete new tasks.

Summarizing the above, we can conclude that application of the concept of the interactive-technological learning has the following advantages:

- *encourages cooperation and intercommunication between students;*
- *intensifies mutual support and help;*
- *cultivates tolerance in relation to other approaches and opinions;*
- *develops collective but also individual responsibility;*
- *each stage achieved in the problem-solving process cultivates self-confidence;*
- *develops self-critical thinking and self-reflection regarding the results obtained.*

Both our own experience and a series of studies in this area demonstrate that cooperative interactive didactic strategies are more effective than those that emphasize an individual approach, while both approaches remain useful and necessary. In this context, the concept of interactive-technological learning is effectively integrated into the development and application of cooperative didactic strategies and STEM education. Table 1 describes some recommendations regarding the implementation of STEM activities/projects and the use of the concept of interactive-technological learning in GT.

Table 1. Didactic recommendations regarding the implementation of STEM activities/projects and the use of the concept of interactive-technological learning in GT

Nr.	Compartments	STEM Activities/Projects Homework Recommendations
1.	Undirected graphs. Introduction	Graph Traversal. Eulerian and Hamiltonian graphs.
2.	Directed graphs	Applying the Kosaraju Algorithm. Coloring of vertices and nodes. Coloring the Map in 4 colors.
3.	Algorithms for determining minimum paths in graphs	Determining the minimum cost path. Application of Dijkstra and Roy-Floyd Algorithm.
4.	Trees, Binary Trees, Partial Minimum Cost Trees	Determining partial minimum cost trees. Kruskal's and Prim's algorithms.

Nr.	Compartments	STEM Activities/Projects Homework Recommendations
5.	Maxheap, Minheap, Heap-Sort algorithms	Construction of a MaxHeap (MinHeap). Application of the HeapSort algorithm.
6.	Ford-Fulkerson Algorithm, Network Flow	Determining the maximum flow in the network. Application of the Ford-Fulkerson Algorithm.
7.	Matchings	Solving management problems by distributing tasks.

Source: Information processed and proposed by the authors

We note that the prior knowledge and skills that contribute to the effective achievement of the intended learning outcomes are the following:

- knowledge and skills regarding: mathematical modeling, algorithm development, algorithm programming;
- skills and abilities to solve problems using the C/C++ or Python programming languages;
- basic skills in Maple and Mathematica;
- knowledge, skills and abilities obtained from fundamental theoretical courses in elementary and higher mathematics.

The overall goal of the "Graph Theory" course

The overall goal of the course is for students to acquire a basic understanding of graph theory, specific algorithms in graph theory, and develop skills in solving problems modeled using graphs, using information technology and the internet.

Cognitive objectives:

- Mastering some basic notions and concepts from graph theory;
- Knowing the properties of particular classes of graphs;
- Knowing the fundamental algorithms from graph theory.

Procedural objectives:

- at the end of the course the student must be able to:
- translate a problem from natural language into graph language, using the specific terminology correctly;
- develop mathematical models using the graph language to solve practical problems;
- apply and implement algorithms for graph representation and traversal;
- apply the formula for calculating the cyclomatic number, the characterizations of trees and tree-like structures;
- apply algorithms for determining partial minimum cost trees;
- apply the characterizations of Eulerian, Hamiltonian, bipartite and planar graphs;
- apply algorithms for determining Eulerian and Hamiltonian cycles and paths;

- apply algorithms for determining minimal paths;
- apply max-heap, min-heap, and heapsort algorithms;
- apply and implement algorithms for determining maximum flows;
- apply and implement matching algorithms;
- apply MAPLE/MATHEMATICA software, internet platforms, C/C++ programming languages to solve graph theory problems;
- develop application projects that incorporate Graph Theory algorithms;
- carry out STEM activities/projects on graph theory in a team a from the perspective of the concept of interactive-technological learning.

Transferable skills:

- development of complex and critical thinking;
- efficient involvement in the activities carried out within the team by applying the rules of organized work;
- adherence to principles and standards of professional ethics;
- development of empathic interpersonal communication, relationship and team collaboration skills;
- use effective methods and techniques for learning, obtaining information, conducting research, and developing skills in using knowledge and abilities through the use of information technology and the Internet;
- rigor in problem solving, algorithm design, and programming.

3. Methodical approaches to solving practical problems in Graph Theory by applying the STEM concept and developing the Technological Map

Taking into account the experience accumulated over the years, in order to solve practical problems related to GT, applying information and Internet technologies, it is rational for students to be involved in carrying out STEM activities or carrying out projects in the STEM key. STEM activities can be carried out during practical (laboratory) hours. And STEM projects are carried out by students over several days or weeks.

To solve such problems, it is recommended to develop the Technological Map of the STEM activity/project – term introduced by Professor Ion Achiri (2022, p. 12). The Technological Map of the STEM activities/projects at GT, in our opinion, should contain the following stages:

1) *Formulating and explaining the problem that needs to be solved. Setting objectives*

The problem, including the STEM activity/project, proposed for implementation is carefully formulated and explained by either the teacher or the team leader. It is recommended that the conditions of the problem be discussed with all teams involved. Discussions stop when there is certainty that all team members have understood the conditions of the problem and have clarified what needs to be learned, found and solved.

Once the problem, in collaboration with the teacher, is clarified and understood by the students, the goals are clearly defined, that is, what needs to be achieved, what should be accomplished. It is recommended that objectives be SMART. The acronym SMART stands for: Specific (clear, simple, meaningful); Measurable (quantifiable, has progress indicators); Achievable (in the sense of being achievable); Relevant (significant, goal-oriented); Time-bound (objectives must be achieved within a clearly defined period of time).

2) *Problem analysis, task setting and planning*

The analysis of the problem under examination is carried out from many perspectives. It clarifies which studied theoretical components can be used, which algorithms can be applied, and how a mathematical model can be constructed. Most problems, including STEM activities/projects, at GT, after building a mathematical model can be solved (achieved) by at least three main methods: the manual method, the programming method, the MAPLE software application method. It is recommended to distribute tasks to each team involved in the implementation of STEM activities/projects in accordance with the relevant methods. Subsequently, the process of distributing and carrying out tasks, including from the perspective of complexity and time for each team member, is planned within the established teams.

3) *Accomplishment of planned tasks*

The teams involved in the process, having well-established objectives for each task, proceed directly to their achievement. In other words, they proceed to solving the mathematical model using: a manual method, a programming method, and the MAPLE software method. It is at this stage that interactive teaching strategies can be successfully implemented, including the concept of interactive-technological learning.

4) *Evaluation and verification of the results obtained. Approbation of theoretical or experimental results*

The evaluation and verification of results is an important stage in the process under review. The fact that teams achieve results does not yet indicate their correctness. The methodology we propose assumes that each of the teams involved should achieve the same result by implementing different methods. The verification process is also done through various methods, including the comparison method. The approval of the results is done by the team leaders. In the situation where the results, obtained through various methods, coincide, team leaders can approve the results, which means that the teams can already move on to the next stage of implementation. Otherwise, all calculations performed are checked.

5) *Practical application of results from an Engineering perspective (applications in the industrial, post-industrial, agricultural, ecological, medical fields, ICT services, etc.)*

At this stage, the possibility of implementing the results obtained in real life, in practice, from various perspectives of modern Engineering (agricultural, industrial, ICT, etc.) is analyzed. Unlike the other stages, in which phenomena or processes of various natures (economic, social, etc.) are examined through the prism of Graph Theory with the aim of establishing certain laws, trends, statements or principles, at this stage the possibility of practical application of the obtained results is studied. The stage is important because it is in this process that students see and are convinced of the existence of strong connections between theory and practice. In the training process at this stage drones, various types of robots, as well as other engineering products that are connected to graphs can be widely applied.

6) *Presentation of results*

It is recommended that the presentation of results be carried out by representatives of all participating teams. Namely, in the final presentation process, it is necessary to highlight the inter/transdisciplinary aspects in the process of carrying out STEM activities/projects as well as the connection with real life, in order to show the effectiveness of this methodology. Table 2 provides methodological recommendations regarding the role and tasks of the teacher and student teams.

Table 2. Methodological recommendations regarding Stages and Roles in STEM activities

Nr.	**Steps STEM**	**The role and tasks of the Teacher in the process of carrying out STEM activities/projects**	**The role and tasks of Student Teams in the process of carrying out STEM activities/projects**
1.	Formulation and explanation of the problem to be solved. Clarification of objectives.	The teacher explains the conditions of the problem and the steps to be taken by the student teams. He explains the criteria for forming the teams. It is pointed out that the results obtained must be applicable in practice.	Students are divided into 3-4 teams, depending on skills and complexity of the problem. Team lea-ders are chosen. Students ask ques-tions, clarify the conditions of the problem, the goal and the time for com-pletion.
2.	Problem analysis, task setting and planning	The teacher as a mentor guides the teams and provides clarifications when necessary.	Students clarify the role and tasks of each team in the problem-solving pro-cess. Within each team, the role and tasks of each student involved are clarified.
3.	Accomplishment of planned tasks	The teacher offers con-sultations and, if neces-sary, facilitates me-etings with experts from other fields or with teachers of other subjects, stimulates	Ideas and strategies for solving the problem are generated. Student teams act according to the plan-ned tasks and commu-nicate on the intermediate

Nr.	Steps STEM	The role and tasks of the Teacher in the process of carrying out STEM activities/projects	The role and tasks of Student Teams in the process of carrying out STEM activities/projects
		the process.	results obtained.
4.	Evaluation and verification of the results obtained. Approbation of theoretical or experimental results.	The teacher evaluates the work of each team and the collaboration between teams from his own perspective.	The teams evaluate and verify the results ob-tained. The results are analyzed. The results are approved and proposals are made regarding their application in practice.
5.	Practical application of results from an Engineering perspective.	The teacher provides consultations and stimulates the process. Can be external experts.	The teams implement the selected idea in practice from an Engineering perspective (applying technologies).
6.	Presentation of results	The teacher presents his/ her own opinion regarding the quality of the work done, the relationship between the teams, and the contribution of each student.	The final report is presented by the student teams. Students express their own opinions on the results obtained and the process of collaboration between them.

Source: Information processed and proposed by the authors

4. Methodological approaches from the STEM perspective

Students are generally successful in completing STEM activities at GT. At the same time, we believe, it is necessary to mention that when implementing the outlined stages, students encounter difficulties both in the process of developing the mathematical model and performing mathematical calculations, as well as in programming the algorithms. These problems are also due to the fact that most students are former graduates of high schools with a humanities profile and fewer from a real profile. The difference in curricula in the respective disciplines speaks for itself. All these trends have a less beneficial impact on studying certain sections of GT, including carried out STEM activities. But, while working in this direction, students develop skills, abilities and competencies in developing and solving mathematical models. In this way, through STEM-related activities, new concepts are modeled and consolidated, and therefore new knowledge is generated (Table 3).

Table 3. STEM Applications: Maximum Network Flow Problem

Name	Explanations
Problem	Determining the maximum flow in the network. Calculating bandwidth
Areas of application	Maximum flow problems arise in many areas, such as: – *Road, river, train transport;* – *Gas, liquid, electricity transport;* – *Electricity networks;* – *Operational research.*
(S) Science	
– Graph Theory; – Physics, Fluid and Gas Mechanics; – Power Transmission and Distribution; – Operational Research (CO).	– *Networks will be modeled as a directed graph. The Ford-Fulkerson Algorithm is applied to solve the problem;* – *Concepts, notions: path, distance, capacity, speed, weight, bandwidth;* – *Examines optimization problems resulting from the mathematical modeling of processes in the economic and scientific-technical fields, etc.*
(T) Technology	– *MAPLE software;* – *Moodle / Classroom educational platforms;* – *Programming languages (Pascal, C/C++, Java, Python);* – *Interactive whiteboard;* – *Internet platforms.*
(E) Engineering	– *Liquid flow;* – *Assembly lines;* – *Power transmission;* – *Electrical power networks;operational research, etc.*
(M) Mathematics	– *Mathematical modeling of the problem;* – *Concepts used: cut in the graph G;* *edge (x, y) crosses the cut (crossedge); s-t cut; minimum s-t cut, minimum cut.*

Source: Information processed and proposed by the authors

Solving problems in a STEM context establishes lasting connections between this type of problem and the concepts, notions used in Science (Graph Theory), Technology (Maple, Internet technologies), Engineering (drones, robots) and Mathematics (theory of functions, matrices, etc.) In this way, students learn how different ideas and concepts are related and integrated with each other in the context of the problem being studied. In this way, they acquire new knowledge that can be applied to solve new problems, in new situations.

To test students' opinions regarding the implementation of the STEM activities/projects when studying Graph Theory from the perspective of the concept of interactive-technological learning, a questionnaire was conducted. Some responses are presented in Table 4.

Table 4. Students' opinions on STEM activities/projects when studying Graph Theory from the perspective of the concept of interactive-technological learning

Nr.	Statement	Totally disagree	Disagree	Neutral	Agree	Completely agree
1.	I know how to learn effectively through Information Technologies and the Internet	0%	0%	0%	100%	0%
2.	The activity allows me personally to encourage cooperation and intercommunication between colleagues	0%	0%	20%	60%	20%
3.	I take advantage of the learning opportunities available to me through Technologies, including Maple.	0%	0%	10%	70%	20%
4.	I work effectively in small groups.	0%	10%	10%	60%	20%
5.	In group work, I respect other points of view.	0%	0%	0%	80%	20%

Source: Information processed and proposed by the authors

From **Table 4** it can be seen that no student chose the option of total disagreement regardless of the statement. From this point of view, it is encouraging.

Only 10% of students believe that working in small groups is ineffective, and 10% are neutral. On the other hand, 60% agree with this statement, and 20% completely agree.

5. The advantages of approaching the STEM methodology

To emphasize the benefits of implementing the STEM concept, we will highlight the difference between traditional Graph Theory learning and learning Graph Theory through the STEM approach (Table 5).

Table 5. Studying Graph Theory: Traditional Approach vs. STEM Approach

Traditional approach to studying Graph Theory	**STEM and interactive-technological approaches to studying Graph Theory**
– The teacher transmits knowledge and pays less attention to its integration in an inter /transdis-ciplinary context; – The latest technologies (MAPLE Software, MATHEMATICA, etc.) are not used in the process of studying Graph Theory; – The connection between knowledge and real-world problems is not always made; Problems are examined more from a mono-disciplinary perspective; – More emphasis is placed on individual work and less on teamwork; – Less attention is paid to the development of skills in the field of science, technology, engineering and mathematics.	– The teacher systematizes information and tends to integrate it in an inter/ pluri/ multi/ transdisciplinary context; – Information and Internet techno-logies (MAPLE Software, MATHEMA-TICA, etc.) are widely implemented in the process of studying Graph Theory; – STEM activities are organized and STEM projects are carried out by students; – The problems proposed for solution are directly related to real life and are examined inter/ transdisciplinary; – It encourages teamwork of students and effective relationships between them; – It promotes the development of ***skills in the field of science, technology, engineering and mathematics.***

Source: Information processed and proposed by the authors

Recording the highlighted advantages requires additional efforts from teachers and student teams regarding the organization, implementation, and monitoring STEM activities/projects in the process of learning Graph Theory.

6. Conclusions

In the process of implementing STEM activities/ projects from the perspective of the concept of interactive-technological learning, educational/ practical consequences related to the learning process were identified between the following evidences:

- Developing skills in research and mastering new knowledge and technologies (Maple, Mathematica, etc. software), including programming.

Students' opinions (Table 4): I know how to study effectively using information technology and the Internet (100% agree).

- Developing critical and analytical thinking in the process of carrying out STEM activities/projects, which involve solving complex problems inspired by real life. Solving such problems is based on their decomposition into simpler ones that require the involvement and collaboration of teams of students specialized in the following fields: mathematical modeling, algorithm development and programming, engineering, etc.

Students' opinions (Table 4): The activity allows me personally to encourage cooperation and intercommunication between colleagues (60% agree, 20% completely agree, 20% neutral); In group work, I respect other points of view (80% agree, 20% completely agree).

- Cultivating qualities regarding continuous learning, adaptability, the teamwork ability and finding solutions through communication and collaboration.

Students' opinions (Table 4): I take advantage of the learning opportunities available to me through Technologies, including Maple (70% agree, 20% - completely agree).

The application of the proposed interactive-technological learning concept has a significant impact on the process of studying Graph Theory through technologies, including MAPLE software, and Internet platforms. The respective concept is implemented in relation to student-student, student-team, student-teacher and student-subject interactions through the lens of information technologies and contributes to streamlining team efforts and collaboration between teams. Thus, following the experiment conducted, following the teaching approaches described above, it was demonstrated that the ability to understand and assimilate the presented material is much deeper by applying the STEM methodology and implementing technologies, compared to the traditional methods used.

Acknowledgement

This study was conducted within the scientific research project "Methodology of ICT implementation in the process of studying real sciences from the perspective of the STEAM concept and Artificial Intelligence", code 040101, within the Institutional Research Program (2024-2027), approved by Ministry of Education and Research of the Republic of Moldova, Order No. 102 of 01.02.2024.

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