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## MOTIVATING STUDENTS FOR SUCCESS: A REVIEW OF NEW PROJECTS IN TEACHING BASED ON STEM EDUCATION

### МОТИВУЄМО УЧНІВ ДО УСПІХУ: ОГЛЯД НОВИХ ПРОЄКТІВ У ВИКЛАДАННІ НА ОСНОВІ STEM-ОСВІТИ

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*Кунья М.Н., Фігейредо Х., Олівейра І., Мачаеш М. Мотивуємо учнів до успіху: огляд нових проєктів у викладанні на основі STEM-освіти. Оглядова стаття.*

Мотивація охоплює емоційні, соціальні та біологічні явища, будучи фактором, відповідальним за керування поведінкою та досягнення цілей. Вона спонукає людей викладатись на повну, робити все можливе, щоб досягти бажаного, долаючи бар'єри. Мотивація студентів стала центральним моментом для досягнення максимального задоволення, ефективності та продуктивності. Дослідження в галузі STEM (наука, технології, інженерія та математика) надають переконливі докази того, що заняття з активним навчанням покращують загальну успішність учнів. Це дослідження має на меті за допомогою кількісного аналізу з'ясувати, як студенти бачать зміни завдяки цьому новому методу активного навчання і наскільки вони вмотивовані до таких змін.

*Ключові слова:* стовбурова освіта, мотивація, педагогіка, технології, цифрова революція

*Cunha M.N., Figueiredo J., Oliveira I., Mações M. Motivating Students for Success: a Review of New Projects in Teaching Based on STEM Education. Review article.*

Motivation involves emotional, social and biological phenomena, being a factor responsible for directing behaviors and achieving goals. It drives individuals to give their best, doing their best to achieve what they want, overcoming barriers. Student motivation has become a central point to achieve maximum satisfaction, performance and productivity. STEM (science, technology, engineering and mathematics) education research provides compelling evidence that active-learning classes improve the overall learning of students. This study aims to understand through a quantitative investigation how students see changes through this new active learning students and how motivated are for this kind of changes.

*Keywords:* stem education, motivation, pedagogy, technology, the digital revolution

Human motivation is considered as a psychological process closely related to the impulse or tendency to perform with persistence certain behaviors. Motivation is highlighted by three distinct components: impulse, direction and persistence of behavior (Ribeiro, Passos & Pereira, 2018). Students' motivation has become a central point to achieve maximum satisfaction, performance and productivity (Tamayo & Paschoal, 2013).

Motivation is the driving force for the study, being the quality of life a primordial principle, personal and organizational, fundamental in university life both at the level of students and the teachers themselves (Ferreira & Dias, 2017). Motivated students maintain better commitments with the university and aim for its growth and favoring (Santos et al., 2016; Ferreira & Dias, 2017).

Team based learning is one of STEM's education frameworks. The benefits of team learning include increased achievement, motivation, and greater retention of concepts learned. Currently, several higher education institutions have been betting on active methodologies as part of teaching practices. Innovative, they are increasingly present in the daily life of this higher education institutions, being part of the routine of thousands of university students worldwide (Cunha et al. 2019; Cunha, 2022). The history of STEM education can be traced back to various milestones and developments in science, technology, engineering, and mathematics education throughout history.

## Analysis of recent research and publications

STEM education continues to evolve, with an increasing emphasis on hands-on, inquiry-based learning, interdisciplinary approaches, and the

integration of emerging technologies. It plays a vital role in preparing individuals for the challenges and opportunities of the modern world (Cunha et. al. 2019; Cunha, 2022; Sousa et al. 2022).

Table 1. Key moments and trends in the history of STEM education

<b>Ancient Civilizations:</b> The foundations of mathematics and science can be traced back to ancient civilizations such as the Babylonians, Egyptians, Greeks, and Romans. They made significant contributions to mathematics, astronomy, and engineering.
<b>Renaissance and Scientific Revolution:</b> The Renaissance period in Europe (14th to 17th centuries) saw a revival of interest in science and mathematics. Pioneers like Galileo Galilei, Johannes Kepler, and Isaac Newton made groundbreaking discoveries, laying the groundwork for modern science and mathematics education.
<b>Industrial Revolution:</b> The 18th and 19th centuries brought the Industrial Revolution, which increased the demand for individuals with technical and engineering skills. Technical schools and vocational education programs emerged to meet these needs.
<b>20th Century:</b> The early 20th century saw the formalization of science and mathematics education in schools, with a focus on traditional subjects. However, this education began to evolve as new fields of science and technology emerged.
<b>Space Race:</b> The Cold War era, particularly the Space Race between the United States and the Soviet Union in the 1950s and 1960s, sparked a renewed interest in science and mathematics education. Governments invested heavily in STEM education to advance space exploration and technology.
<b>Sputnik and STEM Education Reform:</b> The launch of the Soviet satellite Sputnik in 1957 prompted significant educational reforms in the United States. The National Defense Education Act of 1958 and other initiatives aimed to improve STEM education to compete with the Soviet Union in science and technology.
<b>Computing Revolution:</b> The rise of computers and the information age in the latter half of the 20th century emphasized the importance of computer science and technology education. Computer programming became an essential skill.
<b>STEM as an Educational Concept:</b> The term "STEM" as we know it today gained prominence in the 21st century, reflecting the increasing recognition of the interconnectedness of science, technology, engineering, and mathematics. STEM education became a formalized approach to teaching and learning.
<b>1st Century STEM Education:</b> In the 21st century, STEM education has become a global priority. Governments, educational institutions, and organizations have focused on enhancing STEM education to prepare students for careers in STEM-related fields and to address global challenges such as climate change, healthcare, and technology innovation.
<b>Diversity and Inclusion:</b> There is a growing emphasis on promoting diversity and inclusion in STEM education to ensure that individuals from all backgrounds have access to STEM opportunities and careers.
<b>Online and Digital Learning:</b> The rise of online education and digital learning platforms has expanded access to STEM education, allowing students to engage with STEM subjects remotely and at their own pace.

Source: the authors' own elaboration

## The main part

Stem learning and development.

Stem education research provides compelling evidence that active-learning classes improve the overall learning of students. By STEM it is understood an approach to teaching and learning that focuses on four key disciplines: Science, Technology, Engineering, and Mathematics. The goal of STEM education is to integrate these subjects in a way that emphasizes critical thinking, problem-solving, creativity, and innovation (Cunha et. al. 2019; Cunha, 2022; Sousa et al. 2022). STEM education can take place in various settings, including formal classrooms, after-school programs, summer camps, and online courses. It is considered essential for preparing students to meet the challenges of the 21st century and for driving innovation and economic growth in many industries (Cunha et. al. 2019; Cunha, 2022).

Team based learning.

Team-Based Learning (Team based learning) is an instructional strategy and active learning approach that is used in various educational settings to promote student engagement, critical thinking, collaboration, and problem-solving. It was developed by Larry Michaelsen and his colleagues in the 1970s and has

gained popularity in both K-12 and higher education (Cunha, 2022; Sousa et al. 2022).

Team-Based Learning has been found to be effective in promoting deep learning, higher-order thinking skills, and student engagement. It is particularly well-suited for courses where problem-solving, critical thinking, and collaboration are important learning objectives, such as in healthcare education, business, and the sciences (Cunha, 2022; Sousa et al. 2022).

Differences from team-based learning to other active learning.

Team-Based Learning (Team based learning) is just one of many active learning strategies used in education. While team-based learning shares some common principles with other active learning methods, it also has distinct characteristics that set it apart (Cunha et. al. 2019; Cunha, 2022). In team-based learning, students are organized into permanent teams that work together throughout the course or module. This contrasts with some other active learning methods where students may work in different groups or individually for each activity. The permanence of teams in team-based learning fosters a sense of accountability, trust, and collaboration among team members.

Table 2. Key principles and components of Team-Based Learning

<b>Formation of Teams:</b> Students are divided into permanent, diverse teams at the beginning of a course or a specific module. These teams typically consist of 5-7 members, and efforts are made to ensure diversity in terms of backgrounds, skills, and perspectives.
<b>Preparation Before Class:</b> Prior to attending a Team based learning session, students are provided with pre-class materials, such as readings, videos, or assignments, to familiarize themselves with the content that will be covered. This prepares them for active engagement during the in-class session.
<b>Readiness Assurance Process (RAP):</b> During the in-class session, the instructor administers a Readiness Assurance Test individually or as a team. This test assesses the students' understanding of the pre-class materials. RATs are often multiple-choice questions. Students take the test individually first and then as a team, which encourages accountability and discussion.
<b>Immediate Feedback:</b> Instructors provide immediate feedback on the RATs to clarify any misunderstandings or misconceptions. This allows students to learn from their mistakes and ensure they have a solid grasp of the foundational concepts.
<b>Application Activities:</b> Following the RATs and feedback, students engage in application activities or exercises that require them to apply their knowledge collaboratively. These activities often involve problem-solving, case studies, discussions, debates, or hands-on projects.
<b>Team Dynamics:</b> Team based learning promotes teamwork and collaborative skills development. Team members must work together to solve problems, discuss ideas, and arrive at consensus, fostering communication and interpersonal skills.
<b>Instructor Facilitation:</b> Instructors play a facilitative role in Team based learning, guiding discussions, answering questions, and ensuring that the teams stay on track. The focus is on helping students learn from each other rather than solely relying on the instructor for information.
<b>Assessment and Evaluation:</b> Assessment in Team based learning includes both individual and team-based assessments. Individual performance on the RATs and other assignments is evaluated, as is the quality of team discussions and contributions.
<b>Reflection and Feedback:</b> Team based learning often incorporates opportunities for students to reflect on their teamwork and learning experiences. This can involve peer evaluations and self-assessments to improve team dynamics.
<b>Continuous Improvement:</b> Team based learning encourages continuous improvement in both the teaching and learning processes. Instructors can adjust their strategies based on student feedback, and students can refine their teamwork and problem-solving skills over time.

*Source: the authors' own elaboration*

Team based learning places a strong emphasis on pre-class preparation. Students are expected to review assigned materials before the in-class session, such as readings, videos, or assignments. This ensures that students come to class with some foundational knowledge, allowing for deeper engagement with the content during in-class activities. In contrast, some other active learning approaches may not require extensive pre-class preparation. Team based learning incorporates a Readiness Assurance Process (RAP), which involves individual and team-based assessments, such as the Readiness Assurance Test (RAT). This process ensures that students have a baseline understanding of the material before moving on to application activities. Other active learning methods may not have this structured assessment process.

Team based learning typically includes structured team discussions or activities following the RAP. These activities often involve problem-solving, case studies, debates, or other complex tasks that require teams to work together to reach consensus. In some other active learning methods, group activities may be less structured or vary in format. Team based learning places a strong emphasis on immediate feedback. Instructors provide feedback on the RATs and other assessments right after they are completed, allowing students to learn from their mistakes and clarify any misconceptions. This immediate feedback loop is a hallmark of team-based learning.

In team-based learning, the instructor often takes on a facilitative role, guiding discussions and providing clarification when needed. In contrast, some other

active learning methods may involve instructors taking a more active role in delivering content or guiding discussions. Team based learning typically combines individual and team-based assessments. Individual assessments, such as RATs, evaluate individual knowledge, while team-based assessments evaluate teamwork and application of knowledge. Some other active learning methods may focus primarily on individual assessments or team-based activities.

Because of the permanence of teams in Team based learning, there is a strong focus on team dynamics and interpersonal skills development. Other active learning methods that frequently change group compositions may not emphasize team dynamics to the same extent. Team based learning often includes processes for students to reflect on their teamwork and learning experiences, such as peer evaluations and self-assessments. These reflective elements are integral to Team based learning's approach to continuous improvement.

While Team based learning offers a structured and team-focused approach to active learning, it's essential to choose the most suitable method for specific learning objectives and contexts. Other active learning methods, such as problem-based learning, flipped classrooms, or group discussions, may be more appropriate depending on the goals and subject matter of the course (Cunha et. al. 2019; Cunha, 2022).

#### METHODOLOGY

Considering the pretension of carrying out an approach to the phenomenon, with the final objective of knowing its different characteristics, it was considered that the most appropriate methodological

approach to use in this research would be the quantitative (Cunha & Santos, 2018). The quantitative research approach made use of the survey method. The sampling technique used was the convenience sampling approach due to the lack of a sampling frame. The questionnaires were shared by email, obtaining a non-probabilistic sample, by Snowball composed of 1266 students. The gathered data were recorded on a Microsoft Excel spreadsheet after screening returned questionnaires. The data were analysed using the Statistical Package for Social Sciences (SPSS version 27.0). The Statistical Package for the Social Sciences (SPSS) is a software program widely used for statistical analysis in social science research and various other fields. Developed by IBM, SPSS provides a comprehensive set of tools for data management, analysis, and reporting.

This study was based on a questionnaire survey. To ensure that the sample is composed only of students, in the questionnaire, after a short introduction, respondents are asked if they are students, and if not, do not continue to complete the questionnaire. This research study acted in accordance with the ethical standards of academic research, for instance, all participation was voluntary, and it was conducted in an anonymous manner. No personally identifying data was not collected. Participants were briefed on the research and provided consent prior to completion of the questionnaire. No incentives were provided to participants and they were allowed to withdraw from the investigation at any point.

**RESULTS AND DISCUSSION**

**Sociodemographic Profile.**

A sociodemographic profile refers to a collection of data and characteristics that describe a population or a group of people based on various social and demographic factors. These factors provide insights into the composition and characteristics of a particular group. Sociodemographic profiles can be used in a variety of contexts, including public policy development, marketing and advertising targeting, healthcare planning, and social research. By understanding the sociodemographic characteristics of a population, organizations and policymakers can tailor their strategies and services to meet the specific needs and preferences of different groups.

The demography of the sample has been analysed with respect to its different characteristics. Their findings showed that from the 1266 luxury consumers in this study 65% are female while 35% are male. It was possible to analyse the Academic Qualifications of the sample. As we mention before it was our ambition to work only with students so, in order to ensure that the sample is composed only of students, in the questionnaire, after a short introduction, respondents are asked if they are students, and if not, do not continue to complete the questionnaire. Therefore, we have a sample composed of University Students from 18 to 47 years old (69% are degree students. 31% postgraduation, master students and PhD students. It was also possible to verify the region of residence of the students during classes, 39% reside in Portugal, 37% reside in the other countries of Europe, 18% reside in the Africa and only 6% reside in the USA.

Table 3. Means and standard deviations

Item	Mode	Mean	SD
Team based learning classes gave me more opportunity to communicate with colleagues than traditional (exhibition classes)	4	3.87	1.09
The discussion of the questionnaire in group allowed me to correct errors and improve the understanding of the curricular unit subjects	4	3.98	1.07
The individual resolution of the questionnaire helped me learning the subjects of the curricular unit	4	3.65	0.99
I felt more comfortable in a Team based learning class than in a traditional (exhibition class)	3	3.46	1.26
The Team based learning classes helped me prepare for the evaluation of the curricular unit	4	3.75	1.25
I would like to take Team based learning classes in more curricular units	3	3.14	1.29
Team based learning Classes helped me to better understand the subjects of the curricular unit	4	3.78	1.25
Team based learning classes motivated me more than traditional (exhibition classes)	3	3.05	1.18
The study materials available on Moodle are suitable for my study method	4	3.52	1.24
I like studying by videos more than reading texts	4	3.50	1.14
When I didn't study the materials available on Moodle, I felt uncomfortable in Team based learning classes	4	3.46	1.22
I regularly studied the materials available in the Moodle before the Team based learning class was held	4	3.15	1.013
Often, after the Team based learning class, I reviewed the study materials available on Moodle	3	2.98	1.15
I felt integrated into my working group	4	4.21	0.867
I had a collaborative attitude in the discussions of the questionnaire with my group	4	3.89	0.91
I learn better working in groups than working alone	4	3.49	0.97
My group has shown to be motivated to discuss the questionnaire	4	3.21	1.12

*Source: the authors' own elaboration*

**Descriptive statistics.**

Descriptive statistics were used to summarize and describe the features of the sample. These statistics aided in identifying outliers, assess data quality, and make informed decisions about further analysis or

modelling. They also facilitated effective communication of data to a broader audience. When talking about descriptive statistics for the questionnaire items about team-based learning methodology, all the items obtained high scores. Most of them higher than

the intermediate value of the scale. This result seems to indicate that most students had a positive perception of the method in use. The students significantly value the provided team-based learning opportunity to communicate more with colleagues than in exhibition classes (Cicha, Rizun, Rutecka, & Strzelecki, 2021). Means and standard deviations.

The mean is the average value of a set of numbers. The standard deviation is the average amount of variability in our dataset. It tells us, on average, how far each value lies from the mean. A high standard deviation means that values are generally far from the mean, while a low standard deviation indicates that values are clustered close to the mean. The mean and standard deviation are used to describe the shape and spread of a distribution (Marroco, 2020).

When examining the descriptive statistics for the inquiry items about the reaction to TBL methodology it is possible to see that all items have higher scores than the intermediate value of the scale. This result indicates that most learners had a positive perception of the TBL method.

Learners mention that TBL method was very important to them because they had the opportunity to communicate and learn more discussing ideas with classmates. This kind of situation does not happen in exhibition classes (Cunha et. al. 2019; Cicha, Rizun, Rutecka, & Strzelecki, 2021; Cunha, 2022).

Learners also mentioned that the use of the Individual questionnaires, also called RAT, offered a new and dynamic vision of the learning process and that it helped them to prepare better moments of evaluation.

The items "I do not agree or disagree" had a high number of answers. This can be justified by the way students see and feel about this new way of giving classes. It was also possible to see those learners have higher motivation to participate in these kind of classes. They show a better perception with TBL method. And have mention that it would be good to have this method in other disciplines.

The results obtained in this TBL inquiry can be explained by the fact that TBL is a pedagogical practice considerably innovative and dynamic from the practices used by teachers until this moment. It seems important to reiterate that this is a disruptive methodology in relation to the work habits that learners have acquired until the moment.

The table also presents the outcomes of descriptive statistics that shed light on various aspects of student engagement. These aspects encompass not only their interaction with the adopted methodology but also their participation in the course or discipline. Furthermore, they offer a clearer perspective on the learning resources at their disposal. These resources primarily included instructional materials crafted by instructors, incorporating short videos to elucidate intricate concepts. Learners were tasked with weekly study of texts. The findings indicate that while these materials suited their study approach, students expressed a preference for video-based resources over text.

One critical factor for the success of Team-Based Learning is the prior review of study materials before

class sessions (Cunha et. al. 2019; Cunha, 2022; Sannathimmappa, Nambiar, Aravindakshan, & Kumar, 2022). The results reveal that only approximately 43% of students consistently engaged with the materials before class, as indicated by the sum of "I totally agree" and "agree" responses. Tomas, Evans, Doyle and Skamp (2019).

Cunha et. al. (2019) and Cunha (2020) reported a similar outcome and identified time constraints, a lack of motivation, and difficulties in managing individual study as the primary reasons for non-compliance with this task. It is noteworthy that students felt less comfortable in classes where they hadn't reviewed the materials beforehand, and they failed to establish a habit of revisiting course content after class. Finally, questions were posed to gauge students' perception of the effectiveness of group work, another pivotal component of TBL. Successful participation in group work demands teamwork skills, a collaborative attitude toward peers, and the ability to learn from others (Kibble et al., 2016). The groups adhered to the recommended size found in the literature, typically consisting of 5 to 7 members, with a diversity of information processing and perception styles to foster dynamic discussions and motivation for learning. The results indicate that the group learning technique led to a high level of integration, and students reported having a collaborative attitude within their groups. However, motivation waned when it came to discussing the RAT, which could be attributed to the lack of prior material review.

## Conclusions

In conclusion, team-based learning (TBL) is a pedagogical approach that has gained recognition and popularity in various educational settings. It encourages collaboration, critical thinking, and active engagement among students. Through structured activities, team discussions, and assessments, TBL promotes a deeper understanding of course material and the development of essential skills such as communication, problem-solving, and teamwork.

TBL has been proven to enhance student performance and foster a more interactive and dynamic learning environment. By promoting peer teaching and accountability within teams, it not only helps students to master subject matter but also prepares them for the challenges of the real world, where collaborative skills are often essential for success.

As education continues to evolve, TBL is expected to remain a valuable and effective strategy for educators. It aligns with the growing emphasis on active learning and the need for graduates to possess strong interpersonal and problem-solving skills. The future of TBL may see the integration of technology for more flexible and remote learning options, as well as adaptations to cater to the diverse needs of students.

In summary, team-based learning has proven to be a valuable approach in education, fostering a collaborative, active, and effective learning environment. It equips students with not only subject-specific knowledge but also essential life skills, making it a promising strategy for the future of education.

## Abstract

Motivation involves emotional, social and biological phenomena, being a factor responsible for directing behaviors and achieving goals. It drives individuals to give their best, doing their best to achieve what they want, overcoming barriers. Student motivation has become a central point to achieve maximum satisfaction, performance and productivity. Motivation is the driving force for work, being the quality of life a primordial principle, personal and organizational, fundamental in a university. In order to change the continuous waves of demotivation, teachers and researchers decided to change techniques and open horizons for new forms of teaching. STEM education is crucial to meet the needs of a changing world. STEM (science, technology, engineering and mathematics) education research provides compelling evidence that active-learning classes improve the overall learning of students. This study aims to understand through a quantitative investigation how students see changes through this new active learning students and how motivated are for this kind of changes.

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