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Has Creativity in Math Classrooms Disappeared?

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Abstract**—***In Brazil, teachers with a degree in pedagogy are responsible for providing mathematics training to children until a mathematics graduate takes over, after 6 years of basic education, with a huge workload and pressure in prepare to national and international tests. This work reports successful experiences that stimulate creativity in elementary school classrooms, when the teacher has access to educational products and innovative approach techniques. And in higher education we have this discussion? We have some answers.*

Keywords**—** *Creativity, teaching and learning mathematics, educational products, innovation.*

I. Introduction

In Brazil, mathematics in basic education has a very large workload compared to other subjects. This condition stems from the minimum content required for what we call the National Common Curricular Base (BNCC), which regulates what children need to learn in schools and also for them to take international tests, especially PISA. In recent international assessments, such as PISA 2022, Brazil ranked low in mathematics, ranking 65th out of 81 countries, and scored below the international average. Another test, TIMSS 2023, showed the country in 55th place in 4th grade and 41st (second to last) in 8th grade in mathematics, with the vast majority of students not reaching a basic level of proficiency. In Brazil, teachers with a degree in pedagogy are responsible for providing mathematics training to children until a mathematics graduate takes over, after 6 years of basic education, with a huge workload and pressure in preparing for national and international tests.

There's a lot of discussion about creativity in the classroom, the use of active learning methodologies, and other changes in attitudes toward traditional methodologies. How can a teacher of such a demanding subject, for all stakeholders, find the time, availability, and ability to think about teaching a creative class, encourage students to be creative in the classroom, and ultimately change the attitudes of students who find the subject difficult?

The Postgraduate Program in Creativity and Innovation in Higher Education Methodologies (PPGCIMES) at the Federal University of Pará (UFPA), offering master's and now PhD program, employs a multidisciplinary approach, with several educational products delivered alongside theses and dissertations. Some of these educational products, supervised by the author, aim to create products—serious games, workshops, board games, and digital games—that can assist teachers, so they don't waste time preparing such materials, given their current situation, and, most importantly, to motivate them to deliver courses in a more engaging way for students.

Basniak, Silva, and Glaulovski (2017, p. 3) state that "education, as a process of cultural appropriation, cannot be separated from the influence that technology has on society and must permeate teaching and learning processes, contributing to overcoming challenges in both Basic Education and Higher Education."

The research group within PPGCIMES, comprised of students and teachers of public schools, has as its main objectives the design and development of educational products that propose the creation of learning objects (LOs) that are compatible with the educational context of teachers. These products enable the authorial and creative experience of pedagogy students and mathematics graduates, as builders of LOs, digital games, and board games, and the innovation of pedagogical practices of these future teachers through the use of these products in the classroom. This article will cover some examples of completed projects.

II. Creativity in the Classroom

Creativity, according to classic authors such as M. Csikszentmihalyi, T. Amabile, R. Sternberg, including Vygotsky, involves fluidity, flexibility, and originality. It is inherent to human beings, and current neuroscience has even proven that it can be stimulated—that is, it's not simply innate. The question is: how can we incorporate this into math, engineering, and other science classes?

A. Growth Mindsets

Jo Boaler, in her book "Mathematical Mindsets," details advances in neuroscience regarding the changing understanding of brain synapses and how the brain can be stimulated, discouraged, and restimulated on any subject. The findings are alarmingly favorable to creative learning. When a student enters a math classroom, they generally exhibit two types of behavior:

- Fixed mindset;
- Growth mindset.

A student with a fixed mindset is one who enters math already defeated, thinking they won't understand and will struggle enormously. A student with a growth mindset is one who enters confidently, believing they can progress and learn, even though they sometimes find the class difficult and uninteresting, because they have a certain autonomy.

B. The good news: we can change our mindset

Jo Boaler, citing several recent studies, shows us that students' mindsets can shift from fixed to growth mindsets. And when this happens, their approach to learning becomes significantly more positive and successful. Furthermore, students with a growth mindset exhibit more positive brain activity when they make mistakes, with more brain regions lighting up, and increased attention and error correction (J. Boeler, 2017, p. 6).

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Another author who strongly advocates for the value of student error and that error is merely a pathway to precise and correct reasoning is Liping Ma (2011). She compares American and Chinese teachers' classroom procedures and concludes that, despite the better theoretical training of American teachers, Chinese teachers are more flexible in the classroom, valuing students' mistakes, enabling what Liping Ma calls Deep Knowledge of Fundamental Mathematics (DKMF).

C. Teachers (and Professors) and their resources

Among the various resources we have, Silva, G. (2018) summarized the following strategies to become a facilitator and mediator of student creativity:

- Present the content in an understandable way;
- Use diverse teaching practices;
- Demonstrate interest in their learning;
- Believe in them and value their potential;
- Listen to them attentively and be good-natured when they disagree with your method;
- Encourage them to take the initiative when faced with problems (mathematical and life-related);
- Stimulate new discoveries and new ideas about the subject.

The vast majority of teachers (and professors, of course) believe the first point is part of their practice. From the second point onward, things get complicated, as lack of time, excessive student numbers, poor school conditions, and rigid pedagogical projects can discourage any teacher willing to be creative in the classroom.

An alternative, while structural problems remain unresolved, is for teachers to adopt educational products in their classrooms. These can facilitate the process of preparing and applying content, gain time that traditional classes lack, reduce tension between students and teachers with a more fun, playful class, and ultimately help to remove the burden of mathematics as a difficult and discouraging subject. The teacher's role is fundamental in this process, as they must cease to be the math teacher who spends two hours lecturing and asking students to take notes or access their cell phones and tablets, and become a mediator of knowledge.

III. Some Educational Products

Considering the researchs in the Master's and Doctorate in Creativity program at PPGCIMES/UFPA, we had some interesting experiences to mitigate the lack of connection between teacher and student in mathematics classes, including:

- SCRATCH FOR TEACHERS: a proposal for building learning objects (Rosario, A., 2020);
- KNOWLEDGE RECRUITERS: a serious game for formative assessment in mandatory subjects (Pinheiro, L., 2024);
- L'ARRIVÉE: a serious game as an alternative to enhance French teaching (Cavalvante, L., 2023);
- RIOR OF MATHEMATICS: a board game to aid in the learning of mathematical concepts in teacher training in Altamira at UFPA (Vale, R., 2023);
- Use of the Pythagorea 60 app to enhance the learning of fundamental topics in basic geometry. (Souza, E. 2023);
- GO INTERNSHIP: a board game proposal for pedagogy (Costa, T., 2024).

All works above were generated in the PPGCIMES program, except the work with Pythagorea 60, which was a dissertation for the professional master's degree in mathematics (PROFMAT). All of them aimed to generate educational products for use in teachers' classrooms. The products have been tested and are now available for consultation on the CAPES Platform. Furthermore, the author addresses mathematics teaching for educators from first to fifth grade in works such as (Vale, R., Nascimento, M., 2023), (Nascimento, M.L., 2022), and (Nascimento, M.L., Diniz, M.M., 2021), where creativity in teaching and learning methods forms the basis of the motto: "we should not teach the way we were taught, we must go beyond."

IV. Final Considerations

The educational products developed are part of a discussion on creative and innovative methodologies in primary and higher education, addressing the learning process in mathematics, music, languages, and many other areas where teachers need help in their challenging teaching process. We still have much to do.

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