The Creative Process in the Development of Computational Thinking in Higher Education

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Abstract: Today's society, differentiated by knowledge, is characterized by structural changes that require individuals to act in an innovative, interdisciplinary way and linked to Computational Thinking. This skill stands out for its relevance, included in the list of skills and competencies required of 21st-century professionals. Computational thinking encompasses problem-solving using models, abstractions, organization and decomposition of these elements in an algorithmic way. These elements, in turn, impose on subjects a skill that is not widely explored in traditional teaching-learning processes: creativity. Given this panorama, this article presents a study whose objective is to understand the relationship of the Creative Process in the development of Computational Thinking, to assist the teaching and learning of programming. For this, a Conceptual Model was created, relating the pillars of the Creative Process to solve problems using programming and later applied in a class in the Digital Games course, in the Programming discipline. The results point to the relevance of using the Conceptual Model in the cognitive process, indicating that it positively influenced the learning of programming by students, which is reflected in the students' solutions and reports.

1 INTRODUCTION

The Programming discipline is part of the basic training in Computer Science courses. Its content is focused on teaching concepts, computational models and programming language (Bennedsen & Caspersen, 2004).

However, it is important to emphasize that programming education is not limited to teaching a programming language. The process of teaching programming should also involve problem-solving, based on concepts such as association, evaluation, assignment, procedure call and parameter passing (Bennedsen & Caspersen, 2004).

The teaching of programming-related disciplines, including their fundamental concepts and introductory approaches, presents a great challenge for teachers in the search for appropriate teaching methodologies (Bennedsen & Caspersen, 2004).

The traditional teaching methodology, commonly used in programming classes, which are usually divided into theoretical, theoretical-practical and/or laboratory classes, has not been satisfactory (Bennedsen & Caspersen, 2004). These resources are relevant for presenting the results of a process, but they do not show the development process in itself.

Another factor to be considered in the programming teaching-learning process is Creative Thinking. According to Young (1985), we live in a knowledge society, characterized by changes that require innovative individuals. At the same time, the importance of Computational Thinking (National Research Council, 2013) stands out, since it is included in the list of Skills and Competencies required for professionals in the 21st century. According to National Research, Computational Thinking encompasses problem-solving using, models, abstractions, grouping, and decomposition of

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these elements in an algorithmic manner. Although cognitive processes are commonly used by computer science professionals, formal training in this area of knowledge is not necessarily needed since in many of these activities there will be, at least, the use of information technology related to computational (algorithmic) reasoning (National Research Council, 2013).

In this perspective, Computational and Creative Thinking is seen as cognitive tools that expand the knowledge and skills that can be applied in obtaining a solution to a given problem. That is computational tools when used creatively, lead to the development of new approaches to both old and new problems, observing different stimuli and perspectives that may be relevant in their solution (BBC, 2017).

Aiming to propose an approach to the problem of applying programming concepts to solve real-world problems using the elements of the Creative Process and Computational Thinking, this paper presents a research question: QP1 – Are the Creative Process and the development of Computational Thinking factors that influence the learning process of Programming?

From the QP1 inquiry, it is possible to analyze if the Creative Process assists students in learning in programming. To answer the research question the following hypothesis, H1 was formulated: H1: The use of the Creative Process in the development of Computational Thinking helps students solve problems using programming.

The phases involved in the development of such research are described in the present work, which is organized as follows: Section 2 presents the concepts of Computational Thinking. Section 3 addresses Programming Teaching and Learning. Section 4 addresses the definition of Creativity and Creative Process. Section 5 presents Related Works, and Section 6 presents the Conceptual Model. Finally, Section 7 regards the final considerations of the paper, highlighting the contributions of the study.

2 COMPUTATIONAL THINKING

The concept of Computational Thinking (CT) was proposed in 2006 by Jeannette Wing (National Research Council, 2013) and is related to problem-solving and the perception of human behavior, both guided by definitions of the fundamentals of Computer Science (National Research Council, 2013). The CT addresses a set of definitions, skills, and practices of computing that can be applied both in everyday activities and in other areas of knowledge (National Research Council, 2013).

According to the BBC - Computational Thinking (Gomes et. al, 2017), Computational Thinking has four pillars that help solve complex problems: Decomposition, Recognition, Abstraction, and Algorithms.

Decomposition - consists of breaking down a problem or complex system into smaller, more manageable parts.

Pattern Recognition - characterized by looking for similarities between problems and subproblems.

Abstraction - has the purpose of focusing only on important information searching for the solution, ignoring irrelevant details.

Algorithms - intended to develop a systematic solution to the problem, or the rules to follow to solve it.

The use of the four pillars assists in programming and solving complex problems – which are those that, at first sight, one does not know how to solve easily. Finally, these simple steps or rules are used in programming to help solve the problem in the best way (Gomes et. al, 2017). In this research we will use the four pillars of Computational Thinking (Gomes et. al, 2017), corroborating with the objectives of the current proposal.

In this research the four pillars of Computational Thinking (Gomes et. al, 2017) will be used, corroborating with the objectives of the current proposal.

3 PROGRAMMING TEACHING AND LEARNING

The literature presents a set of difficulties associated with programming learning and teaching (Sternberg,2003). Considering the difficulties presented by the students, these were divided into three categories: teaching strategies, student attitudes, study methods, and natural programming difficulties (Sternberg,2003). Many students are accustomed to the memorization strategies (read, see solved exercises), which are not enough to learn to program. It was necessary to engage in intensive problem-solving practice, facing the difficulties related to it and trying to resolve them. This should be based on generic problem-solving skills previously acquired that students generally do not have (Sternberg,2003).

Considering this scenario, some creative strategies can be used in programming teaching, among which we can cite: diversifying the proposed tasks through methods of education, transformation, simulation, among others; usage of Computational Thinking to solve problems; creating a space for the dissemination of student work; sharing personal experiences related to the studied topic; guiding the student to seek additional information on topics of interest to them (BBC, 2017).

4 CREATIVITY AND THE CREATIVE PROCESS

This section presents the definitions that underlie this work regarding Creativity and the Creative Process.

4.1 Creativity

There are several definitions of the term creativity, and there is no consensus as to its exact meaning. Among the authors, this being an issue addressed from multiple points of view, we have, for example, Sternberg's Theory of Creativity (MacKinnon, 1962) and MacKinnon's Theory (Tschimmel, 2010). This is related to the fact that creativity, like intelligence, is a complex construct, with diverse aspects, such as the characteristics of the individual, the creative process, items present in the creative product, or aspects of the environment where people are inserted, which may influence one's creative expression (BBC, 2017).

According to Sternberg's Theory of Investment in Creativity (MacKinnon, 1962), six interrelated elements will be creative: intellectual skills, knowledge, thinking styles, personality, motivation, and appropriate environment. These multiple perspectives of creativity are related to combinations of aspects inherent to the individual, depending on cognitive, emotional and environmental factors.

For MacKinnon (Tschimmel, 2010), three basic conditions are necessary for creativity: the response must be new or at least statistically infrequent; the response must adapt to reality and serve to solve a problem or achieve a recognizable goal and must include the evaluation, design, and development of the original insight.

For this paper, we will use the definition of MacKinnon (Tschimmel, 2010), since it aligns with the research objective of using creativity as a tool to help solve problems.

4.2 Creative Process

The Creative Process is situated at the stage of generating ideas for a solution and the creation of new ideas and uses divergent and convergent thinking in the analysis, synthesis and casual events that are experienced as relevant (Zavadil, 2019). In this process, people use their skills and develop new ones according to the demands and type of activity. These skills involve cognitive procedures that will allow the restructuring of elements and the creation of new combinations for generating an idea or solution in a specific domain (Osborn, 2008).

In this context, the terms Creativity and Creative Process, although sometimes used as synonyms, are used in this study with different meanings. Creativity is the systemic capacity manifested in new and value-added solutions (be them ideas, products, concepts, questions, etc.), influenced by various contextual factors of the social and cultural environment (Zavadil, 2019) (Osborn, 2008). This is done through means of the Creative Process, which consists of methods, techniques, instruments and procedural knowledge that can facilitate the development of new conceptions, dealing with the various factors influencing Creativity and facilitating communication and interaction between the individuals (Osborn, 2008).

4.3 Creative Problem Solving (CPS)

Creative Problem Solving (CPS) was created by Osborn. It is a methodological paradigm composed of methods and techniques to analyze, identify and solve problems.

Research, Discovery of Ideas and Discovery of Solutions. This model's strategy is to obtain a clear and precise definition of the problem and generate several solutions.

The problem is delimited at the Investigation stage. According to Osborn, the definition of the problem is fundamental to propose new questions and possibilities.

The generation and development of ideas happen in the Discovery of Ideas stage. The most promising ideas are then selected and developed in the project activity.

The Solution Discovery phase encompasses the evaluation of the provisional ideas, the choice of the final solution and its subsequent implementation. The evaluation of ideas highlights critical intelligence, analytical thinking, and convergent thinking.

5 RELATED WORK

The literature presents some approaches that use creativity as an element to promote Computational

Thinking and programming learning, however, it is still incipient, especially if the study's objective is teacher training (Miller et al, 2013; et al, 2017).

The study by Shell et. al (2017) addressed the integration of Computational Thinking and Creative Thinking into Computer Science courses to improve the learning and performance of higher education students using Computational Creativity Exercises (CCEs). This research uses Epstein's theory of generationality (2017) to support the definition of Creative Thinking, which divides it into four competencies: capture, challenge, amplify, and engage. Capturing competence refers to the ability to recognize and note unique ideas as they occur. The ability to challenge established thinking and behavior patterns are related to the ability to generate new approaches to problems. The competence to extend, or amplify, one's knowledge beyond one's discipline allows the innovative integration of ideas. And, lastly, the stimulus, that can be social or environmental, can lead to new experiences and ideas. The principles of Computational Creativity Exercises (CCEs) are (1) attribute balancing between Computational and Creative Thinking and (2) mapping between computational and creative concepts and skills, as manifested in different disciplines. For each exercise, the study has a set of creative objectives, computational objectives, and collaborative problem-solving objectives. For the set of computational objectives, two aspects are used: PC concepts, such as classification and logical condition, as well as Computational Thinking skills. The Computational Thinking skills that were used in the study were: problem decomposition, pattern recognition, abstraction, generalization, algorithmic design, and evaluation. The study concluded that the integration of computational creativity exercises based on the creative competencies of Epstein (2017) improved the learning of Computational Thinking in Computer Science courses.

The study by Shell et. al (2017) points out the need to relate the teaching of Computational and Creative Thinking in the Computation course, to help students learn and develop their ability to apply, in a creative way, the knowledge of Computational Thinking in solving problems. However, this study does not clearly show how problem-solving is related to the pillars of Computational Thinking.

6 CONCEPTUAL FRAMEWORK

The study was divided into a few phases and the activities were based on the Conceptual Model. The research is qualitative, carrying out a content analysis of the semi-structured interviews with the students.
The Conceptual Framework was based on the pillars of Computational Thinking and Creative Problem Solving (CPS), to aid programming learning and problem-solving. The model can be viewed in Figure 1.

The Conceptual Framework is divided into three parts: Computational Thinking, CPS and Creativity Techniques. The first two have the purpose of assisting in problem-solving to facilitate the learning of programming and the Creativity Techniques have the objective of developing Creative Thinking.

The Decomposition phase of the Computational Thinking pillars is related to the six hats technique (Bono, 2017), because this technique helps in dividing the problem and observing it from different perspectives, and can be used in the definition phase of the CPS problem.

The Pattern Recognition stage of the Computational Thinking pillars is correlated with the Domite to Destroy (D2D) technique. This technique aims to recognize the patterns to create something new or innovative and concerns the generation phase of the CPS, which is the selected stage for this function.

The Abstraction phase of Computational Thinking pillars is related to the Zoom Out creativity technique, since this technique, as well as abstraction, has the intent to train in an individual the ability to observe the concepts only in a generic form while searching for the most relevant information. Besides, it is localized in the ideas generation phase, a moment of convergence.

Finally, on the Algorithm pillar, this is related to code, UML or any algorithmically representation of the solution and is located in the Action phase of the CPS model, since it is the stage of developing the solution. In the following subsections, the application of this model will be detailed in the game programming class.

6.1 The Participants

The research includes the participation of students from two classes: class 1, with nine students, and class 2, with six students, from the last period of the course of the digital games in higher education who were taking the multiplatform programming discipline. Both classes have already taken the Introduction to Programming course. The average age of students in class 1 was 20 years old and all were male. The average age of students in class 2 was 23 and all were male. The students were chosen because they are in the same period and all have already seen the same number of subjects. The object-oriented programming classes, in C #, were given by the same teacher, before conducting the study using the Conceptual Model. The full transcript of the class 1 interview is on the link.

6.2 The Study

For the application of the Conceptual Framework, an activity was carried out with a duration of 2 weeks, with two classes per week, lasting a total of 3 hours and 30 minutes, in Class 1. This activity intended to study the impact of the Creative Process on the development of Computational Thinking to assist programming learning in the development of a game.

The game was created with Engine Unity and it was necessary to use object-oriented programming with the C # language. This activity involved the whole class. At first, the students made, with the professor's aid, a Timberman style game – a casual game in which a woodcutter needs to cut a tree and not let the branches hit him. Then the students should create a functionality different from the basic game.

Students used Creativity Techniques in conjunction with the Computational Thinking pillars. Before solving the proposed issue, the students divided the problem into smaller pieces (Decomposition), utilizing the six hats technique (Leavy, 2014), to find the solution. They recognized the Pattern of the basic solution through D2D and used abstraction, noting which the most important part of the code should be modified, as well as using Zoom Out to create a creative solution.

The students decided that the new Timberman game would be in line with the theme Jack and the Beanstalk, which is about a fairy tale where the character Jack climbs on a large magic bean tree. Students used the concept of climbing the branches instead of having them descend, just like in the original game. Therefore, they changed the gameplay and altered the game code.

Students who used the Conceptual Framework and those who did not participate in the activity were interviewed after its conclusion, using the Conceptual Framework. The questions can be seen below, in Table 1.

Table 1: Interview questions.

INTERVIEW QUESTIONS
HOW DO YOU DEFINE CREATIVITY?
DO YOU BELIEVE THAT CREATIVITY HELPS IN PROBLEM-SOLVING? YES, NO, AND WHY?
IN YOUR OPINION, CAN CREATIVITY BE USED TO AID IN PROGRAMMING?
DID YOU HAVE ANY DIFFICULTY IN PROGRAMMING? IF YES, WHICH?

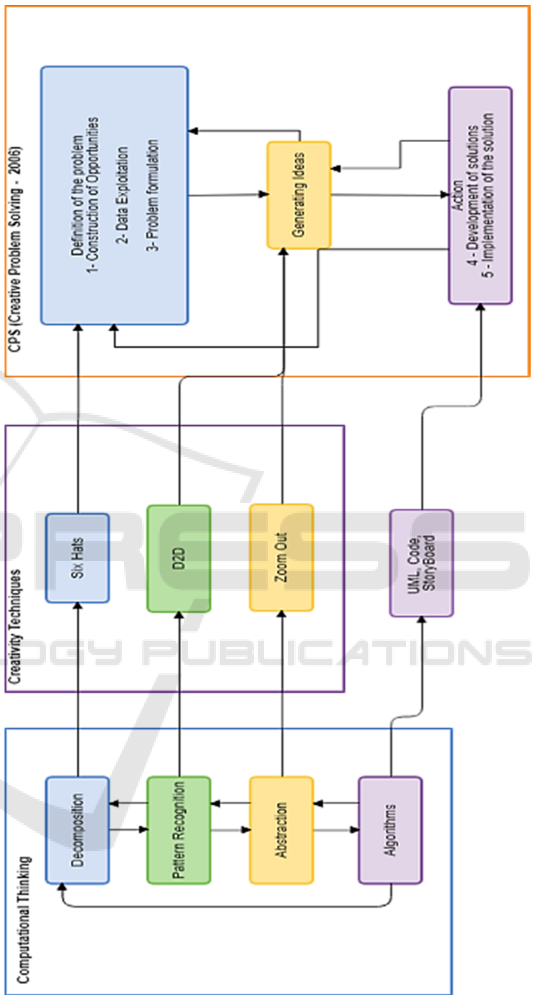

Figure 1: Conceptual Framework.

To analyze the students' responses to the semi-structured interview, we used Content Analysis (Leavy, 2014). Leavy (2014) presents Content Analysis as a qualitative analysis technique, starting from three processes, or phases, understood as necessary to perform a content analysis: 1) pre-analysis, 2) material exploration, and 3) treatment of the results, inference, and interpretation.

The pre-analysis begins the creation of the corpus of the research, through the organization of the material that is to be analyzed, making it operational (Leavy, 2014).

In the material exploration, which characterizes the second phase, corpus coding techniques are administered, including a careful examination of the material for the definition and set of categories. The third step appertains to the results' treatment, as well as its inference and interpretation (Leavy, 2014).

Students in Classes 1 and 2 also answered questions from the Inventory of Teaching Practices for Creativity in Higher Education, validated by Alencar (2004), after the conclusion of the activity utilizing the Conceptual Model. The instrument consists of 37 items that aim to evaluate the teaching practices that favor the development and expression of creative abilities in university students, constituting a first step towards the development of Creative Thinking in the students. The Inventory of Teaching Practices for Creativity in Higher Education can be viewed in Table 2.

Table 2: The Inventory of Teaching Practices for Creativity in Higher Education.

	STRONGLY DISAGREE	**I DISAGREE**	**IN DOUBT**	**I AGREE**	**I FULLY AGREE**
1. CULTIVATE IN STUDENTS THE TASTE FOR DISCOVERY AND THE SEARCH FOR NEW KNOWLEDGE.	1	2	3	4	5
2. ASK CHALLENGING QUESTIONS THAT MOTIVATE STUDENTS TO THINK AND REASON.	1	2	3	4	5
3. ENCOURAGE STUDENTS TO ANALYZE DIFFERENT ASPECTS OF A PROBLEM	1	2	3	4	5
4. STIMULATES STUDENT INITIATIVE	1	2	3	4	5
5. ENCOURAGE THE STUDENT TO HAVE NEW IDEAS RELATED TO THE CONTENT OF THE DISCIPLINE.	1	2	3	4	5
6. PROMOTES STUDENTS' SELF-CONFIDENCE.	1	2	3	4	5
7. IT STIMULATES STUDENTS' CURIOSITY THROUGH THE PROPOSED ACTIVITIES.	1	2	3	4	5
8. ENCOURAGES STUDENT INDEPENDENCE.	1	2	3	4	5
9. DEVELOPS CRITICAL ANALYSIS SKILLS IN STUDENTS.	1	2	3	4	5
10. IT LEADS THE STUDENT TO PERCEIVE AND KNOW DIVERGENT POINTS OF VIEW ABOUT THE SAME PROBLEM OR SUBJECT OF STUDY.	1	2	3	4	5
11. IT VALUES THE STUDENTS' ORIGINAL IDEAS.	1	2	3	4	5
12. ENCOURAGES STUDENTS TO ASK QUESTIONS ABOUT STUDIED.	1	2	3	4	5
13. IT IS ONLY CONCERNED WITH INFORMATION CONTENT.	1	2	3	4	5
14. CREATES AN ENVIRONMENT OF RESPECT AND ACCEPTANCE FOR STUDENTS' IDEAS.	1	2	3	4	5
15. ALLOW TIME FOR STUDENTS TO THINK AND TO DEVELOP NEW IDEAS.	1	2	3	4	5
16. IT GIVES THE STUDENTS A CHANCE TO DISAGREE WITH THEIR POINT OF VIEW.	1	2	3	4	5

Table 2: The Inventory of Teaching Practices for Creativity in Higher Education (cont.).

	STRONGLY DISAGREE	I DISAGREE	IN DOUBT	I AGREE	I FULLY AGREE
17. USES EVALUATION FORMS THAT REQUIRE THE STUDENT TO ONLY REPRODUCE THE CONTENT GIVEN IN CLASS OR CONTAINED IN THE BOOKS / TEXTS.	1	2	3	4	5
18. IT PRESENTS SEVERAL ASPECTS OF AN ISSUE BEING STUDIED.	1	2	3	4	5
19. ALWAYS USE THE SAME TEACHING METHODOLOGY.	1	2	3	4	5
20. PROMOTE THE DEBATE WITH THE ENCOURAGEMENT OF THE PARTICIPATION OF ALL STUDENTS.	1	2	3	4	5
21. ASKS QUESTIONS, SEEKING CONNECTIONS WITH ISSUES ADDRESSED.	1	2	3	4	5
22. USE EXAMPLES TO ILLUSTRATE WHAT IS BEING ADDRESSED IN CLASS.	1	2	3	4	5
23. IS WILLING TO ELUCIDATE STUDENTS' DOUBTS.	1	2	3	4	5
24. PROVIDES EXTENSIVE BIBLIOGRAPHY ON THE TOPICS COVERED.	1	2	3	4	5
25. AWAKENS STUDENTS' INTEREST IN THE CONTENT TAUGHT	1	2	3	4	5
26. IS WILLING TO SERVE STUDENTS OUTSIDE THE CLASSROOM.	1	2	3	4	5
27. IT USES A VARIETY OF FORMS OF EVALUATION.	1	2	3	4	5
28. IT PRESENTS PROBLEM SITUATIONS TO BE SOLVED BY THE STUDENTS.	1	2	3	4	5
29. IT EXPOSES THE CONTENT IN A DIDACTIC WAY.	1	2	3	4	5
30. IT OFFERS STUDENTS LITTLE CHOICE IN THE WORK TO BE DONE.	1	2	3	4	5
31. GIVE CONSTRUCTIVE FEEDBACK TO STUDENTS.	1	2	3	4	5
32. PROVIDES IMPORTANT AND INTERESTING INFORMATION REGARDING THE CONTENT OF THE COURSE.	1	2	3	4	5
33. HAS ENTHUSIASM FOR THE DISCIPLINE HE TEACHES.	1	2	3	4	5
34. LISTEN CAREFULLY TO STUDENTS' INTERVENTIONS.	1	2	3	4	5
35. IS NOT AWARE OF STUDENTS' INTERESTS.	1	2	3	4	5
36. HAS POSITIVE EXPECTATIONS REGARDING STUDENT PERFORMANCE.	1	2	3	4	5
37. HAS A SENSE OF HUMOR IN THE CLASSROOM	1	2	3	4	5

This study, which resulted in the validation of the instrument after a factorial analysis, suggests the following organization: Factor 1 - Incentive to New Ideas, in which it contemplates the items I1-I10, I12, I15, I18, I20, I21; Factor 2 - Climate for Expression of Ideas, that includes items I11, I14, I16, I34, I35, I37; Factor 3 - Teaching Assessment and Methodology, which includes I13, I17, I19, I27 and I30; and Factor 4 - Interest in Student Learning, that addresses items I22 - I29, I31, I32, I33 and I36.

Each of the items is answered on a Likert scale (1932) of five points, ranging from strongly disagree to strongly agree. The instrument is complemented with an initial page with instructions on how to answer it properly, including biographical data of the respondents, information on the courses to which they are related, age and gender, allowing the description of the students' profile.

The Likert scale (1932) is a type of psychometric response often used in questionnaires in the areas of Psychology, Education and Marketing. In responding to a questionnaire based on this scale, respondents detail their level of agreement with a statement (LIKERT, 1932). Based on the questionnaire's answers, the average value of the students' answers was calculated based on the Weighted Arithmetic Mean, as done in Oliveira (2005), using the following formula:

$$\bar{x}_{assertiva} = \frac{\sum_{i=1}^{5} x_i \cdot f_i}{n}$$

assertive

6.3 Results

The responses of the Inventory of Teaching Practices for Creativity in Higher Education were analyzed from a quantitative approach. The study was based on Descriptive Statistics, which is intended to describe and summarize a set of data, that is, to transform the collected data into information.

For this research, Frequency Distribution was used, specifically the Absolute Frequency, to present the data and its respective frequencies. For each assertion, the frequency of the answers given by the participants is shown, according to the Likert scale (1932). As the survey was carried out with 8 students from Class 1 and 9 students from Class 2, then the total of observations for each assertive is 8 and 9, respectively.

The closer to 5, the maximum number on the Likert scale (1932), the higher the level of agreement of the students about the assertions of the Inventory of Teaching Practices for Creativity in Higher Education.

Tables 3, 4, 5 and 6 present the average result of factors 1, 2, 3 and 4, respectively obtained through the students' answers on the Inventory of Teaching Practices for Creativity in Higher Education.

Table 3: Factor 1 - Incentive to New Ideas.

ASSERTIVE	CLASSES	RESULTS BY ASSERTIVE
I1	**1**	**4,25**
	2	**4,22**
I2	**1**	**4,38**
	2	**4,11**
I3	**1**	**3,75**
	2	**4.67**
I4	**1**	**4,13**
	2	**4,11**
I5	**1**	**4,00**
	2	**4,11**
I6	**1**	**3,75**
	2	**4,22**
I7	**1**	**4,13**
	2	**4,44**
I8	**1**	**4,13**
	2	**4,33**
I9	**1**	**3,13**
	2	**3,89**
I10	**1**	**3,50**
	2	**3,89**
I12	**1**	**4,25**
	2	**4,44**
I15	**1**	**4,25**
	2	**4,22**
I18	**1**	**4,38**
	2	**4,00**
I20	**1**	**4,25**
	2	**3,78**

In Table 3, the average result of the answers indicates that Factor 1, called Incentive to New Ideas, related to the stimulation of cognitive abilities and affective characteristics was evaluated positively by the students of the two groups.

Table 4: Factor 2 - Climate for Idea Expression.

ASSERTIVE	CLASSES	RESULTS BY ASSERTIVE
I11	**1**	**4,88**
	2	**4,33**
I14	**1**	**4,25**
	2	**4,33**
I16	**1**	**3,88**
	2	**4,22**
I34	**1**	**4,38**
	2	**4,56**
I35	**1**	**1,75**
	2	**2,00**
I37	**1**	**4,63**
	2	**4,56**

In Table 4 the average result of the answers indicates that Factor 2, called Climate for Expression of Ideas, which refers to the posture and acceptance by the teacher regarding the ideas presented by the students, obtained agreement indexes. The I35 inquiry is emphasized, is that even with a score of less than 5 it is positive, for the question wants to understand if the teacher "is not attentive to the interests of the students", and the students responded by disagreeing with this statement.

Table 5 shows the average result of Factor 3 responses, called Teaching Assessment and Methodology, regarding teaching practices favorable to the development of creative expression, showing that even though the indexes are low in Class 1, that used the Conceptual Model in the activities, they are positive because they are related to the disagreement that the teaching is only informative and that there is only the reproduction without reflection on the content.

Table 5: Factor 3 - Teaching Assessment and Methodology.

ASSERTIVE	CLASSES	RESULTS BY ASSERTIVE
I13	**1**	**2,13**
	2	**3,33**
I17	**1**	**2,25**
	2	**3,33**
I19	**1**	**1,38**
	2	**3,78**
I27	**1**	**4,00**
	2	**3,78**
I30	**1**	**1,75**
	2	**3,44**

Table 6: Factor 4 - Interest in Student Learning.

ASSERTIVE	CLASSES	RESULTS BY ASSERTIVE
I22	**1**	**4,25**
	2	**4,44**
I23	**1**	**4,63**
	2	**4,86**
I24	**1**	**4,00**
	2	**3,89**
I25	**1**	**4,63**
	2	**3,78**
I26	**1**	**3,88**
	2	**4,00**
I28	**1**	**3,75**
	2	**4,56**
I29	**1**	**4,00**
	2	**4,44**
I31	**1**	**4,38**
	2	**4,44**
I32	**1**	**4,38**
	2	**4,67**

Table 6: Factor 4 - Interest in Student Learning (cont.).

ASSERTIVE	CLASSES	RESULTS BY ASSERTIVE
I33	**1**	**4,38**
	2	**4,78**
I36	**1**	**4,38**
	2	**4,22**

In Table 6 the average result of the answers is related to the Factor 4, denominated Interest in Student Learning, related to strategies and educational resources that motivate the student to learn creatively, presented indicators that prove that the students agree with the affirmations in the questionnaire.

Additionally, the Content Analysis was carried out based on the transcripts of the semi-structured interviews. Table 7 presents an overview of the categories created from the students' responses, as can be seen, below. The categories were created using the MAXQDA software. The initial categories went through a synthesis where the authors arrived in the final categories. This modification is part of the third stage of content analysis, as in this phase, the results are treated and the coded data is synthesized, seeking information for analysis, which will result in inferential interpretations. The full transcription of the interviews is in the appendix.

Table 7: Categories.

INITIAL CATEGORY	FINAL CATEGORY
CREATION	**GENERATE NEW IDEAS**
RELATING EXISTING KNOWLEDGE	
INNOVATION	
DIVERGENT THINKING	**DIVERGENT THINKING**
SYNTAX	**THEORETICAL PROGRAMMING CONCEPTS**
SEMANTICS	
RELATING THEORETICAL CONCEPTS WITH PRACTICE	**RELATING THEORETICAL CONCEPTS WITH PRACTICE**
PROGRAMMING LOGIC	**PROGRAMMING LOGIC**
CREATIVE PROCESS	**CREATIVE PROCESS**
CREATIVE PRODUCT	**CREATIVE PRODUCT**
CREATIVITY DOESN'T APPLY TO PROGRAMMING	**CREATIVITY DOESN'T APPLY TO PROGRAMMING**

One issue to remark is the Creative Process category, created in Content Analysis, which emerged from the question "In your opinion, can creativity be used to aid in programming." This category arose only from Class 1, which was applied to the Conceptual Framework.

Besides, the category "Creativity doesn't apply to programming" was identified only in Class 2, to which the Conceptual Framework was not applied in a classroom activity

6.4 Discussion

In this session, we presented the Conceptual Model and its use in a class undertaking the course of Digital Games in a Multiplatform Programming discipline, as well as the results achieved with the study that evaluated the model in an activity taken place in a learning scenario.

The study was taken forth by a research question that sought to verify that the Creative Process is, indeed, a factor that influences the development of Computational Thinking and Programming teaching and learning processes.

Regarding the performed activity using the Conceptual Model, there was greater involvement of the students in the solution of the problem, as well as the resolution itself was completed using elements of the Unity IEnumerator, which was used in the solution and has the function of stopping a process and then resume it. This functionality was not used in the standard solution presented by the teacher.

Regarding the students' responses in the semi-structured interview, the students in class 1 - those in which the Framework was used - when answered about the relationship between programming and creativity, had the perception that the creative process can be inserted in the resolution of problems in use of programming and that not only creative products are the result of the relationship between programming and creativity. As can be seen in the students' speech: Student 5:

> *Yes, mainly because of the programming logic. Why would she, a person like me, for example, that I don't know how to program properly, but I have a good programming logic, this is more creativity and creativity helps you develop a programming logic, so if a person who knows how to program and do not have a good creativity and he is training his creativity naturally he creates a better programming logic that already helps in both cases. (Student 5).*

This may be an indication that students, by using the Conceptual Framework in an activity to solve a problem, have realized that the Creative Process can influence and assist in the solution of a given problem.

The responses of students in Class 1 show that creativity helps in the development of Computational Thinking since students report on their answers that creativity does indeed aid in programming logic and problem-solving, and we can infer from the context of the answers that this definition is related to Computational Thinking.

The students in Class 2 had different answers, stating that creativity is related to programming only to a certain extent. Following are the statements of Student 5:

In programming, creativity will have to be filtered well in fact, because depending on what the person, like, ends up thinking it often becomes very difficult for the level of the person doing it or if they are in a moment that they are not you can adapt the programming, so it has to be well filtered even in this part of creativity. (Student 5).

Regarding the results of the responses of the Inventory of Teaching Practices for Creativity in Higher Education, the factor that had a considerable difference between Class 1 and Class 2 was Factor 3 entitled Teaching Assessment and Methodology, regarding favorable teaching practices to the development of creative expression.

This may be an indicator of the activities that were performed using the Conceptual Model, for in Class 1 the interventions were not only theoretical and the practices in the laboratory made use of the creative techniques that are present in the creative process.

Regarding the problems faced by students in the process of programming learning, the students stated, for the most part, that they have difficulty using knowledge in solving problems. These answers converge with the research question.

7 CONCLUSION

Nowadays, society has increased the degree of requirement regarding the creativity used to solve increasingly complex problems. This fact generates demand for studies on how to stimulate creativity in education, especially in teachers' education (BBC, 2017). The skills and knowledge required today are extensive and include Computational Thinking as one of its key pieces in this context. Computational Thinking enables students to define, analyze and solve complex problems by the use of models and concepts derived from Computer Science, using the technological resources, increasingly more present and accessible, to obtain more efficient solutions (National Research Council, 2013).

The current research is aligned with the context presented, proposing an approach in which the Creative Process is used for the development of Computational Thinking through the resolution of programming problems.

The Conceptual Framework was applied in a higher education class and was later evaluated using Content Analysis to investigate students' perceptions about the relationship between Creativity as a tool to solve problems in programming and through the resolution of the proposed activity. The study presented evidence that there were contributions with the expansion of creativity, since the results of the Content Analysis point in this direction. In this perspective, the educational environment is relevant to the development of creativity, especially in the teacher's actions, seeking to introduce such an element in its practices and leading them to use innovative methods to engage students in becoming more interested in the projects' contents. This approach promotes the active participation of the students in the development of creative and efficient solutions, while also promoting the development of Computational Thinking, confirming the hypothesis of this study.

Finally, we realize that the students of the class to which the Conceptual Framework was applied recognized that the teacher adopts creative practices in the classroom. As discussed in this paper, the expansion of creativity presents itself as part of the skills and competencies expected for individuals in our society. The methodology here presented corroborates with the systematization of this process, presenting techniques to promote the development of Creative Thought through the Creative Process, and, consequently, to favor Computational Thinking, essential elements in programming education.

7.1 Paper Contribution

Considering the perspective of the use of the Creative Process in the development of Computational Thinking to aid programming teaching and learning, the research contributed to problem-solving through programming. The following are the contributions: i) Creation and Evaluation of a Conceptual Model for the development of Computational Thinking using Creative Process to aid in the teaching and learning of programming; ii) Process-based and Creative Thinking helped to solve problems using programming.

7.2 Limitations and Future Works

This research's limitations of will be presented as follows: i) the choice of the students who participated in the research was not randomized; ii) the Creative Process was not introduced at the beginning of the discipline, limiting itself to only one activity; iii) the interview and the questionnaire were performed only once. Therefore, it is important to create other forms of analysis that are used throughout the teaching and learning process. Despite such limitations, the research has shown promise. As a future work, we intend to use the Framework in programming disciplines that are not related to game development. Analyze the profile of students before and after using the Framework. Do activities based on the Framework with more classes and assess student learning throughout the intervention, using Framework.

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APPENDIX

The full transcript of the class 1 interview is on the link. https://drive.google.com/file/d/1wva4--GK31rPTY8-tjNjM615T6nngh2e/view?usp=sharing The full transcript of the class 2 interview is on the link. https://drive.google.com/drive/folders/1oSdc-xR6J3fFZ23yPLSXc8ceH-duIim_?usp=sharing .