Use of active methodologies for the development of a teaching plan for the algorithms subject

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***Abstract*— This Research to Practice Full Paper presents that the contents seen in introductory programming subjects, such as that of algorithms or equivalent subjects, provide a basis for further programming studies provided by computing courses. The contents related to programming are considered complex and difficult to understand, this ends up generating high failure rates in the subjects and, consequently, can influence the increase in the dropout rate in computing courses. Thus, the difficulties faced in learning algorithms require teachers to constantly search for new tools and methodologies that facilitate learning and adequately develop the skills and competences related to programming. Therefore, several forms of interventions in the subjects of algorithms have been used and presented in the specialized literature, with emphasis on active methodologies, which have been generating promising results, making it possible to increase the interaction between students in addition to providing more autonomous learning. Thus, the objective of this work is to present a teaching plan focused on the subject of algorithms, elaborated based on six active methodologies, detailing all the stages of preparing the teaching plan, as well as the teaching units that are worked on each day of class. This work will also present the results of the evaluation of the teaching plan that was carried out by expert teachers in the use of active methodologies and in the teaching of algorithms. For the development of this work, a quasi-Systematic Review of Literature was carried out, which allowed the identification of the main forms of intervention that are currently being used in the teaching of algorithms. Then, the teaching plan was elaborated based on the active methodologies that were identified in the previous step and, finally, the evaluation was carried out using the peer review technique, which counted on the participation of teachers with experience in teaching algorithms and using active methodologies. As a result, there is a teaching plan that is entirely shaped by active methodologies, which consists of 17 theoretical and practical classes, distributed in 5 modules. This plan is based on curriculum references such as the Brazilian Computer Society (SBC) and Association for Computing Machinery / Institute of Electrical and Electronic Engineers (ACM / IEEE). In addition, the plan also has support materials for all classes. The elaboration of a teaching plan of great importance, as it allows to diversify the way of teaching complex subjects that cause a high failure rate in algorithm subjects.**

Keywords—active methodologies, teaching plan, algorithms.

I. INTRODUCTION

Programming skills are crucial for computer students, as they allow the development of a new way of thinking and solving real life problems by algorithms [1]. However, students constantly report that learning programming content is a challenging task and one that involves countless difficulties [2]. It was found in [2] that one in three students enrolled in computer programming subjects is unable to complete it due to the difficulties faced during the classes.

According to [3], the difficulties faced by students are closely linked to the low level of knowledge in programming logic, to the difficulties in identifying and abstracting the characteristics that are necessary for understanding and solving problems worked in the subjects.

The traditional teaching methodology is mainly focused on instruction from teachers to students, which automatically leads to the "indoctrination classroom" way, causing students to lose interest in learning [4]. Therefore, teaching approaches and content need to be constantly updated and / or modified [5].

To combat students' difficulties in learning programming, teachers need to use strategies that motivate students and improve their programming skills. Active methodologies and student-centered instruction can be a solution to get students interested in the subject. These student-centered approaches allow them to develop extra-class tasks, while also learning in the classroom. In this way, this work aims to present a teaching plan for the subject of algorithms, elaborated based on active methodologies.

For the elaboration of this work, a review of the literature was initially carried out, which allowed to identify in the specialized studies the approaches that are currently being worked in the teaching of computer programming. After the identification and selection of the approaches, the teaching plan was elaborated. In addition to the teaching plan, support materials were also prepared, such as slides, spreadsheets and lists of activities. Then, a peer review was carried out in order to identify possible fails in the teaching plan. After the peer review, the necessary adjustments were made to all documents that make up the teaching plan.

As a result, a teaching plan was developed for content in the algorithm subject, consisting of six active methodologies, namely: Problem Based Learning (PBL),

Coding Dojo, Gamification, Serious Games, Flipped Classroom and Virtual Environments. The plan consists of 17 classes, divided into 5 modules: Initial Evaluation Module, Module I, Module II, Module III and Final Evaluation Module. With the exception of the first and the last module, the others are made up of theoretical and practical classes, exercises and extra-class activities.

In addition to this introductory section, Section II presents some related work, Section III discusses the methodology for preparing the teaching plan, Section IV discusses the preparation of the plan, Section V presents the evaluation of the plan, Section VI deals with threats to the validity of this work and, finally, Section VII presents the conclusions of the work.

II. Related Works

In [6], a teaching plan was elaborated in which it introduces some active methodologies for teaching programming. In this work, the author approaches four methodologies for the elaboration of the teaching plan, namely: flipped classroom, gamification, BYOD and the use of individual students' skills to solve the proposed problems. However, the author turned his attention only to the subject of web programming.

The work [7] presents a teaching plan aimed at the final subjects of the Computer Engineering course. The plan is characterized by flexibility, since the active methodologies used for its elaboration can be applied in several subjects, among them programming subjects, as is the case of the web programming subject mentioned in the work. Although the plan proposed by the authors is quite comprehensive, since it allows its use in different computing subjects, it does not have a specific focus, nor does it have a detail on how to use it in the programming subjects. The plan is limited to presenting the active methodologies that should be used and in which part of the classes these methodologies can best be applied.

In [1] the implementation of some active methodologies in the teaching of introductory programming in an undergraduate course in Computer Engineering is presented. Regarding the active methodologies used, the author used Problem Based Learning (PBL) so that students can deal with challenges they may face in the job market; and Flipped Classroom, so that students develop greater autonomy in solving the proposed problems and improve communication. Despite the work applying active methodologies in the teaching of introductory programming, the author did not elaborate a teaching plan. In addition, the work addresses only the way in which each methodology was applied in the subject without specifying in which class it occurred.

In [8] is reported through a descriptive and exploratory study the use of active methodologies in an introductory programming subject, offered in a Geology course. The methodologies were applied based on a problem proposed by the professor of the subject, in which students should build a project that solved an engineering and geology problem through information processing. For this, methodologies such as: PBL, flipped classroom and collaborative work were used. As can be seen, the work is developed based on the application of methodologies in a non-computational course. In addition, the results of the work were obtained based on only one application.

The work [9] presents the application of four active methodologies in a programming subject. The application of methodologies occurred through a mentoring program for teachers. The four methodologies used by the author were: Flipped Classroom (which in the work in question the author calls flipped learning), Case-Based Learning, Problem-Based Learning and Guided Learning Projects. However, the author applied these methodologies only during a program that was being developed, that is, the methodologies were not applied during the entire period of offer of the subject.

As can be seen, most of the works presented in this section address active methodologies without the use of a teaching plan. Likewise, those who developed teaching plans did not turn to introductory programming subjects. On the other hand, this work presents a plan that details clearly and objectively the methodologies that must be applied in each class, the most appropriate moment for that application. In addition, the plan proposed in this paper makes it clear how each of the methodologies should be used to obtain a higher performance from the students.

It is worth mentioning that this work differs from the others by using an quasi-Systematic Review of Literature as the criterion for choosing methodologies, which allowed the identification of the most used approaches. Another point to be highlighted concerns the focus of the work, since the purpose is to prioritize the base of programming, taking into account that from the base, learning the other programming subjects can be easier.

III. Methodology for the Elaboration of the Teaching Plan

The planning of the elaboration of the teaching plan allowed to identify the necessary steps for the construction of the material, as well as all the work products that would be generated in each activity. In this sense, 7 activities were defined and will be detailed in the next subsections.

A. Review of Literature

In order to know which approaches are currently being used in teaching algorithms in higher education institutions, a quasi-Systematic Review of Literature (qSRL) was carried out. The review was classified as quasi-Systematic, as it did not make comparisons between identified studies, but sought to preserve the same formalism presented in the process of conducting a Systematic Review of Literature. As it is an exploratory research and does not make comparisons between the identified scientific studies, the review can be classified as quasi-Systematic [10]. With the realization of the qSRL, the 15 most used approaches in

teaching algorithms in the period from 2016 to 2019 were identified [11].

B. Selection of Active Methodologies among the Works arising from the q-SRL

The choice of active methodologies that would be used in the teaching plan was made based on the approaches identified in [11]. In this sense, we sought to analyze the use of each methodology, as well as its main advantages and the difficulties of its applications in teaching algorithms. With the analysis of the methodologies, it was possible to identify 6 approaches that could be worked together within an algorithm subject, as shown in Table I.

TABLE I. APPROACHES SELECTED

ID	Approaches [A]
[A1]	Virtual Learning Environment – VLE
[A2]	Coding Dojo
[A3]	Gamification
[A4]	Problem Based Learning - PBL
[A5]	Flliped Classroom
[A6]	Serious Games

C. Understanding of Algorithm Teaching Units

In parallel with the choice of approaches that would be used in the teaching plan, we also sought to understand the specificities of each teaching unit in the subject of algorithms. For this step, syllabus of algorithm subjects that are used in higher education institutions in Brazil were used as support material, which are prepared by professors with extensive experience in the area and are based on curriculum references such as the Brazilian Computer Society (SBC), Association for Computing Machinery (ACM) and Institute of Electrical and Electronic Engineers (IEEE). In this sense, it was possible to analyze the main objectives of the subject, as well as to identify which skills and competences should be stimulated in the teaching of algorithms.

As objectives, it can be noted that the subject of algorithms seeks the development of logical reasoning aimed at the creation of computer programs, as well as the translation of this knowledge by programming language.

As a way to achieve these objectives, it can be noted in the specialized literature that higher education institutions usually work with content that is considered to be fundamental in the subject of algorithms. Based on [12], it is possible to list the following teaching units that are worked in the subjects of algorithms: (1) Notions of Logic, (2) Introduction to Algorithms, (3) Types of Data, (4) Variables and Constants, (5) Expressions and Operators, (6) Conditional Structures, (7) Repeating Structures and (8) Arrays, and (9) Programming Language.

Based on the 9 teaching units that were previously identified, students are able to develop the ability to analyze problems and implement their solutions in programming language. With regard to the skills that are developed in the subjects of algorithms, the ability to relate problems with the elaboration of solutions that involve the basic elements of the construction of algorithms can be highlighted, as well as the ability to identify the data structures that can be used to solve a particular problem.

D. Identification of which Active Methodologies would be most suitable for application in each Unit

After understanding the teaching units, together with their skills and competences, we sought to identify which active methodologies could be used together in the teaching units, as shown in Table II.

TABLE II. CORRELATION: CONTENT X APPROACH

Contents of the Subject	Approaches [A]
(1) Notions of Logic	[A1], [A3], [A4]
(2) Introduction to Algorithms	[A1], [A3], [A4]
(3) Types of Data	[A1], [A3], [A4]
(4) Variables and Constants	[A1], [A3], [A4]
(5) Expressions and Operators	[A1], [A2], [A3], [A4]
(6) Conditional Structures	[A1], [A3], [A4], [A6]
(7) Repeating Structures	[A1], [A3], [A4], [A6]
(8) Arrays	[A1], [A2], [A3], [A4], [A6]
(9) Programming Language	[A1], [A2], [A3], [A4], [A5]

Due to the complexity of the content of algorithms increasing with the course of the subject, the distribution of methodologies was carried out gradually, considering that students also need to understand and become familiar with how to use each active methodology.

For the contents (1), (2), (3) and (4) the methodologies of VLE [A1], Gamification [A3] and PBL [A4] were used, because with the use of VLE the student has the possibility to access the content of the course remotely, as well as interact with other students through discussion forums and thus mitigate possible doubts and exchange knowledge. Gamification [A3] was used to allow the application of the subject's evaluation criteria. In addition, the game elements present in this methodology allows the teacher to work on complex and difficult-to-understand content in a more playful and interactive way. The PBL [A4] is also done, as it allows students to always be looking for the fixation of knowledge through an approach that is focused on solving problems in a more practical way, therefore, it becomes of great importance its application during the practical activities of the subject.

For the contents (5), (6) and (7) the methodologies of VLE [A1], Gamification [A3] and PBL [A4] were also used, due to the benefits already mentioned. In addition, the use of the Coding Dojo methodology [A2] was included, which will enable and stimulate the collective work of students in the search for problem solving. Likewise, from the content (6), the use of Serious Games [6] begins, which will allow students to immerse themselves in key contents

of the subject so that they apply the knowledge acquired in in the classroom, building simplified games.

For the content (8) we used the good practices present in [A1], [A2], [A3], [A4] and [A6] and for (9) we used [A1], [A2], [A3], [A4] and [A5]. The great differential of (9) in relation to (8) is the use of the methodology [A5], which makes possible the inversion of the traditional teaching logistics, in order to promote a greater protagonism for the students, because first the student seeks for the acquisition and fixing the contents outside the classroom and then, in the school environment, the socialization of knowledge takes place through debates and the applicability of knowledge in practical activities.

In addition, three other activities were carried out with this research: elaboration of the teaching plan, evaluation of the plan based on peer review and adjustments to the teaching plan, which will be presented in detail in the following sections.

IV. Elaboration of the Teaching Plan

The Teaching Plan was prepared based on well-defined steps, based on the model proposed by [13], as shown in Figure 1.

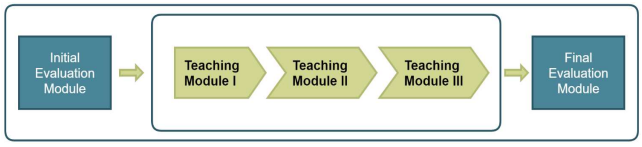


Fig. 1. The model proposed.

The Initial Evaluation Module (AVI) lasts for 2 class-hours and takes place on the first academic day of the subject. The objective of the AVI is to carry out an initial evaluation that consists of the application of a questionnaire, in order to identify the level of prior knowledge that the student has and that can be used during the course. At this time, it is also sought to present the proposed model and how the evaluation process will take place, allowing the student to be aware of how the teaching and learning process will occur. Studies show that learning can become more meaningful when students know how the teaching process will be conducted and when there is a dialogue about the activities and their form of evaluation. For this, it is necessary to know and map the profile of students to bring them closer to the teaching and learning process [14].

In this sense, the strategies for implementing the approaches present in the teaching plan were based on good practices recommended in the specialized literature, such as: gradual implementation of active methodologies, use of multiple strategies to teach the contents, promotion of collaborative learning, constant evaluation and immediate feedback [15].

Teaching Modules I, II and III are intended for teaching and learning algorithm teaching units. It is during the Teaching Modules that classes and evaluative activities will take place, which will be guided by the active methodologies applied to the contents of the respective Teaching Modules. The Teaching Modules have a certain standardization in relation to their general structure, so that all teaching materials (class slides, books and other support materials) must be accessible to students in the VLE at the beginning of each module, as well as the Extra-Class Challenges of that Teaching Module.

The delivery of Extra-Class Challenges for the teacher to evaluate is always done at the end of each Teaching Module, together with the Missions. As a way of preparing students for Missions, practical activities are carried out using the Coding Dojo approach [A2] before each Mission is carried out. Classes are expository and are divided into two moments. At the first moment, the teacher must present the content planned for the day and mitigate students' doubts. The second moment of the class is dedicated to the application of Challenges that involve the content previously discussed. It is recommended that the teacher divide the time that will be dedicated on the present day, so that each of the two moments of class is contemplated with 50% of the time planned for each day of class.

In view of the above, the Teaching Module I starts after the completion of the previous stage (AVI), its duration is 18 class-hours and its objective is focused on the development of programming logic, as well as working on the initial concepts of algorithms. In this sense, we seek to stimulate the development of logical reasoning, addressing initial contents of algorithms through the use of methods such as Gamification, PBL, Coding Dojo and VLE. The subjects covered in Teaching Module I are: What is an algorithm ? What is a programming language ? Ways of representing an algorithm, Variables, Operators (Logical and Arithmetic), and Linearization of expressions.

As it is the first Teaching Module and involves the first contact of students with content related to algorithms, adaptability and acceptance of the practices proposed in the teaching plan are essential. Therefore, in this module it is of great importance that the teacher encourages the active participation of students during the classes, so that they have less difficulties with the proposed approaches. For this reason, approaches that involve the use of Scratch, Serious Games and Flipped Classroom will be used only in the modules subsequent to this one.

The Teaching Module II has a duration of 24 class-hours and aims to use PBL, Coding Dojo, Gamification and Serious Games in the teaching and learning of algorithms, through programming in Blocks using the Scratch tool. The subjects covered in the Teaching Module II are: Introduction to the Scratch Environment, Variables, Conditional Structures, Repeating structures and Arrays.

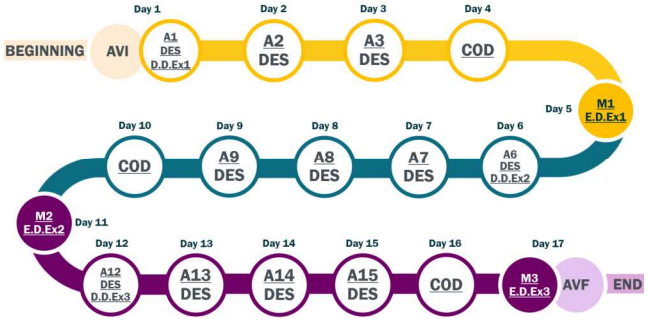
The use of an approach focused on Serious Games in this module aims to teach programming and at the same time make students practice in a more playful way the knowledge and skills acquired during classes. With the Serious Games the teacher will be able to monitor the student's development, as well as check if the student can

suggest and apply solutions for the practical activities that will be presented during the classes.

In Teaching Module III we seek to work directly with programming language. For this, active approaches are used: Gamification, PBL, Coding Dojo, VLE and Flipped Classroom in teaching and learning a programming language, its duration is 22 class-hours. The subjects covered in Teaching Module III are: Introduction to C Programming Language, Variables, operators and main commands of the C programming language, Conditional structures in C programming language, Repeating structures in C programming language, and Arrays in C programming language.

It is justified to use the Flipped Classroom at this moment, due to the fact that students already have a certain knowledge and skills in programming logic, just as they will be more experienced and mature with regard to the acquisition of knowledge autonomously, thus favoring the application of an active approach that further stimulates autonomy in studies and greater student engagement.

Finally, the Final Evaluation Module (AVF) has a duration of 2 class-hours and occurs after the closure of Teaching Module III. The AVF seeks to evaluate the effects of applying the teaching plan through feedback from students and the teacher, so that it is possible to identify the positive points and also possible threats that may implicate future applications of the teaching plan. In this sense, Figure 2 illustrates the activity plan of the teaching plan.



Subtitle:

Initial Evaluation Module Duration of 2 class-hours	**Teaching Module I** Duration of 18 class-hours
	Teaching Module II Duration of 24 class-hours
Final Evaluation Module Duration of 2 class-hours	**Teaching Module III** Duration of 22 class-hours
AVI – Initial Evaluation Module	**A1, A2, ... A16** – Classes
DES – Challenges	**COD** – Coding Dojo
D.D.Ex1, **D.D.Ex2**, **D.D.Ex3** – Availability of Extra-Class Challenges	**E.D.Ex1**, **E.D.Ex2**, **E.D.Ex3** – Delivery of Extra-Class Challenges
AVF – Final Evaluation Module	**M1, M2, M3** – Missions (Evaluations)

Fig. 2. Roadmap for teaching plan activities

With regard to the distribution of the contents referring to the teaching units, they were distributed over the 17 days. On 1st day, the content worked in the classroom is aimed at teaching introductory concepts of algorithms, computer programming and programming language. On 2nd and 3rd days, we seek to work with content related to the development of programming logic and problem solving in an algorithmic way.

The 4th day is dedicated to practical activities using the Coding Dojo approach. This moment is intended for the fixation of the contents studied in the classroom, so that students are able to use the acquired knowledge and apply it in solving problems. On the 5th day, an evaluation is carried out (Mission 1), which seeks to measure the learning that the students had from the contents that have already been studied.

The content worked on the 6th day is focused on the Scratch tool, which allows students to work with block programming. On that day, the block programming environment and the basic commands of the tool will be presented. Thus, on the 7th day students will have contact with the conditional structures through the Scratch tool. Likewise, on the 8th day the content worked in the classroom is focused on repetition structures.

After having contact with the conditional and repetition structures, students will be able to start their studies with the content of the 9th day, which is focused on arrays through the Scratch environment. The 10th day is intended for practical activities with Coding Dojo. This moment allows students to practice, through problem solving, the contents studied from the 6th to the 9th days. Subsequently, on the 11th day a second evaluation is carried out (Mission 2), which aims to evaluate the degree of learning of the contents seen on days 6, 7, 8, and 9.

Beginning on the 12th day, students start working with the C programming language. Thus, the teaching of introductory concepts of the C programming language takes place. On the 13th day students will have contact with the conditional and control structures of the C language, so that they will start to manipulate the if-else and switch case commands. The content worked on the 14th day is focused on repetition structures. On that day, the students will work with the while, do-while and for commands. This will allow students to have a solid knowledge base and to be able to work without major difficulties on the contents of the 15th day, which is focused on teaching arrays in C language.

In this sense, the 16th day is intended for practical activities using the Coding Dojo approach, at which time students will be able to interact and apply the knowledge acquired during the 12th, 13th, 14th and 15th days. Finally, on the 17th day the last evaluation of the subject (Mission 3) is carried out, which seeks to evaluate the students' level of learning based on the contents studied from the 12th until the 15th days.

With this content distribution, it is possible to contemplate all the elements provided for in the teaching units that were presented in this work.

V. EVALUATION OF THE TEACHING PLAN

The evaluation of the Teaching Plan took place using the peer review technique, which was carried out in order to evaluate the applicability of the active methodologies in the teaching units. Thus, we sought to identify inconsistencies and / or factors that could compromise the applicability of the proposed material.

The first step of peer review consisted of identifying reviewers who had knowledge and experience in teaching algorithms, as well as using active methodologies. In this way, some characteristics were analyzed for the selection of a qualified evaluator to carry out the peer review, such as: (i) the time of experience in teaching algorithms, (ii) experience in using the active methodologies used in the teaching plan, and (iii) experience in the elaboration of teaching plans for the subject of algorithms.

In this sense, it is possible to identify 3 profiles of evaluators who met the selection criteria, so that Evaluator 1 reported having approximately 5 years of experience with teaching algorithms and using active methodologies. In addition, he has participated in the development of teaching plans for algorithms 6 times and considers his level of experience in teaching programming as a medium. Evaluator 2 also reported having approximately 5 years of experience with teaching algorithms, as well as using active methodologies. Regarding the experience in the elaboration of teaching plans for algorithms, he has already performed this activity 6 times and considers having a high level of experience with teaching programming. Evaluator 3 reported having approximately 1 year of experience with teaching algorithms and using active methodologies. The same evaluator has already participated in the elaboration of teaching plans twice and classifies his experience with teaching algorithms as low.

In this way, it was possible to select evaluators who have already had contact with the teaching of algorithms and the use of active methodologies, with diverse experiences. This allowed to evaluate the degree of difficulty in using / interpreting the approaches in the teaching plan, both by professionals with little experience, and by more experienced professionals in the teaching of algorithms and in the use of active methodologies.

In this sense, the evaluators were responsible for analyzing the following documents: (1) teaching plan for the subject of algorithms presented in this paper, (2) peer review form, containing the criteria for conducting the review, available in *https://rebrand.ly/drjq9*, and (3) support materials (class slides, materials with practical activities and evaluations), available in *https://rebrand.ly/i9sa5*. The problems identified by the evaluators were classified as: **TA (High Technical)**, indicating that a problem was found in an item that, if not changed, will compromise the considerations, **TB (Low Technical)**, indicating that a problem was found in an item that would be convenient to change, **E (Editorial)**, indicating that a gramatical error was found or that the text can be improved, **Q (Questioning)**, indicating that there were doubts regarding the content of the considerations, **G (General)**, indicating that the comment is general in relation to the considerations. The data resulting from the peer review were analyzed and tabulated, the problems identified by each evaluator were accounted for and grouped by type, as shown in Figure 3.

Evaluator 1 identified one (1) problem classified as TA, which was related to the use of the VLE methodology in the teaching plan, one (1) TB, which was related to the guidelines on how to apply the active methodologies in the subject of algorithms, one (1) E, referring to spelling problems in the evaluated material and three (3) problems classified as Q where he presented considerations about the teaching plan in a more lenient way. Evaluator 1 did not identify any problem classified as G.

Evaluator 2 identified three (3) problems classified as Q, which were related to the joint use of active methodologies, as well as how to carry out evaluations and the use of gamification to promote student engagement. Evaluator 2 did not identify any TA, TB, E or G problems.

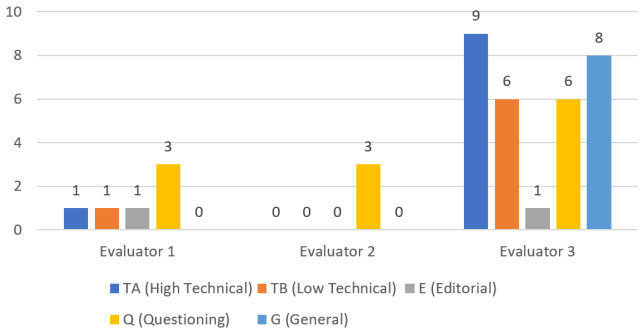


Fig. 3. Problems identified by evaluator.

Finally, Evaluator 3 identified nine (9) TA problems, referring to the scoring criteria of the gamification methodology, guidance on how to conduct the Coding Dojo approach and adjustments to the lesson materials (slides). Six (6) TB problems were also identified, which were related to the delimitation of time (which the evaluator considered to be a short time) for the performance of some activities and low quality of some images present in the slides of the classes. The editorial problem (E) was related to the identification of spelling errors in the teaching plan, six (6) Q that were related to the form of application of evaluative activities and practical activities such as the Coding Dojo, as well as the understanding about the definition of some rules present in the teaching plan. Finally, eight (8) G problems were identified, which were related to the standardization of items on the slides such as font size and type, examples of content with illustrations and alignment of some definitions presented in table format in the teaching plan.

The recommendations that the evaluators made based on the identified problems were analyzed if they were subject to acceptance or not. In this step, 3 acceptance criteria were

adopted (Fully Complied, Partially Complied and Not Complied). With the analysis of the considerations made by each evaluator, it was found that the majority should be accepted and the items where problems were identified should be corrected, as shown in Table 3.

TABLE III. COMPLIANCE WITH IDENTIFIED PROBLEMS.

EVALUATORS	CRITERIA	TA	TB	E	Q	G
Evaluator 1	Fully Complied	0	0	1	2	0
	Partial Complied	0	0	0	1	0
	Not Complied	1	1	0	0	0
Evaluator 2	Fully Complied	0	0	0	2	0
	Partial Complied	0	0	0	0	0
	Not Complied	0	0	0	1	0
Evaluator 3	Fully Complied	7	5	1	5	8
	Partial Complied	1	0	0	0	1
	Not Complied	1	1	0	1	0

Three items identified by Evaluator 1 were Fully Complied, one E problem that pointed out problems related to the spelling of the text and that should be corrected, two Q problems, the first was related to the treatment of serious games approaches and Virtual Environments, as the evaluator suggested that works from the literature be included in the teaching plan that classified the two items mentioned above as active methodologies. The second problem was related to the choice of the methodology used in the Final Evaluation Module, that the Evaluator recommended making it clearer how this procedure took place.

A problem identified as Q was Partially Complied, as the author suggested including works from Literature that use the nomenclature of “Active Methodologies” for approaches to Serious Games and Virtual Learning Environments ”The service was partial because the plan teaching already contemplated such a recommendation, however the material was rewritten, in order to make the content referring to the mentioned items clearer.

Finally, two items were classified as Not Complied, as one of them (TA) Evaluator 1 recommended the creation of an extra session in the teaching plan to treat VLE as a teaching methodology. The item was not answered because the teaching plan already has a session designed to present VLE and its characteristics and throughout all activities there are guidelines on how to use it during classes. The second problem Not Complied (TB), it was recommended to add examples or describe the application of the method, directing to the subject of each class. During the analysis of this item, it was noticed that the description of the application of the method has reference to the sessions that detail the application of each approach used in each class. Soon, it was noticed that the item was already covered, so it was classified as "Not Complied".

Evaluator 2 had two problems Fully Complied, the first (Q) reported a question regarding how to maintain student engagement throughout the course from the Active Methodologies. This item was completely met, since the Teaching Plan was built based on scientific works and reports of experiences extracted from the literature that recommend good practices in the use of Active Methodologies. In addition, it is important to emphasize that the Teaching Plan is still a proposal and the activities still need to be evaluated in a real scenario. The second Fully Complied problem was also classified as Q and related to the possibility of measuring the effectiveness of the application of each active methodology used in the teaching plan. The item was fully complied to, as Final Evaluation Module seeks to assess the effectiveness of the plan, as well as its strengths and weaknesses. Therefore, the methodologies used are also included in the assessment.

None items identified were Partially Complied to and in only one Q problem the criterion “Not Complied” was applied, as Evaluator 2 presented a question regarding the form of evaluation, arguing whether the evaluations of the teaching plan should not be in groups and / or mixed during the activities, considering that active methodologies are used. It is justified that this item is not met due to the fact that individual evaluations already take place in each class (Challenges) and are registered by the bonus criteria arising from gamification. In addition, at the end of each Teaching Module, evaluations (Missions) are carried out, whose objective is to measure the degree of knowledge that the student obtained in each Teaching Module.

Evaluator 3 identified 31 problems in the teaching plan, of which 25 were Fully Complied. In this sense, of this problems, 7 were classified as TA and were related to adjustments in: (i) scoring and bonus rules, (ii) content of the challenges, (iii) Coding Dojo, (iv) and (v) slide content, and (vi) and (vii) details of the teaching plan. Likewise, 4 TB problems were Fully Complied, which were related to (i) slide content, (ii) formatting of coding dojo material, (iii) standardization over time of the Coding Dojo, (iv) improvements in the quality of the images used in the materials, and (v) adjustments to the scoring rules for gamification. Four problems classified as Q were Fully Complied, which suggested improvements in: (i) instructions on the resolutions of the activities present in Initial and Final Evaluation Modules, (ii) guidelines for coding dojo practices to be carried out, (iii) description of scoring calculation rules used in gamification, and (iv) adjustments to the guidelines for driving dynamics using PBL.

Finally, 8 problems classified as G were Fully Complied, which were related to: (i) standardization of sources in the class slides, (ii) standardization in the number of examples with illustrations for each class, (iii) standardization in the amount of practical exercises applied in each class, (iv) adequacy in the content of the class held on 3th day, (v) inform in the class slides the moment of application of each challenge, (vi) improvement in the quality of the images used in the class on the 6th day, (vii) adjustments to the general guidelines for Coding Dojo, (viii) adjustments to the content of Table 1 of the teaching plan. In the same way, there was a problem as E related to

adjustments on the description of the class-hour, as it was recommended to insert guidelines that allow us to understand that each class-hour mentioned in the teaching plan lasts 50 minutes. Therefore, this problem has also been fully complied.

The problems identified by Evaluator 3 that were Partially Complied are: (i) TA, referring to adjustments in Table 1, as the evaluator suggested presenting the partial score obtained in each stage found in the table. However, the purpose of the aforementioned table is to present the stages of the teaching plan in general. Thus, the adjustment made allowed to present only the maximum score obtained at the end of each stage, partially meeting the recommendation of the evaluator. (ii) One G problem was partially complied, since the content "linearization of mathematical expressions" addressed in one of the classes was considered difficult by Evaluator 3 and he recommended analyzing the feasibility of removing the content in the teaching plan. This item was partially met, as it was considered extremely important to address the referred subject, so that it underwent adjustments in an attempt to simplify it, partially meeting the request.

With regard to the problems identified by Evaluator 3, which were highlighted as Not Complied, we have: (i) TA, referring to the viability of extra-class challenges, as the evaluator questioned that students might not perform the extra-class activities properly, in this case, consulting the materials when necessary or using ready-made responses available on the internet. It was decided to keep the Extra-Class Challenges, as the teaching plan requires the commitment and dedication of the student. Therefore, it is important that he dedicates himself to being able to autonomously carry out the tasks of the subject. (ii) TB, the evaluator did not identify one of the elements of gamification described in the teaching plan and recommended its inclusion. However, it was observed that the said element was present in the materials and to make identification easier, adjustments were made to the documents. Therefore, the recommendation was classified as not being met. (iii) Q, the evaluator did not identify the description of "M1", "M2" and "M3" in the teaching plan. However, the information was described in the document and the item was classified as Not Complied.

VI. Threats to Validity

During the conduct of this research, some threats were identified, which will be presented below, as well as the way used to mitigate or minimize possible threats. With regard to the threat related to the subjectivity of the choice of active methodologies, this problem was mitigated by defining and applying inclusion and exclusion criteria in the choice of methodologies, in addition to holding consensus meetings to validate the choices.

As for the threat related to a possible limitation of the Units applied in the Teaching Plan, which may suffer small variations depending on the educational institution, the analysis of the syllabus that were generated from curriculum references such as SBC and ACM / IEEE was carried out, aiming to ensure the inclusion of the contents considered basic in the teaching units.

Another threat is related to the possible lack of experience in the use of Active Methodologies by the authors of the research. We tried to circumvent this problem with the evaluation of the teaching plan by teachers who teach the subject of algorithms and who have some experience with the use of active methodologies and in the preparation of teaching plans in higher education courses.

Regarding the threats related to a possible low number of reviewers, it is worth noting that, in addition to pointing out improvements in the teaching plan, they showed interest in the application of the teaching plan throughout the course of their subjects in the future. The threats related to the different times of experience of the reviewers, showed that the teaching plan can be easily understood and applied by teachers with little or vast experience in teaching algorithms, as well as in the use of active methodologies.

Finally, the threat related to the lack of application of the Teaching Plan, stands out that, initially, the focus of this research was first focused on the technical understanding of the use of active methodologies, as well as their validation through peer review. The analysis of the effect of these approaches over the teaching and learning process will be carried out in the future with classes of algorithms in higher education courses.

VII. Conclusions

It is noticed that the teaching plan is in line with the curricular references followed by Brazilian higher education institutions, allowing the application of active methodologies in the basic teaching units of the subject.

The teaching plan was designed to make teaching and learning algorithmic teaching units more dynamic and motivating. As a way to evaluated the proper application of the active methodologies in the teaching units, the material was revised based on the peer review technique, which had the collaboration of three teachers with experience in teaching algorithms, as well as in the use of active methodologies. The evaluation of the teaching plan allowed the identification of elements that needed adjustments, thus allowing the necessary changes to be made the material suitable to be applied in real scenarios.

The elaboration of a teaching plan that was built based on reports and good practices present in the literature, becomes of great importance, as it allows to diversify the way of teaching complex subjects that cause a high failure rate in algorithm subjects. In addition, the material serves as a basis for future research that seeks to develop tools to support the teaching and learning process of algorithms. As future work, we intend to apply the Teaching Plan to an Algorithms class and analyze the effects of using Active Methodologies, making it possible to evaluate the effectiveness of the proposed approach in a real scenario.

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