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A Study on the Active Methodologies Applied to Teaching and Learning Process in the Computing Area

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ABSTRACT Active Methodologies allow an active process in teaching and learning contents, promote responsible student involvement and bring satisfaction and enrichment to educational practices and active learning. Generally, students have learning difficulties in Computer Science courses, as they need to develop computational skills and thinking. The goals of this article is to characterize and analyze the types of Active Methodologies that are being applied in teaching and learning activities in Computer Science. Thus, this investigation was carried out through a Systematic Mapping Study, focusing on the use of the types of methodologies in view of the results achieved. It presents students' perceptions, benefits, and difficulties in adopting these methodologies in the classroom. The results show 6 types of different Active Methodologies used in 35 publications selected, different types of techniques or studies that were used, the publications trend per year, the courses that were worked in analyzed publications, and some benefits and difficulty related to the adoption of Active Methodologies. Regarding to students' perception, we identified different type feelings. Thus, the contributions of this study consist in a research focused on the use of Active Methodologies in a very broad sense, including the perceptions of teachers and students regarding the use of different teaching and learning methodologies. In addition, it shows the specific benefits and possible difficulties experienced in the use of Active Methodologies as teaching strategies. Consequently, some findings from this study may have the potential to support or direct choices of these methodologies in different Computer Science courses.

INDEX TERMS Active methodologies, teaching in computing, learning, students' perception.

I. INTRODUCTION

The old method of teaching in which students were getting used to stay seated on their places, writing down and listening to a lecture of a teacher, have changed [1]. The nature of computer use has changed remarkably in the past fifty years. However, most Computer Science (CS) courses are still often teaching through that old paradigm that is not adequated to deal with modern concerns. Even in the face of the current generation of students and the nature of computing, most computer courses are still teaching in traditional ways [2]. That scenario needs a new conception that can brought a profound pedagogical renewal that requires knowledge and domain of new methodologies [3].

Active methodologies (AM) can support the development of self-competencies and skills. Because, on an increasingly complex society, mere transmission of information no longer characterizes an efficient teaching and learning process [4]. Therefore, AM are teaching strategies centered on the effective participation of students in the construction of the learning process, in a flexible, interconnected and hybrid way [5]. Also, on the new way, the act of learning needs to become a reconstructive process that allows the students to establish different relationships between facts and objects, producing resignifications and reconstructions and contributing to their application in different contexts [6], brings satisfaction and enrichment for both teacher and students [7].

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Although there are several papers investigating about AM in teaching and learning, there is still a shortage of papers that shows how these AM influence and also can be exploited for support knowledge of teaching and learning in CS courses. Therefore, we have identified the need for a comprehensive research bout influence and support AM in teaching and learning in CS courses.

Systematic Mapping Studies (SMS) provides an overview of a research area, identifying the quantity, the types of research carried out, the results available, in addition to the frequency of publications over time to identify trends [8]. Our aims in this study, is characterizes and analyzes types of AM most applied to teaching and learning activities in CS courses. It also presents the students' perceptions about the AM applied in teaching, some benefits, and difficulties in adopting the different types of AM inside of a classroom.

From an initial selection of 753 publications, we have identified 35 different publications that have used AM to support in teaching and learning in CS courses. From the selected publications, the following AM were the most cited: Gamification (GM); Problem-Based Learning (PBL); Project-Based Learning (ProjBL); Peer instruction (PI); Flipped classroom (FC); and Team-Based Learning (TBL). Also, we have identified the research goal per AM applied, the publications trend per year, the main proposals of the studies mapped, technical or studies used per methodology, the computing area and active methodology applied, the courses that were worked in analyzed publications, and some benefits and difficulty related to the adoption of AM. Regarding to students' perception, we identified the feelings of Satisfaction in learning the content, Motivation to learn content and Feeling of mastery of content.

Besides this introductory section, this paper is structured as follows: Section 2 present related works; Section 3 describes the research method to define search strategy and research questions; Section 4 discusses the results; finally, Section 5 describes limitations and validity of this article, and Section 6 shows some conclusions.

II. RELATED WORKS

In recent years, several studies have reported evaluations and comparisons regarding of use of AM as teaching strategies in computer science e.g., [9]–[11]. The goal of those studies was to demonstrate the use of the AM with a focus on its use and apply them as teaching methods. Those works point out to AM as possible support to improve teaching in the computing and, consequently, to minimize the avoidance of courses in the area.

Raes *et al.* [12] present the results of an experiment on that subject comparing the students' learning experiences in a lecture face-to-face versus virtual students. The results show that although the hybrid virtual classroom is promising flexibility in education as it gives to students the choice for when and where attend the course, it is also the most challenging one to teach and to learn as a remote participant.

Farias & Nunes [13] argue that many studies in computing and education science present tools or environments related to teach in programming that does not reach the expected effect on the students' learning experience. That research also shows some relevant studies that, involving active programming learning for high school and university students, contribute to the construction of an innovative educational scenarios involving active programming learning.

Silva & Oliveira [14] have published an experience report of how robotics fits as an effective instrument from the perspective of AM for education. Those authors point out that robotics in education presents a possible path to be taken and used as a strategy applied to AM for the development and assimilation of knowledge, capable of promoting increasing participation and interest on the part of students, inside and outside school.

Moreno [15] proposes the discussion of evaluating how the principles, values, techniques and agile development processes can be relate to the AM to optimize teaching and learning process in introductory programming subjects with focus, specifically, on students of the high school. Thus, that author seeks to understand how teaching and learning, in introduction to programming, can be optimized by converging the active techniques widely discussed in the literature with those considered agile in software engineering.

The paper of Silva *et al.* [16], by his turn, seems to aim to present an systematic literature review on the use of digital games on teaching of programming for beginners in computing at university level in the last decade in Brazil. The authors argue that teaching programming is part of the basic academic training in CS and related areas.

We have observed that the use of AM in the context of learning computing still faces some challenges, mainly in relation to the attitude of the teacher and the students in relation to the use and effective applicability of the methodologies. In addition, the students' posture in relation to his autonomy for studies or in relation to an active posture for his studies inside or outside classroom, negatively reflect on skills related to computational thinking and learning computing [17], [18].

Resuming, all those previous works show that, besides a positive differential for teaching computing, today the adoption of AM are still a challenge because some teachers have resistance to adopt new teaching techniques. Furthermore, the training of new professionals in the area of technology, as well as in other areas of knowledge in computer programming, is a challenging task for hundreds of scientific researches, proposing several strategies that address from robotics, programming language, and educational games and to pedagogical approaches [19]. Also, that review has concluded that students have their own problems related to autonomy for study.

III. METHODS

For this paper, we have conducted SMS to collect all evidences that fit eligible criteria pre-specified following the

recommendations presented by Kitchenham & Charters [20]. Those kinds of studies also help to identify gaps in current research in order to suggest areas for further investigation [21] and by gathering, synthesizing and reviewing study findings [22]. So, this map was undertaken in three phases: planning, conducting, and reporting based on a systematic review protocol. Details of those stages are described in the following sub-sections.

To examine the current use of AM applied in CS courses, our research questions were:

RQ1. Which types of AM are being applied in teaching and learning activities in computing courses?

RQ2. Which are the courses' perceptions about the AM applied in teaching?

RQ3. Which are the benefits and difficulties in relation to the adoption of AM?

A. DATA SOURCE

The main digital libraries that were used to search for primary studies was Scopus, because: (i) It provides Index for publications of most events in the computer and education area, according to Dybá *et al.* [23]; (ii) It is an important repositories and are widely used for research in the scientific community; (iii) Its databases provide the best results, have strengths in different areas and return papers from more traditionally indexed [24]. In addition, we also manually searched the symposium and conference proceedings and journals in which relevant studies to the computer and education area domain had previously been published: (i) Brazilian Symposium on Informatics in Education (SBIE); (ii) Brazilian Symposium on Games and Digital Entertainment (SBGames); (iii) Computer Workshop at School (WIE); (iv) Computer Education Workshop (WEI); (v) New Technologies in Education Journal (RENOTE); (vi) Journal of Informatics in Education (RBIE); and (vii) International Congress of Educational Informatics (TISE). The period of analysis of the proceedings of the symposium above was from 2010 to 2019. Also, it is important to mention that in the Brazilian Symposium on Games and Digital Entertainment the search was made in all tracks; however, the proceedings of this symposium of the year 2014 was not used, as it is not available at the time of the search.

B. SEARCH STRATEGY

For the construction and refinement of the search string, we have flowed the recommendations of Petersen *et al.* [8]. We have performed the three advise steps, which are: (i) Consultation to the experts for the construction of the mapping protocol; (ii) The refinement and (iii) Test of the search string and selection of the keywords for manually searched.

Furthermore, to facilitate the identification of search string terms, the terms were defined from the Population, Intervention, Comparison, Output (PICO) parameters, by Kitchenham & Charters [20] and the terms related to each parameter, when applicable (see Table 1).

TABLE 1. Terms used to instantiate parameters PICO.

Parameter	Used terms of search
(P) Population: Works published in conferences or journals presenting models and artifacts involving active methodologies	"active methodologies" OR "methodologies" OR "active learning" OR "teaching computer" OR "educational experiences" OR "computer programming skills"
(I) Intervention: Teaching-learning activities of computer science course	activities OR teaching OR learning OR course OR computing
(C) Comparison: It does not apply, because it is a characterization review	not applicable, is a mapping for characterization
(O) Output: Concepts, definitions, methods, models, applications, discussion of problems	concepts OR approach OR method OR model

(("active methodologies" OR "methodologies" OR "active learning" OR "teaching computer" OR "educational experiences" OR "computer programming skills")
AND
(activities OR teaching OR learning OR course OR computing)
AND
(concepts OR approach OR method OR model))

FIGURE 1. Search string used in the SMS.

Moreover, we used the search string in which Boolean OR has been applied to join alternate terms and synonyms in each main part; and Boolean AND has been used to join the three main parts. Figure 1 shows the search string of this work.

C. STUDY SELECTION

During the SMS, only relevant publications to the research question were selected for further analysis. Kitchenham & Charters [20] had suggested the definition of inclusion and exclusion criteria for papers that are returned by the search string. Any paper that did not meet all the inclusion criteria must be deleted. Therefore, we have used the five inclusion criteria to select articles (see TABLE 2).

D. SEARCH RETURNS AND DATA EXTRACTION

The literature search identified 753 publications. After the removal of 105 duplicate papers, applying the 1st filter (selection based on title, keywords and abstract) and 2nd filter

TABLE 2. Inclusion set of criteria.

id	Inclusion criteria
Inc 1	Publication must present topics related to the use of AM in teaching activities in the context of computer and education area.
Inc 2	Publication must present details for applying of AM in teaching activities of course computer science.
Inc 3	Publication must present concepts, approach, method or model in the context of computer and education area.
Inc 4	Articles were written in English and Brazilian Portuguese.
Inc 5	Articles were published between 2010 to 2019.

(complete analysis of the study) to removal out-of-scope and duplicate papers (see Fig. 2), the final number of studies reviewed was reduced to 35 relevant papers that are listed in the (Supplementary data Appendix 1).

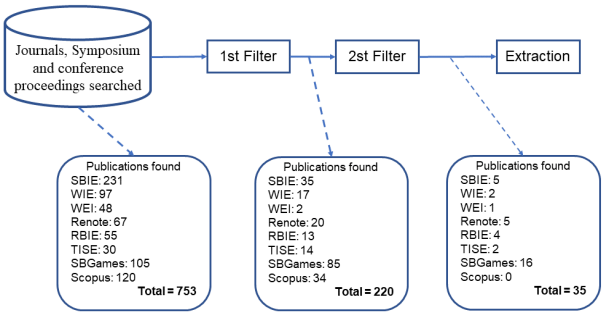

FIGURE 2. Shows the results obtained that answers the research.

In this scenario, we can observe that most of the researches selected in this mapping were published in SBGames, i.e., in this symposium the community can find most of publications related to AM teaching strategies in computer science. Also, we can observe SBIE, another symposium also used by the computer community in education. Furthermore, the journals RENOTE and RBIE also have been used.

IV. RESULTS AND ANALYSIS

In this section, we present our results according to the research questions.

A. ACTIVE METHODOLOGIES IN TEACHING OF COMPUTING

RQ1. Which types of AM are being applied in teaching and learning activities in computing courses?

Fig. 3 shows the results of 6 different types of AM most applied in the teaching and learning activities of different CS courses: GM; PBL; ProjBL; PI; FC and TBL.

Between publications analyzed, were applied the TBL and PI, but those types were used not alone in the work. For example, on the publications [10], [25]–[27] the researchers have used more than one AM as teaching strategies in their research. TBL methodology goes beyond covering the content, as it allows the use of course concepts to solve problems. Therefore, on TBL, learning is favored through group interaction; after the questions raised, they are discussed within the groups, the answers are presented to the class, thus revising the main points of the subject [18], [28]. The professional school educators have found TBL particularly attractive because it offers powerful solutions to several major problems they face in teaching [29]. Thus, it is an active learning method developed to help students achieve goals of the course while learning how to function in teams.

FC is a methodology that means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa. The use of learning technologies, particularly multimedia, provides new

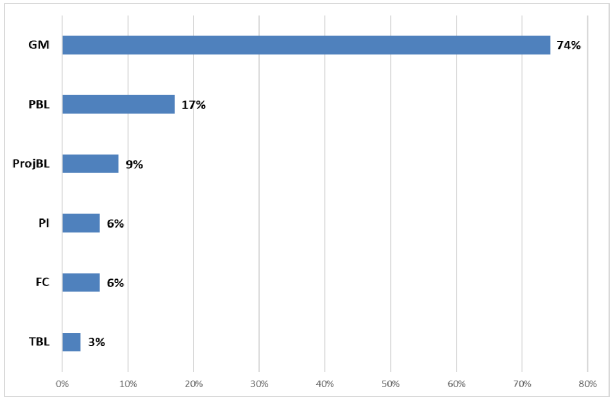

FIGURE 3. Types of AM are applied. In increasing order: TBL; FC; PI; ProjBL; PBL and GM.

opportunities for students to learn, opportunities that are not possible with other media [30]. Basically, the concept of a flipped class is this: what is traditionally done in class is now done at home, and what is traditionally done as homework is now completed in class. In the flipped model, the time is completely restructured [31].

Furthermore, it is important to mention that the AM applied in conjunction with TBL and PI were the PBL, ProjBL, FC and GM together, i.e., around 14% (5 publications) of set analyzed. PI is collaborative methodology, developed by teacher Eric Mazur of Harvard University. It aims to involve all students during class, promoting activities in which they are encouraged to apply the concepts discussed at that time, while explaining them to their colleagues [18]. Therefore, approach with PI will help them learn, mainly because the students have to play a central role in their own learning with the instructor as their coach [32] [33].

PBL is a methodology emerged in the 70s, through the doctor Howard Barrows, being applied in medical classes and has gained acceptance and is becoming increasingly effective across a variety of course in higher education and an educational method for the teaching of computing is being used in computer science [9]. It is considered to be an educational strategy centered on the students, which helps him in the development of reasoning and communication, essential skills for success in his professional life [34].

Fig. 3 shows the mapping results, PBL, ProjBL, PI and FC types of AM that were used in a few publications. Those methodologies were used just in 17% (7 publications), 9% (3 publications) and 6% (2 publications) respectively of the total set analyzed. Therefore, researches that use the methodology PBL, in general, seems to challenge the students to perform high-level mental tasks, such as analysis, synthesis and evaluation. That method was used totally focused on the health area, but nowadays it has been accepted in the teaching of several areas of knowledge, mainly in Computing, both on elementary and on high school [9].

ProjBL is a methodology that organizes learning around projects, according to definitions found in Project-based learning handbooks for teachers. For this methodology,

projects are complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making, or investigative activities; give students the opportunity to work relatively autonomously over extended periods of time; and culminate in realistic products or presentations [35] [36].

Ultimately, around 71% of the studies (25 publications) of set analyzed presented works used GM as methodology to teaching courses or measure the learning. Thus, it is the use of game elements and design for purposes unrelated to games to get people motivated to achieve specific goals [37] [38]. Therefore, gamification can provide an edge in learning delivery when it is designed, developed, and deployed properly. Thus, the effort should not focus solely on points, badges, and leader boards. Results of the change have bilateral nature– they can affect students' results and help them to understand the educational content and create conditions for an effective learning process [39]. We have observed that, on large-scale, concepts of gamification are applied into other areas almost every day [40]. And, on educational context, it is no different, because those researches have linked positive impacts on game experiences in different cases, particularly on player's experiences and interactions during learning courses on computing.

That scenario address that there is a greater production of procedure or technique for teaching in computing applying AM. Thus, we can notice a great concern of the educational community that demands of teachers to prepare dynamic classes and master how to use the different AM to motivate students in addition to producing different materials. It is important, because an increasing number of strategies are gaining prominence in terms of getting students' attention, changing the traditional way of teaching and learning [1], and support the search for learning objects that might help teachers on that task.

We also have analyzed the main objective of the researchers in relation to the use of AM; those research interests present different challenges encountered in the studies for the application of AM on teaching of computation (see Table 3). Those investigated studies, in general, present their objective as a search for different strategies for teaching and learning applying different AM, which results in different solutions for teaching.

This overview of research goal shows the importance of knowing about that topic and the need for developing more work to understand and increase useful tools to improve different means about teaching and learning. It is so because educational field is facing an impasse due to numerous changes in society: it is necessary to evolve and to make everyone learn in a competent and constructive way [41]. Also, the current social demands require much more from teachers in the classroom, not only a new attitude, but new ways of transmitting their knowledge [42].

Table 3, in general, shows concerns related to teaching and learning of content by students, research to awaken motivation and interest in the studied subject, research for developing quality professionals applying methodologies that leave behind the traditional method of decorating content and its mechanical reproduction. Thus, those researches have used different types of AM, as case studies involving the active learning of programming for students of different levels of education, since basic education up to postgraduate. Therefore, we can conclude that more research is required to improve innovative educational scenarios involving active learning in computer science.

Notably, the results shows that around 63% of the students (22 publications) analyzed applied AM as teaching strategies for teaching University. While around 20% of the studies (7 publications) were focused on Technical High School, just around 12% of the studies (4 publications) are related with others education levels, e.g., Postgraduate studies, High school, and Basic education. That scenario shows that AM are being adopted at all levels of education, i.e., it reveals that education professionals, especially in computing, are looking for innovate in relation to their teaching methodologies adopted in the classroom (see Fig. 4).

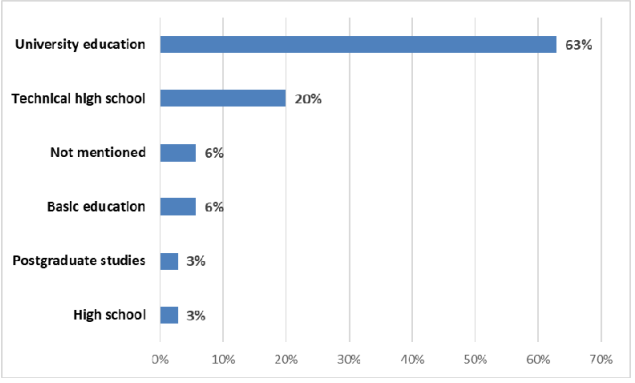

FIGURE 4. Education level system: High school, Postgraduate studies, Basic education, Not mentioned, Technical high school, University education.

Some results also revealed that the effects of the transition from a teaching-centered model of education to a learning-centered one involves a great cultural change for the University as an educational institution [43]. However, the social changes have leading to a change of perception in the teaching-learning process that promotes the emergence of the so-called active learning methodologies [18]. It is more perspective on higher education, so, we have analyzed the education level system in publications, because in higher education, there are growing trends toward flexible online course delivery [44].

Besides that, it is important to recognize that during the past few years, primary studies have been increased published regarding use AM as teaching strategies in the context of education [45]–[47] and have helped to refocus academic researches on method to teaching and learning, but it is still insufficient. Table 4 shows AM apply by education level system.

TABLE 3. Research goal per AM applied.

AM	Research Goal	Reference
ProjBL, PBL, TBL and PI	Increase students' motivation, belief in self-efficacy and autonomy, enhancing the learning of programming languages.	1
	Report the results of experience as the case study carried out for the first two periods of curriculum reformulation.	1
ProjBL and PBL	To present an analysis of AM aimed to learning undergraduate and graduate students.	1
GM, FC, and PI	Report experience of the use of gamification elements in conjunction with the hybrid teaching methodology in the inverted classroom modality applied to programming course.	1
FC	Resolution of practical problems, involving automation of solutions for monitoring network equipment and user actions, log analysis, data synchronization and automatic emission of alert messages, implemented in the Python programming language.	1
PBL	Shows how the use of PBL can contribute both to learning software engineering and to stimulating professional skills. Train programmers based on methodologies that focus on students learning and that favors the development of programming skills.	3
	Tests AM in undergraduate teaching and checks if students feel more engaged and motivated to carry out activities and develop their knowledge.	2
GM	Investigates the influence of gamification on students' engagement and performance in programming learning.	11
	Motivates students by serving as a tool to aid the teaching and learning process, making the practice of logic skills, and casting a light on creating algorithms, making fun and relaxed activity to be applied both inside and outside the classroom.	9
	Helps students to practice some introductory programming content in a fun way.	5

TABLE 4. AM applied by education level system.

AM	Education level system	Ref.
ProjBL, PBL, TBL and PI	Technical High School	1
ProjBL and PBL	University Education	1
	Postgraduate studies	1
GM, FC, and PI	University Education	1
FC	University Education	1
PBL	University Education	4
GM	Basic Education	1
	High School	1
	Technical High School	7
	University Education	17

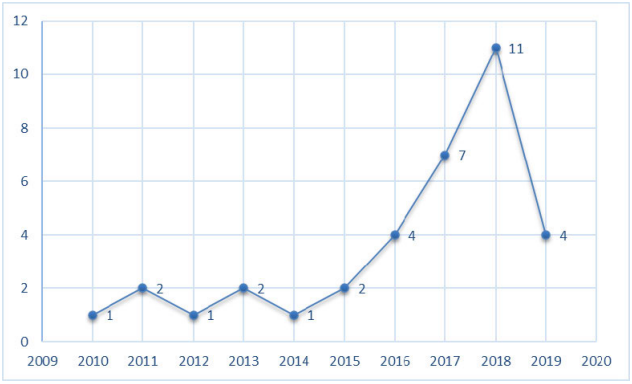

FIGURE 5. Publications per year. The figure includes line graphs showing number of publications returned by search and publications that met the inclusion criteria (2010-2019 period).

We have observed that GM is being applied more among the methodologies mapped in this study, that its use ranges from basic education to graduation and it is present in 74% of the analyzed publications that use GM as an AM in teaching. Following, PBL methodology appears in 4 surveys, i.e., about 11%. Finally, the TBL, PI, FC and ProjBL methodologies are mentioned each in only 1 survey, i.e., about 2.80% of the analyzed publications.

The results presented above show us that, among the most significant and applied AM as teaching strategies in the computation, we can find GM and PBL. However, a few applications in the classroom were also using FC, PI, TBL and ProjBL. This scenario demonstrates that the use of those teaching methodologies, as teaching strategies in computing, can be seen as effective teaching methods, as they support the stimulation of the students' initiative to create opportunities for learning content inside and outside the classroom, because AM can promote proactivity, commitment to the educational process and linking learning to significant aspects of reality [48].

In additional, we also have analyzed the distribution of publications per year (Fig. 5). The interest of investigations on topic of AM as teaching strategies in computing has began around 2010 with 1 publication. In the following years, from 2010 to 2015, publications remained stable, 1 or 2 paper per year. But, in 2016 and 2017 the number of publications has increased up to 4 and 7, respectively. 2018 confirms that evolution becoming the year in which most researches were publishing on that subject, 11 in total. But in 2019, that number fell again, just 4 publications.

However, we have considered an incipient number of publications for whom that applied of AM, supported by the principle of autonomy into the classroom, becomes of vital importance due to impact they can have on students' learning [49]. Also, AM have numerous forms of use for teaching and learning the computing courses. Furthermore, the applying of AM can favor the autonomy of the students both in face-to-face and distance education, favoring curiosity, stimulating individual and collective decision making, arising from activities of social practice and of students' contexts [50]. Therefore, AM emerges as a proposal to focus on the process of teaching and learning in the search for the

TABLE 5. Students' perceptions about AM.

AM	Students' Perception	Reference
ProjBL, PBL, TBL and PI	Developed confidence and interest in learning the contents.	1
ProjBL and PBL	Developed skills and experience in carrying out projects with execution efficiently.	1
GM, FC, and PI	Improve academic performance and, consequently, increasing programming skills.	1
FC	Represented a significant improvement in the group's performance.	1
PBL	Most students managed to learn the new concepts.	3
	Best comprehension and facilitated learning even for students inexperienced in programming.	2
	Focused on learning, being motivated to study, and learn the content provided. Students seem to have more desire to learn.	2
	Realized the importance of their own commitment, started to value the engagement of the team and collective practices.	1
GM	Learned basic programming concepts and developed logical-mathematical reasoning. There was a significant gain in learning the contents.	4
	Aroused great interest in the students remained engaged in their goals until the end of the activity.	2
	Stimulated by the new methodology, many students continued to attend the course.	3
	They had a pleasant experience and they managed to learn the proposed content.	2
	Students cited the game's ability to teach programming in a fun way.	2
	The students started to perform activities in the middle of the weekend, so they surprised, and this showed the degree of involvement provided by the game.	3
	Students assessed the gamified course more motivating than a non-gamified course and considered the practice interesting for learning.	4
	They wanted to learn more about the topic and noted that there was no difficulty in understanding. They were able to associate it with content already learned and that the level of complexity was adequate. The majority agreed that they learned surprising or unexpected concepts.	2
	Participating in the proposed activities, students experience and carry out exercises that allowed them to verify their speed and practicality in performing them.	2
	Provided a positive experience for players regarding social interaction and fun. In addition, students pointed out that the experience with the game will contribute to their performance in professional life.	
	Understanding about collaborative activity carried out by teams of students, considered the practice interesting for learning. It influenced them to study, so that the goals and activities could be fulfilled, which allowed them to advance in the game by their own effort.	3
	Learned and remembered the concepts of project management, because allowed students to fix the subjects better understanding the way of creating the missions, testing, and consequently improving the applicability of techniques.	2

active participation of all involved, centered on the reality in which they are inserted [51].

Thereby, that scenario shows combination of learning by challenges, the use of real problems and the games with the flipped classroom allow students to learn by doing, together and at their own place [41]. At the same time, teacher acts as an advisor, supervisor, and facilitator of the learning process, not only as the sole source of information and knowledge [45]. Thus, AM are teaching strategies centered on the effective participation of students in the construction of the learning process, in a flexible, interconnected and hybrid way [17].

B. STUDENTS' PERCEPTION ABOUT ACTIVE METHODOLOGIES IN TEACHING COMPUTING

RQ2. Which are the students' perceptions about the AM applied in teaching?

Table 5 shows AM applied and description in relation to students' perception; there were feeling of Satisfaction in learning the content, Motivation to learn content, and Feeling of mastery of content. Those results have indicated, in general, that the students' perceptions were positives regarding AM applied as strategy in teaching, i.e. AM enable greater interaction between teachers and students, benefiting both. Students acquire greater protagonism and independence in teaching and learning process. Teachers have a great opportunity to innovate, to propose new ways to teach and to stimulate their students [42], but it is necessary their full commitment with all process. It is required from them to be aware of their role in order to achieve successful results, also need to actively practice the directions proposed by that type of methodology. So it can be seen as liberating for both in the sense of leaving the traditional forms of teaching and learning in favor of a new way to enhance the productive involvement of the teacher and the consequent active and innovative learning of the students.

The informations obtained from this mapping have made possible to identify the students' perceptions aroused with the use of different types of AM, enabling teachers to identify pedagogical practices that most attract student's participation. Because, reflecting on education in the contemporary context, includes, among other important aspects, the discussion on AM produced in a collaborative way and its implications for the experiences of students in the classroom [17].

We have considered that, from those three dimensions, the students' perspectives presented in some publications, in general, can support the construction of knowledge in order to monitor and to measure the data related to the acquisition and development of knowledge, skills and attitudes achieved by students, according to the research goals in question.

TABLE 6. Dimension of students' perception.

Dimensions in relation to students' perception	AM	Reference
Satisfaction in learning the content	GM, ProjBL, PBL, FC, PI and TBL	23
Motivation to learn content	GM, ProjBL, PBL, FC, PI and TBL	22
Feeling of mastery of content	GM, ProjBL, PBL, PI and TBL	11

Also, many teachers imagine that all learning, including expository class, is inherently active. They consider that, while the students participates watching an expository class, they are actively involved, but cognitive science researches has indicated that students must do more than simply listen for an effective learning [18].

Therefore, from the adoption of active teaching methodological practices combined with Digital Information and Communication Technologies (TDICs), inherent to the CS, today's teacher and future teachers can make teaching and learning process more attractive to the eyes of students [52] and, for that, it is possible to use the AM as teaching strategies in computing new didactic methods seeking to combine the use of technologies, pedagogical knowledge and the different types of AM that currently exist for teaching.

Table 6 has mapping results organized in dimension identified to reply research question RQ 2. Not all articles explicitly have presented the students' perceptions regarding the applying of AM. Thus, some perceptions presented are based on the researchers' observations made during their field research. It can be observed when in some publications survey were used to learn about the acceptance and the applying of AM to learn the content. It was possible to identify three dimensions in relation to students' perception presented in those publications: a) Satisfaction in learning the proposed content: concerns the perception of the students about his learning of the concepts treated in the teaching of the subject's contents appears in 23 publication (65%); b) Motivation to learn the content: it is related to the students' perception of will and searches to learn even more about the concepts treated in the teaching of the subject's contents and it was observed in 22 publication (62%); and c) Feeling of mastery in relation to the proposed content: this perception is related to the ability to practice activities outside the classroom, to teach or share the content learned with colleagues and was notice in 11 papers (31%).

The new generation of students from the end of the 20th century seems not to be interested in attending a class in the same way every day [52]. Originally, the active method of learning works with the child's experience, so the teacher could support his students to reflect and encourage him to make decisions [53]. To understand the students' perceptions about the AM applied in teaching, we have applied different technical or studies to obtain the results presented.

TABLE 7. Technical or studies used per methodology.

Technical or Studies Used	AM	Reference
Online tool and survey	GM and PBL	6
Survey	GM	4
Survey and Game	GM	4
Computer tool	PBL and GM	2
Case study	PBL and GM	2
Case study and survey	PBL	2
Survey and framework	GM	1
Survey, online tool, and game	GM	1
Survey, online tool, and WhatsApp	FC	1
Survey and computer tool	GM	1
Case study and tool	PBL	1
Case study, survey, and game	GM	1
Framework	GM	1
Survey, framework, and online tool	GM	1
Game and interview	GM	1
Online tool and manual game	GM	1
Survey and manual game	GM	1
Survey and online course	ProjBL	1
Online tool	GM	1
Survey and game	GM	1
Survey, workshop, and focus group	GM	1

We can observe in mapping results that some researches have used more than one different technical or study to AM apply. Table 7 presents that scenario mapped.

It shows us that most of the researches have used the following technical or studies to get and analyze the perceptions of students: Survey, Online Tool, Games, Case Study, Framework, Manual Game, Computer Tool, Online Course, Focus Group, Interview, Workshop and Software. We have observed that most researches have used survey technical to gathering information about students' perspectives. In general, the goals was to explore the perception of students in the CS in order to analyze improvements, or the lack of it, in learning, according to different active teaching methodologies that have been used and in order to stimulate the knowledge skills of the studied contents.

Thus, we have noticed that survey, online tools, games, and case study were technical or studies most used by researchers. Also, those technical or studies were used together with others on most researchers analyzed, i.e. researchers as Oliveira & Barros [54] that applied the case study, game, and survey to get data about students' perceptions. In this sense, interview, focus group, workshop and online tools, online course, manual game, framework software and use of WhatsApp were combined with those technical or studies to understand the students' perceptions about the AM applied in teaching, presented in Table 7.

Thereby, the use of those techniques reflects the interest of the author to know how the students' perceptions about the AM applied in teaching of computing courses

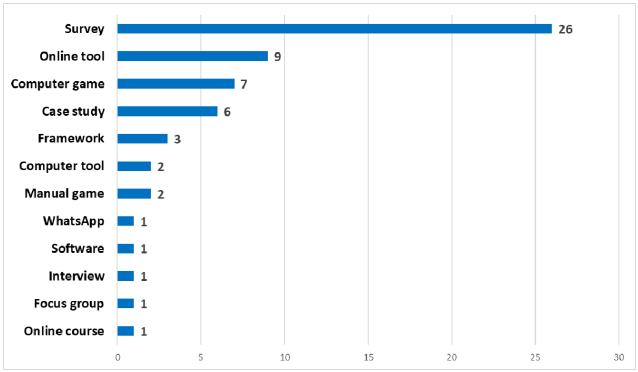

FIGURE 6. Type of technical or studies used in research. Bars graph showing the number of technical that used to apply AM. In increasing order: Online course, Focus group, Interview, Software, WhatsApp, Manual game, Computer tool, Framework, Case study, Computer game, Online tool, and Survey.

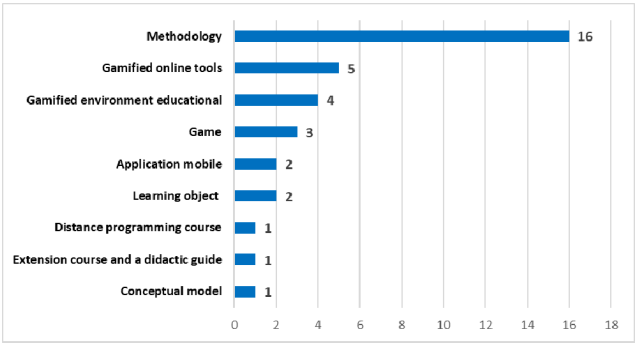

FIGURE 7. Proposals de studies mapping. Bars graph showing the type and number of proposals of studies that used to apply AM. In increasing order: Conceptual model, Extension course and a didactic guide, Distance programming course, Learning object, Application mobile, Game, Gamified environment educational, Gamified online tools, and Methodology.

could better support the learning process and could motivate researches to produce knowledge about process of teaching. Also, it becomes an important way to provide different and new ways of getting experiences in computing. So, in this context, it can be seen that most of the researchers have applied AM in teaching to instigate the students to participate in the class, through group works or discussion of problems. Those type of methodologies, as Lovato *et al.* [18] points, are those that place students as protagonists, while the teachers are mediators or facilitators of the process.

Fig. 6 shows some scenario about number of publications by type of technique or study used on the researchers analyzed. In relation of survey, this technical appears in 26 of publications. In sequence, the most used were online tools in 9 publications, the computer games in 7, and case study in 6 researches. The techniques or studies less used were the framework in 3, manual game and computer tool appears in 2 publications, while the others were, in general, used just one per each publication.

We observed that those techniques or studies have been used in education as a form to know different types of knowledge and to promote a critical, creative, and reflective attitude concerning to adoption of AM strategy in computer science. Because, the technological evolution that we are witnessing today brings challenges on the reality of education and so it points to need for changes that allows a redirection capable of answering those challenges and improve the skills of the new generations of students, since their educational beginning, allowing them to develop knowledge and skills for a future in which technology undergoes continuous developments [14].

Fig. 7 presents the distribution of publications per proposal presented by the research. We have noticed that between those proposals analyzed are commonly presented in works that seek to analyze students' school performance and as well as improve teaching and learning process. Also, those proposals seek to provide experience in the use of gamified on-line tools, to support teaching and learning in the most diverse course of computing area. They also seek to start the stimulation of computational thinking through a gamified application and to motivate students to practice some introductory content in the area of computing in a fun way.

Table 8 shows the mains courses worked on those research analyzed. It may reflect, in general, two propositions regarding traditional methodologies in computing: (i) those courses are more difficult to learn; and (ii) they are more difficult to teach using traditional methodologies. In any case, we can infer that those researchers were looking for solutions to problems that are evident, and we understand that this problem is not an exception. Therefore, the courses presented above can reflect the research' interest and necessity in knowing how AM can be used like teaching strategies centered on effective participation both the teacher and the students. Thus, on non-collaborative processes, teachers have more roles to perform, as work is controlled and organized by them, while in the collaborative process it is more opened and students become more active [55].

Thereby, it might help students to acquire autonomy over their interests and skills, motivating them to search and to research on the topics brought by contents. In short, they might realize that is worth learning [56], because with the appearance of the so-called AM of learning, the students becomes the protagonist and the use of this type of methodology allows the development of new skills, such as initiative, creativity, criticality reflective, capacity for self-assessment and cooperation to work as a team; and the teacher acts as an advisor, supervisor, and facilitator of the process [18], being necessary for this sense observing the different learning processes.

In this scenario, observing and evaluating the students' perception of his or her learning while AM are adopted as teaching strategies is not a trivial task. However, the literature shows that several studies are being carried out in order to analyze the potential of AM for learning [49], [52] or to facilitate retention of knowledge by students [18], [57]. Nevertheless, so far, there are few studies that aim to evaluate students' experiences in relation to active teaching methodologies [58]. Also, we have noticed that it is necessary, due to the similarities between some active methodologies, to give

TABLE 8. Courses worked in analyzed publications.

AM	Course	Reference
ProjBL, PBL, TBL and PI	Computer programming	1
ProjBL and PBL	Software testing	1
	Computer programming	1
GM, FC, and PI	Project management	1
	Computer programming	1
FC	Computer network	1
PBL	Programming logic	1
	Software engineering	1
	Troubleshooting I	1
	Computer programming	2
GM	Algorithms	2
	Data base	1
	Data structure	1
	Project management	1
	Introduction of informatics	1
	Introduction of programming	2
	Programming logic	4
	Scientific methodology	1
	Computer programming	9
	Free and proprietary software	1
	Theory of graphs	1
	Software testing	1

support for teachers on some type of learning. It is so because, in general, various AM were applied on those articles analyzed, however, in the course of this research, we have faced a lack of classification that could clearly present the use of AM in relation to the categorization of types of learning.

Thus, we have reached a conclusion that the interest in knowing the students' perception in this mapping of the literature can be very useful in different aspects regarding teaching and learning process. For example, it may be possible to know if some students need additional help to understand the information explained in the classroom or even to promote the intuition of means to help those students in their presented difficulty. Each study here analyzed has presented students' perceptions in different ways, i.e. they did not clearly show types of perception of the students regarding percentage of acceptance in relation to the applying of AM in the classroom. So, we think that is important present one classification that could help following researches and teachers that are interested on applying such methodology.

Therefore, considering the course of the computer science organized in three different fields, following the Reference Curriculum for Undergraduate Courses in Computing and Informatics by Brazilian Computer Society (SBC): I) Computability Fundaments (CF), which comprises the core of subjects that involve scientific parts and the fundamental techniques for the solid formation of the various computer program; II) Computing Technology (CT), which comprises the core of the course and represents a set of aggregated and consolidated knowledge that enable students to develop solving problems in the various application domains; and III) Information Systems (IS), which comprises the core of the course that enables students to use the resources of Information Technology in solving problems of productive sectors of society.

Table 9 presents the AM used per field of computing area in relation to the course worked on the researches analyzed in this paper. Therefore, it reflects, generally, that the GM and PBL were types of AM more used in three different area of computing. Thus, those types of AM can provide positives students' perception in relation of learning of course, because learning is most effective when it is active, experiential, situated, problem-based and provides immediate feedback [59]. Also, this research demonstrates that students engagement in course remains mixed, because, the GM and PBL were used in tree field of computing area and they are often put forth as a possible answer to change the teaching and learning landscape and to make it more attractive and interactive for students. Those types of AM, generally, can support students in relation of learning, because our results show that students' motivation and engagement is positively related to use of different AM in course.

TABLE 9. Computing area and active methodology applied.

Computing area	AM
Computability Fundaments	GM, PBL, ProjBL, TBL and PI
Computing Technology	GM, PBL and FC
Information Systems	GM, PI, ProjBL and PBL

ProjBL and PI are the types of AM most used to teach in the fields of IS and CF. It might means that teacher has to adapt his/her programming languages or programming technique, because the quality of the teaching is partly dependent on the teacher's competence in using the technology [12], and this type of course requires some changes in the teachers' teaching methods and different approaches in order to motivate and to engage students in program. ProjBL and PI are most used both in IS and CF. FC and TBL are most used only in CF. It might mean that teacher needs to actively learn how to work with different AM and has to get opportunities to try things out and to evaluates outcomes taking students' perceptions as basis, because courses of CF are core of CS learning.

So, to deal with the needs for more significant learning in CS, those types of AM can be developed and provide a richer engaging learning experience for teachers and students. Those methodologies can motivate processes of teaching and learning in different courses, because those methodologies might stimulate and engage all people involved in this process of teaching and learning. Also, it agrees with education literatures when they address AM like a set of processes, procedures, techniques, and tools that involve the students actively in the teaching and learning process.

TABLE 10. Benefits in relation to the adoption of AM.

AM	Description	Reference
ProjBL, PBL, TBL and PI	Improved students' confidence, encouraging them to seek answers to their questions on their own.	1
ProjBL and PBL	Integrated practice of different course. Development of high level social and cognitive skills.	1
GM, FC, and PI	Reconcile theory and practice and turn activities into meaningful learning.	1
	Significant increase in students' averages. The failure rate dropped. The approval rating has increased.	1
	Significant improvement in group performance, significant increase in the average.	1
PBL	Recognition of the importance of collective practices in their formation. Stimulated self-assessment in relation to their own involvement in teamwork and the involvement of other colleagues. Greater approximation between theory and practice.	2
	It stimulated programming skills such as comprehension, analysis, observation of details, sequencing, and abstraction.	1
	The increased sense of responsibility of the students, who obtained engagement and course to study the contents related to the context of the problem, better understanding the situation presented; encouraging reading, the use of logical reasoning and discussions; encouraging more detailed and in-depth investigation of the problem presented.	1
	It allowed students having a vision of how the practical experience in a real project helps the team to have a better understanding of the theories, practices, methods, processes, and tools that involve Software Engineering. Make classes dynamic and attractive; and created an environment of cooperation between students. Encouragement of proactivity in the search for knowledge, confidence in your skills and that of your peers, commitment to solving tasks, teamwork, strategic thinking, and resilience in the face of difficult tasks.	1
GM	Make classes dynamic and attractive; and created an environment of cooperation between students, serving as a stimulus for their integral development. Encouragement of proactivity in the search for knowledge, confidence in your skills and that of your peers, commitment to solving tasks, teamwork, strategic thinking, and resilience in the face of difficult tasks.	4
	Caused a decrease in any interaction resistance. It provoked greater interest in the students, when it was evidenced that they felt stimulated to obtain a good performance. Position the students (player) in the role of a researcher involved in a rich narrative, thus simulating the activities that he should perform in his studies.	2
	Aroused creativity and the ability to think and act in a favorable condition in the conduct of computer studies, making the learning process more attractive and interactive, understood as an important tool to support teachers in school education.	2
	Considerable drop in the number of failing students. Improvement in students' performance in the course. Minimized the students' difficulties in relation to the difficulty in learning computer programming. It motivates students' interaction, and engagement to carry out the activities.	3
	Great impact on students' participation and development levels. Increase in attendance to classes. Improved students learning outcomes. Significant impact on classroom participation, and evidence that attention to support material and learning outcomes may benefit.	2
	It brought together several elements and references, such as board, cards, characters, and obstacles, in a simple system that adheres to the reality of the classrooms. The students developed five PC-related skills: data analysis skills, data collection skills, decomposition, abstraction, and data representation.	6
	Motivated the study of computer programming at the levels: basic knowledge of programming and basic concepts and assessment of the ability to read codes. Positive influenced on using gamification, engagement techniques to achieve the educational goals required to learn programming.	2
	Competitiveness influences students' motivation to learn and overcome challenges. It provides the students with learning in a playful and enjoyable way; makes it possible to relate scientific and abstract concepts with familiar terms, with the students' reality.	2
	Reduction in the number of failures in the courses.	3

C. BENEFITS AND DIFFICULTIES IN RELATION TO ADOPTION ACTIVE METHODOLOGIES IN TEACHING OF COMPUTING

RQ3: Which are the benefits and difficulties in relation to the adoption of AM?

We have observed the most studies, in general, obtained benefits when they adopted GM as an AM for teaching, see Table 10. However, they also reflects difficulties (see Table 11), caused by the lack of commitment of students outside the classroom. Thereby, we have chosen to present those reports in relation to the benefits and difficulties presented in the texts of the publications. In general, it can support the use or adequacy of new teaching techniques applying AM, in addition to sharing the related benefits and difficulties in order to direct new practices.

Attracting students' attention and keeping them involved are essential points for the process of learning and developing critical thinking. Teacher plays a role as an activator of learning [49]. Therefore, the adoption of this type of methodology for teaching in computing will certainly bring benefits for both students and teachers.

In the scenario presented by Table 10, we have understood that it is possible to infer that there is a positive influence on teaching and learning process in relation to the use of AM in CS courses. For example, GM, according to the analyzed works, is an engagement technique for achieve the educational goals required to learn programming. However, we also have observed that even with the positive influence of the use of AM as teaching strategies, there were yet difficulties (see Table 11), mainly in relation to the students' awareness

TABLE 11. Difficulty in relation to the adoption of AM.

AM	Description	Reference
ProjBL, PBL, TBL and PI	Lack of motivation and difficulties in understanding the content.	1
	Difficulty in motivating and mobilizing the attention of students. They can't obtain a broader view of the acquired concepts and establish a connection between theory and practice with greater effectiveness.	1
ProjBL and PBL	Not all students were able to acquire the skills in a timely manner to apply these concepts in solving the problem. Some students, when finishing a problem without completing all the requirements, had difficulties in continuing the same project in the subsequent problem. Finally, this change brought some difficulties in learning, the accumulation of deficiencies in projects of longer duration and the cognitive overload in dealing with several concepts simultaneously.	1
GM, FC, and PI	Lack of motivation of students to carry out practical activities. Lack of commitment on the part of some students, who insist on not studying the content before the class (face-to-face meeting), thus promoting a lesser use in the course.	1
FC	Leave the comfort zone, access the platform, and frequently participate in the flexible study environment available. Make students aware of how to access and participate frequently in the available materials, as students do not have the habit of accessing the study station or actively participating in face-to-face meetings.	1
	The course duration was considered insufficient for all the suggested activities to be completed comfortably.	2
	Difficulties of students with solving problems involving programming. Difficulties were also evidenced with basic questions about computer network theories. In autonomous studies, we observed difficulties for students to study alone, as it was a new practice for most.	1
PBL	Many academics have difficulties in positioning themselves in front of colleagues and tutors to expose their work and answer questions. Also, some aspects related to the programming and operation of the computer and difficulties in relation to technical issues.	2
	Identify which students are really engaged in the tasks and which are collaborating with the team, since simply sharing tasks does not represent group work.	1
GM	Low understanding of the basics in programing; a weak mathematical base; the lack of understanding of the statements; exercises dissociated from "real" problems and little extra-class availability for studies.	6
	Difficulties in coding, due to the lack of programming logic base, presenting a great deficit of basic technical knowledge necessary for the good progress of the course. Lack of basic prior knowledge to study data structure. Little time available for studies.	4
	The lack of motivation of students and their difficulty in maintaining a continuous pace of study.	5
	Large classes, which make it impossible to carry out individualized monitoring and heterogeneous, which present disparity of knowledge and learning pace.	1
	Diversity of students learning rhythms, combined with large classes and lack of motivation.	1
	The workload required to keep the rankings and the site up to date, as two different platforms are being used to present and correct challenges.	1
	The need for faculty involvement and collaboration for the success of gamification and the right time for its application. In addition, achieving an appropriate balance between education and entertainment.	1
	Ensure the motivational factor of students. Mentality based on the repetition and memorization of concepts and content, without the concern of abstracting the knowledge acquired in solving problems.	3
	Lack of infrastructure and, in some cases, difficulties in applying non-traditional teaching methodologies due to students' cultural issues, awakening in teachers the need to use new technologies.	2

about importance of their self-studies organization and their autonomy, especially when adopted a technique in which teacher acts just presenting a problem and students should acting looking for solutions.

Table 11 shows difficulties presented by teachers. In general, those difficulties were related to use new teaching techniques. It is important to mention that those difficulties are not linked only to students' awareness of the importance of their studies, i. e., the difficulties involved, range from the structures available for teaching to the behavior of the teaching staff facing the *new* need to adopt different methodologies for more effective teaching. Thereby, it is necessary to know the method that can fulfill the needs of educational institutions in which the teacher operates, whether in basic education, high school, undergraduate and among others [60]. Because, within education, it is necessary to debate whether or not learning improves when students are allowed to explore the educational content by themselves or if students must be strictly guided in the topics to be learned. On the other hand, in classroom environments, teachers present students choices because they believe it increases effort and learning [61].

Those result have demonstrated that most researchers have found different benefits in relation to the AM. It is important to mention that not all publications clearly show the items benefits or difficulties. However, they present the results achieved and the difficulties faced in conducting their researches. Thereby, we can infer that the use of different AM positively influences the teaching because, in general way, it addresses different techniques for teaching,, and it addresses new activities and new engagement techniques required to achieve educational goals in learning different CS courses.

Therefore, AM have produced positive results for students in relation to learning and, for teachers, in relation to teaching practices, because, as Michaelsen have pointed [62], it forces students to break with their passivity. Considering the benefits presented in the analyzed publications, some advantages could be: (i) developing students' skills at a high level; (ii) promoting the development of personal and team skills; and (iii) also bringing advantages to the teacher, such as enthusiasm them in the classroom and career continuity as pointed by Guimarães *et al.* [52]. Those results are very

important, because in the 20th century, education is a consequence of a process that involves several thinkers, who discuss teaching models and highlight the need for students' autonomy [18].

Finally, notably, all those researches also confirm a need for reflection about our traditional teaching practices and the adoption of AM applied in teaching and learning course on computing area. Because, according to the words of Vanbecelaere *et al.* [59] ''learning is most effective when it is active, experiential, situated, problem-based and provides immediate feedback''. So, without any doubts, technology has found its way into many classrooms around the world to help educational process to be more effective and enjoyable. Despite the great potential may technology have for facilitating and promoting students learning, teachers are also challenged to not only familiarize themselves with those technologies but to put it in practice as well [63].

V. THREATS TO VALIDITY

We believe that some limitations of this study can be related to publication, selection bias, inaccuracy in data extraction and erroneous classification. For Kitchenham & Charters [20], limitations related to publication bias refers to the problem that positive results are more likely to be published than negatives, because negative results take longer to be published or are mentioned in other publications to a lesser extent. In order to reduce that obstacle, as much as possible, we have done search on symposium, conference proceedings and journals in which the most relevant studies to the Computer and Education area are published frequently: Brazilian Symposium on Informatics in Education, Brazilian Symposium on Games and Digital, Entertainment, Computer Workshop at School, Computer Education Workshop, New Technologies in Education Magazine, Journal of Informatics in Education, International Congress of Educational Informatics and Scopus Library. This last platform is a digital library that is frequently used for researchers for access to relevant journals related to the same subject that we have been studying here. However, we did not consider other sources such as searching on conference bases or workshops that may affect, somehow, the validity of our results.

The bias that refers to the selection of publications is related to distortions that could happened in a statistical analysis due to the criteria used to select publications. In order to mitigate that threat, we have used the inclusion criteria to gather the largest possible number of publications that fit the AM as being applied in the teaching and learning activities of course of computing area, as well as the criteria for the exclusion of articles that did not present the necessary information related to this study. So, we have elaborated a SMS and validated it with other professionals of the areas with recognized experience in the conduction of that kind of work. We also have detected other limitations that could bring some problems to the results of this work and that are related to the systematic of procedure in carrying out this study. Thus, analyzing our main goals in relation to the accomplishment of this SMS, we have decided to categorize the selected publications and to identify representative studies instead of carrying out tests of validations on the results achieved by those authors. Besides that, we also have included on our mapping others specific questions, such as, regarding methodologies, technical or studies used, and this may have affected our results.

VI. CONCLUSION

This paper have presented a SMS that summarizes existing information regarding types of AM being applied in teaching and learning activities in CS courses. From an initial number of 753 papers, a total of 35 were selected for carrying out the mapping study. And the results obtained have allowed us to extract some conclusions regarding the state-of-the-art in the area, to identify several research gaps, and to extract some guidelines for innovative directions in computing education. Moreover, the application of a well-defined review protocol will also allow us to efficiently update and extend the SMS in future years.

As a result, our analyses have revealed or presented the following significant findings: a) an overview of the active methodologies applied to teach in computation that shows a variety of 6 types of AM; b) the AM used per field of computing area in relation to students' perception; c) different types of technical or studies used in research; d) and some benefits and difficulties in relation to the adoption of AM to teaching. According to those findings, we suggest that this review can greatly help and inform about the use of AM in the teaching and learning computing. Our review has showed a variety of AM that have been used and have identified the most common ones. It also has provided an overview of the methods used when validating the corresponding active methodology applied. In recent years, a great number of AM has been used as techniques for teaching in computing. However, in the current existing mapping studies, the perceptions of students have been forgotten. So, we have joined our mapping of both teachers' and students' points of view.

Finally, we expect that AM used in teaching computing in this review could also be effective in solving problems in other areas that share similar characteristics about learning difficulty, practice, and content abstraction students. Thus, it might allow teachers to experience the consequences of different methodologies choices as powerful approach to promote engagement, motivation, empathy, awareness, and constructive behavior for students. Also, we have highlighted the importance of continuing this research, such as those analyzed about mapping, in order to increase and to offer more consistent bibliography, both qualitative and quantitative data. That way, our research could sensibly allows the measurement and validation of the applicability of the AM as a strategic tool for teaching different contents in different course on computing or other areas.

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