Active Methodologies in Incoming Programming Classes

João Paulo Aires
Departamento Acadêmico de Computação (DAINF),
Federal University of Technology of Paraná (UTFPR), Brasil

Simone Bello Kaminski Aires
Departamento Acadêmico de Computação (DAINF),
Federal University of Technology of Paraná (UTFPR), Brasil

Maria João Varanda Pereira
Research Centre in Digitalization and Intelligent Robotics (CeDRI),
Polytechnic Institute of Bragança, Portugal

Luís M. Alves[1]
Research Centre in Digitalization and Intelligent Robotics (CeDRI),
Polytechnic Institute of Bragança, Portugal

Abstract

Innovative approaches in teaching programming have been required to improve the success of incoming programming students. This work presents the initial results of a teaching strategy implemented in the Algorithms subject of a Computer Science course. Ninety-five students, enrolled in this subject during the first semester of the course, participated in the research. The reported activity is related with active methodologies of teaching and Problem-Based Learning, being developed on the first day of class in groups of up to five students. The activity was based in two actions: 1) answering a questionnaire associating computing elements to daily life routines; and, 2) even without programming concepts knowledge, develop a smartphone application. Each group received a questionnaire containing 19 questions, divided into four blocks. What can be perceived with the accomplishment of this work, was the enthusiasm, motivation and engagement of the students who, even being unknown from each other, organized themselves in the groups and researched the necessary strategies to complete the challenge. The teacher acted as an advisor in the teaching process, conducting the experiment in order to lead students to find the solution.

2012 ACM Subject Classification Social and professional topics → Computer science education; Software and its engineering → Imperative languages

Keywords and phrases Teaching Programming, Active Methodologies, Learning Innovation

Digital Object Identifier 10.4230/OASIcs.ICPEC.2021.8

Category Short Paper

Funding This work has been supported by FCT - Fundação para a Ciência e Tecnologia within the Projects Scopes: UIDB/05757/2020 and UIDB/00319/2020.

1 Introduction

Nowadays there are countless advances that strengthen the educational environment [2] and, among them, two factors stand out: science and technology. Complementarily, Aires and Pilatti [2] emphasize that it is essential at all levels of education (from basic education to postgraduate), to have two fundamental elements: 1) people enthusiastic in the transformation of educational processes; 2) school/university management combined with community

[1] to mark corresponding author

Second International Computer Programming Education Conference (ICPEC 2021).
Editors: Pedro Rangel Henriques, Filipe Portela, Ricardo Queirós, and Alberto Simões; Article No. 8; pp. 8:1–8:9
OpenAccess Series in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

interests. Studies indicate that students' demotivation and the consequent failure rate in undergraduate courses is associated with factors inside and outside the classroom [11, 12], highlighting: the efficiency of the teaching methodology used by the teacher; the immaturity of many students when entering higher education; and, the previous knowledge brought by the student and that can favor a meaningful learning [11, 12, 22].

Thus, for a successful learning, it is necessary that both the student and the teacher apply differentiated teaching methods and that they deem appropriate, in order to promote the absorption of content in an appropriate way [1]. In view of this scenario, with the objective of promoting student engagement and motivation, and consequently expanding the use of the contents worked on, we sought to apply a teaching and learning methodology based on problems. This methodology was used on the first day of class in the subject of Algorithms in an undergraduate course in Computing.

The subject of Algorithms, which has a workload of 90 hours, belongs to the first semester of the course and aims to introduce the student to the universe of programming and the problem solving. The syllabus of this subject contains the introduction to variables, data types, conditional and cyclic structures and manipulation of homogeneous data structures (unidimensional and multidimensional). Since it is a discipline that has historically a high failure rate and student dropout, it is necessary to use teaching strategies that facilitate the learning of content, the motivation to attend the course and school success.

Regarding the activity described in this article, it should be noted that, because it is carried out on the first day, it does not contemplate or intend to contemplate all the basic programming contents, but will only serve as a motivation for the art of programming. In the initial approach of the task, the initial contents of the discipline are identified/explored, such as: assignment, input and output of data, types of data, variables, memory allocation. Problem solving is also addressed using conditional and repetitive structures, control variables and modularization. But all of this is addressed as the need arises to be discussed in order to solve the proposed problem.

The experiment described in this paper shows that an innovative approach can make the difference in terms of motivation level and dropout reduction in the first programming classes. It enhanced the integration of the students and the cooperation between classmates from the very first day of classes, through the formation of groups and discussion about the problem presented by the teacher. Such a problem makes a connection between the real world (common sense knowledge) and the discipline of initial programming. The main objective of the experiment was to get students to reflect on basic/elementary concepts of computing (such as: operating system, memory, processing, storage, data types, input and output, among others), which are present on their daily life, especially on their smartphones. It is important to say that, to carry out the activity, it was not necessary any previous knowledge about programming.

2 Active methodologies in the teaching and learning process

Active Teaching and Learning Methodologies can be understood as any teaching strategies aimed at promoting the effective participation of students in the organization and continuous construction of their learning in a flexible way, adaptable to each one and leading to meaningful learning [3, 4]. Such active methodologies favor the contact with new experiences for students, whether in interventions promoted by the teacher, or in discussions promoted with colleagues. Through them, the student, in an autonomous way, seeks the necessary elements for the consolidation of knowledge, contributing to his personal and professional life, because, in addition to strengthening his role, he improves the ability to face daily challenges. Additionally, Mitre et al. [18] argue that active methodologies should always use problematization, in order to challenge and motivate the student, since the problem allows the class to analyze the objectives, reflect on the hypotheses, relate the possible solutions and test/record the findings obtained. Learning through this strategy will allow maximum student involvement, acting actively as protagonist in the professional training process.

Finally, following Moran [19], active methodologies are based on the student as the center of learning, being associated in individual or group activities, participating in learning processes in a collaborative way and through the exchange of experiences.

According to Barseghian [6], Spricigo [21], Farias et al. [9], Mazur [15], Leal et al. [5], Silva, Sales and Castro [20], Larmer and Mergendoller [14], Hanney [13] and Bender [7] there are several strategies to be used in the classroom, especially: expository class dialogue; case study; Team-Based Learning (TBL); Problem-Based Learning (PBL); Project-Based Learning (PBL); peer instruction; flipped classroom; gamification. Studies by Mitre et al. [18], Barseghian[6], Berbel [8] point out that the use of active methodologies enables new experiences for the class, regardless of the content worked on. The student, on his own and knowing the real need for such action, seeks the new, and this initiative contributes greatly to becoming critical and reflective in his professional life, working on autonomy and the ability to face challenges. However, if on the one hand it is up to the student to seek additional concepts to solve a certain problem, on the other hand, the application of these strategies depends, essentially, on an effort by the teacher to reorganize the discipline aimed at given to the students the main role.

3 Methodology

This research work, which is under development, follows an exploratory approach, using a predominantly qualitative analysis of the problem. In relation to technical procedures, a survey was carried out, and the composition of the documentary corpus was based on questionnaires collected from students who participated in the project. The study was applied during two semesters (2019-2 and 2020-1), in the initial classes of the Algorithms discipline (taught to new students). 95 students participated (47 students in 2019 and 48 students in 2020), enrolled in the first period of the mentioned discipline. For the purposes of this study, we used the active Problem-Based Learning (PBL) methodology, which aims to place students facing a real problem, to be solved through the creation of working groups. In order to generate engagement and interest with the content of the discipline, the teacher uses the first class to present a problem related with something that is strongly familiar to all the students: the use of smartphones. The main functionalities of a smartphone are discussed with students, such as capturing photos, making video calls, editing e-mail, accessing social networks. Then a questionnaire is proposed to the students to reflect on internal features/characteristics of the device. In the questionnaire, students are invited to immerse/reflect on their smartphone. Many questions were asked based on the essential settings that are evaluated when someone is looking for a cell phone to buy. According to Felder and Brent [10], the tasks to be distributed to students must be organized in such a way as to be carried out in a short time, so as not to discourage the student from participating. Thus, the questionnaire (which contains 19 questions in total) was divided into four blocks/parts and can be viewed at `http://encurtador.com.br/krtHT`. Such activity was structured in such a way that the questions (however basic they may seem) were related to the world of computing, seeking a correlation with the real world and the initial contents of the programming discipline. Then, a challenge is launched to students: to develop an APP for smartphone. After the initial reflections and discussions, the strategy was composed by the following steps:

1. Presentation of the problem;
2. Possibility to develop the APP in a group or individually;
3. Without explaining about refined programming concepts, the class was asked to develop a smartphone application;
4. The development would follow some rules and should be carried out through MIT App Inventor [16];
5. The APP should be installed and tested on the smartphone;
6. Within a week, students present the developed applications.

To carry out the proposed activity as a challenge, the tool developed by MIT called App Inventor was used. The MIT App Inventor (available at `https://appinventor.mit.edu/`) is a block-based visual programming environment that allows even beginners to develop full (and fully functional) applications for Android devices. The platform does not require programming in any language, making the implementation of the features very intuitive using a process of *dragging* blocks of commands. As it is a visual environment, as the blocks are inserted (that is, some functionality is implemented) it is possible to visualize the change instantly, through the simulator attached to the platform. At the end of the implementation (and the tests carried out in the simulation), an .apk file can be created so that the application can be installed on the Android device. It is important to highlight that, despite not needing knowledge of programming languages, it is important to understand that the construction of thinking to solve the problem must be created step by step, from beginning to end, just as in an algorithm. Thus, when the teacher explains the general concept of Algorithm (finite sequence of steps, executed in a certain order), the student is already able to understand how the blocks should be organized, so that their application works properly.

Figure 1 shows steps 1 and 2 developed in the proposed methodology. Initially (step 1) the groups of students answer the questionnaire that relates functionalities contained in their smartphones with the functionalities of a computer. After discussing the questions proposed in the questionnaires, students are encouraged to develop an APP for their smartphones (step 2). The images presented in Figure 1 were extracted from the APPs developed by the students.

Figure 2 shows the Team 1 block program for the Calculator problem using App Inventor. As we can see, the pieces fit together forming a puzzle. Students have the possibility to learn programming logic in a playful and intuitive way. Access to a complete code, developed by the groups, is available at `http://encurtador.com.br/dfvV7`.

4 Discussion

The research activities developed in this experiment were based on active teaching and learning methodologies using groups with a maximum of five students. Since the students are new in the Computing Science Course, the research was conducted in order to careful choose the topics to be worked on, as well as the reasoning sequence (the steps) to obtain the desired learning results. Following Felder and Brent [10], the activity time cannot exceed 20 minutes because after that time the students will lost the focus. In this way, the questions were presented and discussed in four blocks containing four to six questions each. Each block of question is presented to the groups and, afterwards, a discussion is made with the whole class, collecting the answers obtained by the groups. It is important to note that some students participate more as listeners, when they are shy or have little knowledge about the subject. It is part of the teacher's task to form the groups, so that the challenges are developed collaboratively, with the participation of all. However, there is no way to

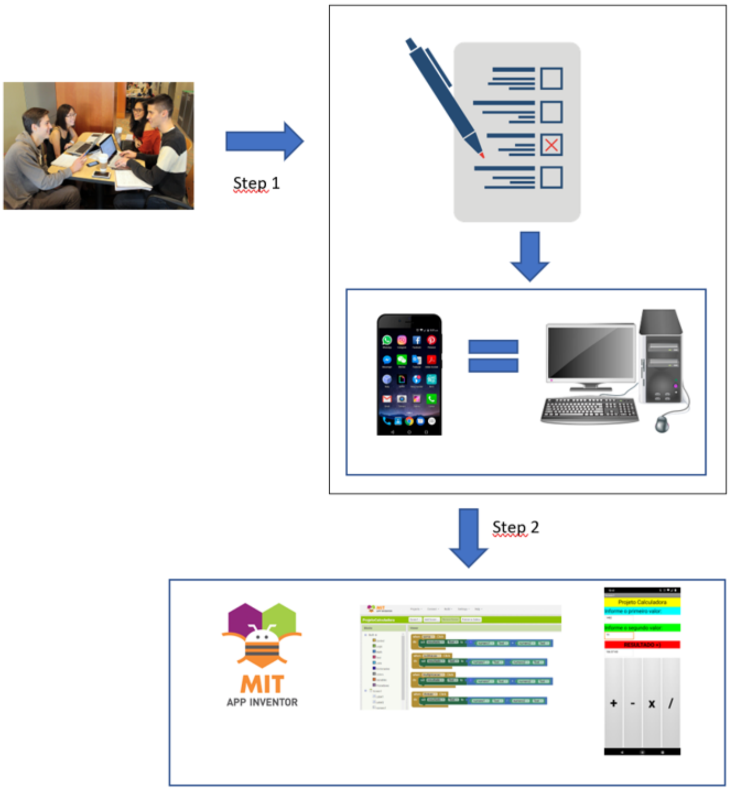

Figure 1 PBL - APP smartphone.

guarantee that this will happen at every stage of the process. For each block of questions, the applied dynamics occurs in two moments: initially, the groups meet, explore and discuss the presented questions and after ten minutes of discussion in the group, the debate expands with the whole class, in which each group presents its answers. At this moment, cooperation between groups was observed and, often, a group complements the answer of the previous one. It is up to the teacher to mediate/organize the answers presented and instigate cooperation between the groups and how the information can be complementary. Whenever necessary, the teacher must explain the content not understood or complete any important information that has not been observed by any group. Figure 3 shows the blocks of responses registered in different groups, taking into account the 19 questions made available in the class activity (responses from other groups, can be viewed at `http://encurtador.com.br/epvLP`). As pointed out in the methodology, the number of activities was dimensioned in order to avoid a low student involvement.

In Figure 3 can be seen that the answers follow the particularities of each group's smartphones. It is also observed that some groups recorded different information for the same question, due to the configuration of the devices of the group members. This was very interesting, as it demonstrates that they perceived the existence of different configurations, favoring them to carry out a more in-depth analysis, at the time of a future acquisition. When the problem is presented to the class, it is observed that students with improved knowledge asked if they can develop the APP using their previous knowledge in programming. On the other hand, students who have no experience about the programming, are apprehensive and scared, thinking about how to solve the task. At this point, it is up to the teacher to

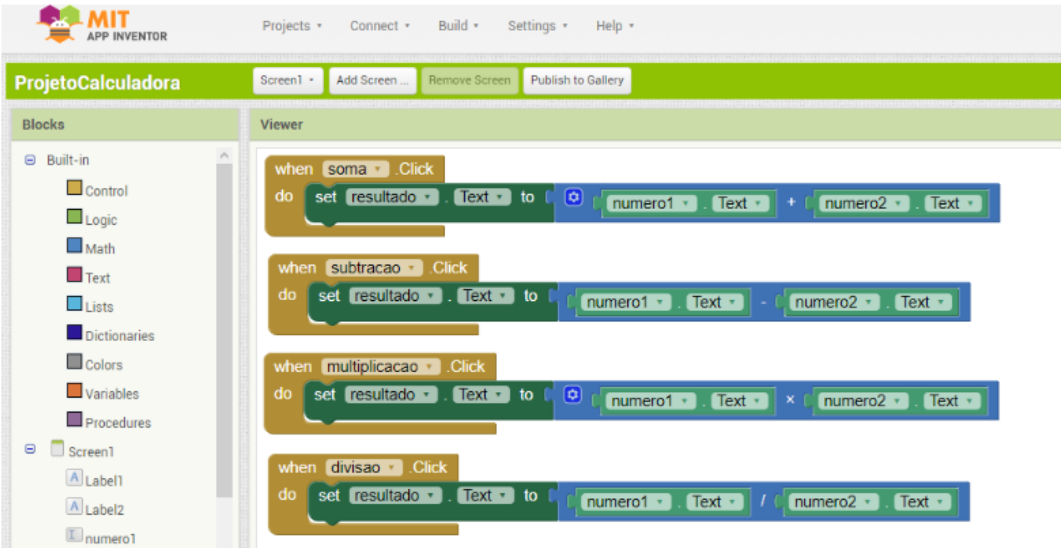

Figure 2 Team 1 block program for the Calculator problem.

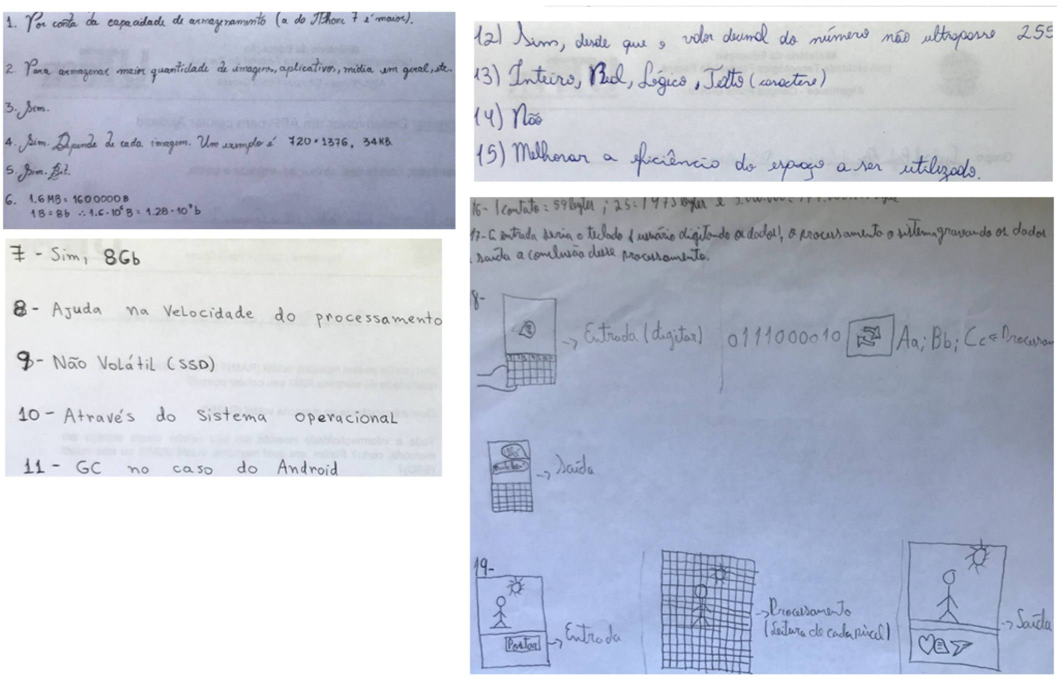

Figure 3 Answers from different groups.

Figure 4 Calculator.

present possibilities to solve the problem. Among them, the MIT App inventor platform (developed by MIT) is explained, in which it is possible to perform the task using only block programming (similar to what happens in Scratch [17]). The teacher's intervention, guiding and conducting the students, does not solve the problem by itself. It works just as a tutoring/orientation task, guiding the students research in order to autonomously reflect and develop the proposed problem. After the questionnaire discussions, students had two days to present the solution to the problem (the APP developed and working on the smartphone). The Figure 4 illustrates some of the application screens developed by the students, proving that all the groups found a solution to the proposed challenge. Note that it was possible to construct a big diversity of interfaces and different ideas had emerged without initially need to know a programming language.

The experience proved to be valid and interesting, due to the involvement level of the students, their integration in the groups, their motivation in the promoted discussions and the developed applications, thus the objective of the activity was accomplish. In addition, it should be noted that the anxiety and concern of students entering the course were overcome by the possibility of getting involved in a work group from the beginning. What at first was something that shocked them, because they imagined they were not able to accomplish it, generated additional motivation and dispute in the class, to see who could finish first. The exchange of the APP developed among students was observed, as well as others implemented by them on the same platform, which was possible with the experience and knowledge acquired in this activity.

In order to verify the understanding of the content worked on and the learning of the initial concepts of computing, an evaluation was carried out with the class using the Moodle Platform. The assessment contained 13 questions (10 of which were multiple choice and 3 descriptive) with the aim of verifying how each student would make the relationship between the problem studied and the concepts inserted in the proposed challenge. Some examples of those questions are:

1. Considering the questions discussed in the activity on cell phones, what questions/subjects brought you new knowledge?
2. In general, would you know how to explain the computer system you use when sending an e-mail? What would be the input(s), processing(s) and output(s)?
3. Who manages the memory space on the cell phone?

4. When we install an APP on our cell phone is it stored in non-volatile memory (SSD)?
5. Whenever I open an APP (for example: Instagram) it is loaded into the SSD memory?

The class consisted of 87 students and, of these, 67 answered the questionnaire applied, with an average grade of 7.7. Of the total responses, 56 students (84% of participants) scored higher than the university average (6.0 points) and 11 students (16%) scored lower but six of these ones scored between 5.1 and 5.8 (close to the average pass). Facing and analyzing the results obtained, it is possible to state that the strategy used in the classroom obtained positive results, since the students were able to relate the concepts addressed in the activity with the content necessary for the beginning of the discipline, since a good part of the class (84%) scored higher than the average required for approval.

5 Conclusion

When the students faced the problem to be solved (APP development for smartphone) they reacted with concern saying: *How can I develop an application if I never programmed?*, *How can I solve that?*, *How to start?*, *How to develop?*. However, after research and discussion with colleagues, the initial fear was replaced by the motivation to find the solution, develop the APP, install on the smartphone and see it working (just like any native APP or that they have installed). The differentiated teaching methodology, as pointed out by Fragelli [11] and Tavares [22], provided moments of enthusiasm, involvement in the class and integration between colleagues who had just met. The initial impact and anxiety gave way to motivation for the content worked on, with an important detail: many of the students who participated in this experience, had not even had contact with programming before entering the course. It was noted that the strategy used was well received by the class, which allows advancing in the application of new (and innovative) methodologies so that the contents were better assimilated by students and provides them a meaningful learning. For future work, the knowledge acquired by each student will be individually evaluated through questions related to the questionnaire discussed in group and the APP developed. In this way it is possible to verify the involvement of each student in the activity, assessing the size of the groups and the need to reinforce some unconsolidated content. Furthermore, it is intended to expand cooperation between groups, proposing more complex problems that have dependencies on solutions developed by different groups. The idea is to simulate a work environment, in which the final solution will depend on the results and cooperation between the teams.

References

1 João Paulo Aires and Luiz Alberto Pilatti. Aprendizagem significativa por meio do ensino adaptativo. *Revista Espacios*, 37(29), 2016.

2 João Paulo Aires and Luiz Alberto Pilatti. Feyerabend promovendo a aprendizagem significativa por intermédio do ensino adaptativo. In *IV Congresso Nacional de Educação (CONEDU 2017)*. Editora Realize, 2017.

3 David P. Ausubel. *Aquisição e Retenção de Conhecimentos: Uma Perspectiva Cognitiva*. Plátano-Edições Técnicas, 04-2003 edition, 2003.

4 Lilian Bacich and José Moran. *Metodologias Ativas para uma Educação Inovadora*. Penso, Porto Alegre, 10-2017 edition, 2017.

5 Lilian Bacich and José Moran. *Revolucionando a sala de aula: como envolver o estudante aplicando técnicas de metodologias ativas de aprendizagem*. SAtlas, 1. edição edition, 2017.

6 Tina Barseghian. Three trends that define the future of teaching and learning. `https://www.kqed.org/mindshift/7854/three-trends-that-define-the-future-of-teaching-and-learning`. Accessed: 2021-02-09.

7 William Bender. *Project-Based Learning: Differentiating Instruction for the 21st Century*. Corwin, 1st edition, 2012.

8 Neusi A. N. Berbel. As metodologias ativas e a promoção da autonomia de estudantes. *Ciências Sociais e Humanas*, 32(1):25–40, 2011.

9 Pablo Farias, Ana Martin, and CÃŋnthia Cristo. Aprendizagem ativa na educação em saúde: Percurso histórico e aplicações. *Revista Brasileira de Educação Médica*, 39(1):143–150, 2015.

10 Richard M. Felder and Rebecca Brent. Active learning: An introduction. *ASQ Higher Education Brief*, 2(4), 2009.

11 Ricardo R. Fragelli. Trezentos: Aprendizagem colaborativa como uma alternativa ao problema da ansiedade em provas. *Revista Eletrônica Gestão & Saúde Brasília*, 6(2):860–872, 2015.

12 Ricardo R. Fragelli and T. B. Fragelli. Three hundred: the human dimension of the method. *Educar em Revista*, 1(63):253–265, 2017.

13 Roy Hanney. Doing, being, becoming: a historical appraisal of the modalities of project-based learning. *Teaching in Higher Education*, 23(6):769–783, 2018.

14 John Larmer and John Mergendoller. *Setting the Standard for Project Based Learning*. ASCD, Alexandria, VA, USA, 2015.

15 Eric Mazur. *Peer Instruction: a revolução da aprendizagem ativa*. Penso, Porto Alegre, 2015.

16 MIT. Mit app inventor. `https://appinventor.mit.edu/`. Accessed: 2021-03-08.

17 MIT. Scratch. `https://scratch.mit.edu/`. Accessed: 2021-03-08.

18 Sandra Mitre, Rodrigo Siqueira-Batista, José Girardi-de Mendonça, Neila Morais-Pinto, Cynthia Meirelles, Cláudia Pinto-Porto, Tânia Moreira, and Leandro Hoffmann. Metodologias ativas de ensino-aprendizagem na formação profissional em saúde: debates atuais. *Ciência & Saúde Coletiva*, 2(13):2133–2144, 2008.

19 José Morán. Mudando a educação com metodologias ativas. *Coleção Mídias Contemporâneas. Convergências Midiáticas, Educação e Cidadania: aproximações jovens*, 2:15–32, 2015.

20 João Silva, Gilvandenys Sales, and Juscileide Castro. Gamificação como estratégia de aprendizagem ativa no ensino de física. *Revista Brasileira de Ensino de Física*, 41(4), 2019.

21 Cinthia B. Spricigo. Estudo de caso como abordagem de ensino. *Revista Tuiuti: Ciência e Cultura*, 5(58), 2019.

22 Romero Tavares. Aprendizagem significativa, codificação dual e objetos de aprendizagem. *Revista Brasileira de Informaático na Educação*, 18(2):4–16, 2010.