# Presenting Do-it, a method to teach students how to perform systematic mappings - A example case of its first use


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***Abstract* - After years teaching courses of introduction to research, we understand that many undergraduate students fail to develop skills to systematize literature reviews processes properly, and we address this issue in this Research-to-practice full paper. A teaching method named Do-it was designed to support how students might learn to perform systematic mappings. We present the Do-it method and some preliminary findings from the example case of using the proposed method. Do-it is based on principles like cooperation, active learning, constant and incremental feedback. The steps of Do-It are presented intertwined with its first application in a project involving 24 students attending in a course of introduction to research. The students worked on a systematic mapping using Do-it in order to identify systematic reviews related to the usage of games in Computer Science (CS) classes. Games were chosen as the target to the students' project because they are used as a motivating resource, considering students' difficulty in learning CS concepts. We did automatic and manual searches on well-known Brazilian sources of computing education studies, looking for relevant papers published between 2009 and 2019. Therefore, in this paper, the method Do-It; a summary of some findings that was arisen from the systematic mapping and the teaching experience using Do-it are presented.**



***Keywords — Teaching of systematic mappings, Active learning, Research methods***


## I. Introduction

Many young people in higher education have very great skills regarding the use of technologies available on the Internet. However, a significant proportion of the students will not develop the skills to systematize the process of reviewing[1] literature with scientific quality, even in advanced stages of their academic qualification. This issue was addressed more than a decade ago, since the authors [6] have already been reflecting on how the students were unaware of scientific databases and unable to evaluate the reliability of some publications sources. As a result, the inclusion of papers that had not been through a more rigorous review process in their readings could impair the credibility of what they learned during the literature review process. In their discussions, the authors also emphasized the importance of developing that skill in the qualification of students while they are still undergraduates was underestimated, which affected the experience and performance of numerous students who chose to continue their academic careers in graduate programs.

Over the years, it was possible to notice the presence of this problem in the Teaching Degree in Computer Science program at the Federal University od Paraiba (UFPB). When observing several classes in an introductory scientific research course, it was noticed that students struggle in perceiving the importance of systematizing processes to understand and analyze a section of literature in a given study area, along with learning the existing processes and differentiating them. Developing this certain skill takes time and effort, since there is a usual need to read a considerable amount of material. It negatively affects the engagement of the students who are not used to or do not like reading, especially when it comes to papers that they are not intrinsically interested in. There is still an important point: the course load does not always enable this topic to be taught in an ideal way. Many students finish the course with a theoretical and inaccurate view of the processes that a systematic literature review involves. The consequences of that fact may vary, yet one of them recur frequently when we observe senior students from our undergraduate program: the hardship that some of them face to write their undergraduate theses. Not always because of technical inability, but sometimes because they do not master systematic techniques to review the literature in the area in which they intend to work, therefore it takes them much longer to define the research problem and the scope of their work. Thus, it is during their final semester that some students understand the need to learn a technique, often at the request of the advisor, so that they can adequately define research questions and properly understand the works related to what they intend to propose.

In Brazil, numerous higher education programs in Computing offer, up to the first half of the program, at least one course that aims to present concepts and techniques on how to produce scientific knowledge. According to the curricular guidelines for courses in the field of Computing in the country [1], the development of scientific thinking is one of the essential pillars for technological advancement. During their training process, learning how to review the literature to identify strong evidence in a specific field is an important skill to be developed.

[1] In this paper, when using the term ***review***, no distinction is made among methods such as: systematic reviews, systematic mappings or meta-analysis.

In the course Introduction to Applied Research (in Portuguese, Pesquisa Aplicada à Computação - PAC), which has a 60-hour workload, the teaching of systematic literature review techniques comprises about 20% of the course. As stated by the course description of that component, regarding this topic, it is expected that the student learns to use scientific databases, systematize the process of searching for publications and, among other aspects, understand ethical issues, such as those related to plagiarism.

The authors' experience in teaching PAC classes for numerous years has shown that the expository approach combined with some practical tasks was ineffective for students to learn how to conduct any systematic literature review process, no matter how simple they were. They finished the course knowing the techniques but were unable to differentiate and execute them.

In this paper, we present an experience report to cover the application of a teaching method named Do-It. The Do-It method has been designed and refined over two years and aims to brief professors instructing research beginners on how to teach their students to perform systematic mappings (SM). Through Do-It, we intend not only to achieve the pedagogical purpose of informing students on the existence of systematic processes to conduct reviews, since it is important to have knowledge about other existing techniques, but also and more importantly to teach them how to conduct systematic mappings with a clear vision of the purpose and the limitations of this method.

The application of the method sought to find literature systematic reviews carried out between the years 2009 and 2019 which approached the use of games to teach Computer Science. The choice to use games in the project was due to them being widely mentioned in the literature as motivational resources in the teaching-learning process, given the students' difficulty to learn Science concepts. It is important to mention that, besides what is discussed by [6], to the best of our knowledge, none related work to ours was unveiled.

This paper is organized in the following structure: Section 2 describes the Do-It method. Section 3 presents the result of the method application and the findings. Section 4 presents a critical analysis regarding the experience of applying the method for the first time.

## II. The Do-It method and the report of its first application

Before reaching a structured version of the method, the authors acted as observers and critics of how they taught this topic in the course. Accordingly, The Do-It method was conceived in a way that one could follow the steps prescribed in a systematic mapping while introducing elements that could make students exercise their critical thinking, carry out collaborative work, and provide learning opportunities that encourage them to keep in touch with tasks that promote autonomous, participatory and protagonist attitudes. Those are important aspects, especially when one understands the power of adopting practices based on active methodologies [7] [8].

Thus, Do-It is a simple method that is based on the adoption of didactic incentives, minimizing the theoretical exposure of concepts, and maximizing practical activities. The structure of the Do-It method is constituted by the steps of a systematic mapping plus the encouraging elements that we will mention in the report.

In the experience to be related, 24 students were enrolled in the Applied Research course. To apply the method, six meetings were required, which totaled 12 hours. However, numerous tasks took place outside class hours. The amount of time each student needed for extra-class tasks varied according to the individual learning pace and the student's commitment to the tasks. It was not the objective of the first application of the method to make this measurement, but this is an important element that is intended to be incorporated into Do-It. Why? So that the student can have some idea about the average time, for example, with which colleagues carry out the tasks and for the professor to have a parameter to moderate the volume of weekly tasks or, even, the time that may be dedicated to each step of the systematic mapping.

Following the steps defined in [4] for the execution of a systematic mapping, the pedagogical scheme of Do-it is supported by eleven actions. Some of them, as the reader might notice, were executed iteratively through cycles in which the students revisited their own decisions. This encouraging element was important to make them understand, for example, the difference between a mapping and a systematic review. The first, in this case, is a technique with a more quantitative look at the studies, which allows to identify patterns or trends in a research area, while the second, the systematic review, is more qualitative. The Do-It steps are listed below, describing how their application occurred. Namely:

- **Step 1: Teach why narrative reviews can be defective, unreliable, and biased**. In the laboratory, students were encouraged to search for research topics. Then they were encouraged to talk about how they used to do research on subjects they needed to learn in other courses. The professor, who acted as a mediator similar to that of a focus group, asked questions such as "How do you know if what you are examining, which seems to be the most recent, is really important in this literature", "How to know if other authors bring up divergent topics", "Why were the articles that you found not the same as those found by other colleagues", and "How do you know if you found 'all' that was most important to the literature?" Collectively, students constructed arguments and came up with answers to the questions proposed and, more importantly, they raised new questions. To make this moment more dynamic, Post-its were distributed to students to leave their impressions on the blackboard. In this step, the professor was able to stimulate the students' critical thinking, collaboration, curiosity and protagonism in the construction of an idea or opinion while discussing, as an example, divergent answers or arguments that could emerge.
- **Step 2: Explain what it means to systematize the process of "reading" a literature section.** The second step is the opportunity to introduce the origin of systematic mapping and review techniques; the area in which the techniques emerged, and why. It is also possible to explore the protocol concepts and their basic elements: time window, key, and sources. At this moment, based on the previous discussion on narrative reviews, the authors linked the students' arguments and ideas to situate the importance of these elements and how the decision of the group can

be somehow subjective, however it remains guided by the objective that the researcher intended to achieve.

- **Step 3: Present a platform to organize the information that will be generated during the SM, because it is important to teach them how to organize the volume of content that they will have to deal with.** The platform used was Parsifal[2]. The professors demonstrated some features and asked the students to create individual accounts and to browse the screens so they could get familiar with the features available in the environment. Students were encouraged to explore Parsifal in pairs. Then, they listed some fields that caught their attention in a shared document on Google Drive, whether because they understood what they were about, or because they could not understand the fields at all. Trough Parsifal, professors can stimulate the students' curiosity regarding SM's most important elements by asking what must be described in the "Research Question" field.

- **Step 4: Deliver an initial set of research questions and pay attention to ensure that one of them is focused on the search for studies that present systematic reviews.** Young people who have never had contact with research find it difficult to establish research questions, especially because they define issues that are unreachable with a literature review technique (either review or systematic mapping). In Do-It, the professor should provide some Research Questions (in Portuguese, Questões de Pesquisa - QP) as the starting point and to explain that not every QP is adequate to guide a SM. This is an opportunity to practice critical thinking and collaboration among students. The discussions may help to identify the differences regarding the existing techniques. Since the students in the class had no experience, it was possible to notice the difficulty in classifying possible QPs to be answered under the SM method. At the end of the meeting, it was suggested that only two starting QPs should be established. During the SM process, it was natural for others to be included. To put the project of conducting a SM into operation, we explored areas regarding the usage of games for teaching Computing. It is proposed in the Do-It method that students "go in search" of studies that are systematic reviews. This is a way to reduce the number of works returned and even to help them better understand the technique when reading papers that will mention it, indispensably. Therefore, one of the SM questions focused on the search for studies that were systematic reviews. In the first application of Do-It, the questions were: *"QP1. How many systematic reviews focused on the usage of games for teaching Computing were published between 2009 and 2019?"* and *"QP2. Which QPs were defined by the authors in their systematic reviews?"*

- **Step 5: Elaborate a simple search key with the students**. After discussing the obstacles that could emerge while developing a search key, the students collectively established the first key. We sought to start with the simplest key: ("systematic review" AND "teaching Computing" AND "games"). However, the professors created strategies for the elaboration and refinement of this element of the protocol, such as the use of synonyms, thesaurus, collection of terms in the keywords of the relevant papers in the searches—an allusion to snowball sampling—and the use of logical operators. To keep the subjectivity to a minimum in the mapping since the project was being carried out by 24 students, the simplicity of the key was maintained, without adding synonyms, as an example. However, it provided enough clarification to the fact that the key could be improved, as well as the implications of this decision, such as the need to re-execute the searches to capture important studies.

- **Step 6: Use only one data source, but make sure to explain the importance of identifying others that are also relevant**. The professors presented five sources[3], explaining what they were (whether search engines or not), highlighting what each offered, their limitations, and how search engines handled the syntax of logical operators differently. They also explained that some engines indexed the same information, so it could be redundant to opt for combining some of them. For the sake of simplicity, it was suggested that only one base should be included in the protocol. During the project, Google Scholar was the chosen engine. This decision resulted from the fact that the platform allows to perform advanced searches, with the combination of multiple logical operators and the fact that it indexes databases of conferences and journals related to education in Computer Science. The possibility of manual searches and snowball sampling was also explained as a useful strategy to identify relevant systematic reviews. Although the method suggests using only one data source, manual searches were also subsequently carried out in two important events on computer teaching in Brazil: Brazilian Journal of Computers in Education [4] and Workshop on Computing Education (WEI)[5].

- **Step 7: Execute the first version of the protocol**. Each student carried out a search considering the elements discussed collaboratively to compose the protocol. The corpus was composed of 80 publications. In order to make the execution of the protocol feasible at the time of the course, four papers were allocated to each student. Parsifal identifies duplicated publications, but because they

[2] www.parsif.al

[3] Google Scholar; Capes Periodical Base; Renote, Brazilian Journal of Informatics in Education, and the website of the Congress of the Brazilian Computing Society, in particular WEI (Informatics Education Workshop)

[4] https://www.br-ie.org/pub/index.php/rbie

[5] https://sol.sbc.org.br/index.php/wei/issue/archive

were using different accounts, we used a shared spreadsheet on Google Drive so that students could identify duplicates manually (each sought to identify whether another classmate had allocated a paper that has been already allocated). By the end of this step, 24 remaining papers were redistributed to the students and reorganized in the spreadsheet. Before reading the papers, they were instructed on the need to plan two new elements of the protocol: the inclusion and exclusion criteria.

- **Step 8: Help students to think about the importance of defining inclusion criteria.** The Do-It method suggest the professor to ask students: *Should all the results presented by the search engines be included? Why?* This collective discussion, once again, encourages group communication and reflection. Considering the QPs of the project that we established, we realized that productive discussions were stimulated by students. Some of them found, for example, that publications should be included when they approached only the use of games in higher education. Others that inclusion should be expanded to include mentions of Computing education in general. This moment was important to explain how bias can be incorporated in the study since this judgment is subjective. Thus, planning the strategy to include the studies was a situated learning exercise. After being instructed on how to apply these criteria and jointly deciding which elements of the studies would be considered to form an evaluation (whether considering just the title and the abstract, for example), the students applied the filter, and the spreadsheet was updated again.

- **Step 9: Ask students what should be excluded from the results**. Based on the subset of articles resulting from the previous step, this step stimulated the students to think about a list of exclusion criteria. The discussions stemmed from what-if questions generated by the professors. For example: Do you think that articles that do not explicitly mention the term systematic review should be maintained? "Who" must decide whether the paper can be categorized into this type? Could your classmate make a different evaluation from yours and store papers that you do not agree with in the dataset? How can we make the process less subjective at this stage? Once again, the Do-It method encourages the student to be a protagonist, either by issuing an opinion or formulating arguments. Many students understood that papers that did not mention this should be excluded, and the class agreed that this was an important exclusion criterion. Other criteria were suggested by the professor—the page limit and the type of work (whether thesis, dissertation or technical report). After this stage, seven papers were kept in the SM. Each of the papers was then analyzed by three students. This provided them with the practical experience of collaboration and conflict resolution in times of disagreement during the analysis.

- **Step 10: Guide the data extraction process.** The extraction work concentrated on QP2. However, two questions were added during the process. Since it was intended to map which QPs the authors sought to answer through systematic reviews, it made sense to capture the answers found as well. This is QP3. QP4 established: "What themes were more recurrent in the systematic reviews?" With this question, we sought to identify, for example, if the authors were interested in investigating specific aspects of the use of games for teaching Computing. Each student created an extraction form with their Parsifal account again, in order to make them understand the platform's potential. They did the extraction there. After everyone finished this step, the corpus was transferred to the shared spreadsheet so that everyone had access to the individual extractions. This decision prepared the corpus for analysis since it organized the data so that students could more easily identify the occurrence of patterns.

- **Step 11: Simplify the analysis but teach a technique for students to identify patterns in the data**. Because the objective was to exercise in some degree the analysis of the data corpus, only QP4 (What themes were more recurrent in the systematic reviews?) was used as a motto for this didactic purpose. In a simplified way, the Thematic Analysis technique was explained so that students could understand how to code the data and identify the occurrence of patterns in the codes [2]. This stage of the process is the one that requires more elaborate levels of critical thinking from students and ability to connect ideas and resolve conflicts. It is extremely important stage for them to understand how scientific evidence can be generated, which is important to ensure the validity of the discoveries in a secondary study, as is the case with systematic mappings. In addition, as mappings are more quantitative, the focus on identifying patterns helped students to understand the goal of conducting systematic mapping.

One fact to be highlighted is the choice to research only papers in Portuguese. That is due to two facts: (1) since the students are still in the first half of the undergraduate program, many of them still do not have the required fluency to carry out research in English, and (2) to be able to build an overview of the use of games to teach Computing in Brazil, the home country of all participants on this research.

## III. Initial Results of the SM Conducted by the Students

The students were able to achieve satisfactory results, considering the limited time to execute the SM, and the fact they were learning the technique. We will present here some of the initial findings of the mapping conducted by the students. Table I shows the papers that were analyzed in this study with their title, authors, and year of publication.

TABLE I. PAPERS ANALYZED

| Id | Title | Authors | Year |
|---|---|---|---|
| [a] | Revisão sistemática sobre avaliação de jogos voltados para aprendizagem de programação no Brasil | Souza, A. L. Coutinho, J. C. S. | 2009 |

| Id | Title | Authors | Year |
|---|---|---|---|
| [b] | Ensino de programação utilizando jogos digitais: uma revisão sistemática da literatura | Medeiros, T. J.<br>Silva, T. R.<br>Aranha, E. H. S | 2013 |
| [c] | Jogos digitais para ensino e aprendizagem de programação: uma revisão sistemática da literatura | Silva, T. R.<br>Medeiros, T. J.<br>Aranha, E. H. S | 2014 |
| [d] | Uso de Jogos em Cursos Introdutórios de Programação: Uma Revisão Sistemática | Scaico, A.<br>Scaico, P. D. | 2016 |
| [e] | Aprendizagem Móvel de Conceitos Introdutórios de Programação: Uma Revisão Sistemática dos Jogos | Soares, L. | 2017 |
| [f] | Panorama da Utilização de Jogos Digitais no Ensino de Programação no Nível Superior na Última Década: Uma Revisão Sistemática da Literatura | Silva, R. R.<br>Fernandes, J.<br>Santos. R. | 2018 |
| [g] | Uma Análise do Cenário Nacional do Uso de Jogos para o Ensino e Aprendizagem de Computação | Silva, T. R.<br>Cordeiro, J. R.<br>Santos, R. S. F.<br>Santos. F. G.<br>Aranha, E. H. S.<br>Silva, F. G. | 2018 |

Analyzing the systematic reviews found by students, it was observed that four research questions were more prevalent, which we list here in order of prevalence: (1) What tools or games are most used by educators when teaching topics related to Computer Science? (2) How do researchers and professors try to measure efficiency in terms of what is the impact of their teaching approach with games on the students? (3) Are there reports of educators using games with assistive technology? And (4) What pedagogical theories are the educators who use games for teaching based on?

Not only the answers to these questions will be presented subsequently, but also to other relevant questions regarding the use of games for teaching Computing in Brazil. Due to the limited space available in this paper, this information will be briefly presented.

The first noticeable fact is that, except for paper [g], the reviews that have been devised focus on the use of games for teaching programming rather than on other courses in Computer Science. While analyzing the articles, it was found that this choice for focusing on teaching programming rather than other subjects in Computer Science was because of the high failure rates in introductory programming courses, and the large number of students who abandon Computing courses in the first year of graduation.

Regarding the most used tools or games (question (1)), the most cited are PyGame, Game Maker, Construct 2, Robomind, and Lego Mindstorm. Several others are also cited, with a wide variety of tools being used by educators. Regarding the games used, the researchers themselves developed the vast majority, focusing on a specific aspect they wished to teach. Only a few studies used commercial video games, such as CodeSpells, Lightbot, and Minecraft.

For the measurement of efficiency, referring to question (2), there was a common understanding concerning the lack of evidence to indicate the effectiveness of games as resources for teaching programming. A lower interest was noted in identifying, through the reviews, which engines were present in the games used for the programming teaching process, and which concepts were addressed in educational games. Overall, researchers assessed efficiency subjectively without relying on reliable scientific metrics. Several scientific works said that the use of games for teaching was effective, it contributed to learning, and increased motivation and engagement, but this evaluation came mostly from the authors' perceptions of observations, interviews, and questionnaires. An interesting conclusion from the review [g] was that the use of games engaged and motivated students, however, this was not causally related to improving learning or increasing student´s grades.

Unfortunately, although it is a topic of great importance, the answer to question (3) is that no games using assistive technologies were found.

As for question (4), which seeks to verify which pedagogical theories the researchers were based on when it comes to planning the use of games for teaching Computer Science, we also had a discouraging result. The vast majority were not based on any pedagogical theory to support the development and/or application of games. In the few studies that explained a pedagogical theory, we can mention, in order of frequency: Constructivist Pedagogical Theory, Bloom's Taxonomy, and Meaningful Learning Theory.

After presenting the results for the most recurrent research questions among the systematic reviews found in this mapping, other relevant pieces of information present in the reviews will be listed. The first noticeable fact, already mentioned, is that except for review [g] the focus of the reviews that have been devised was the use of games for teaching programming rather than other Computer Science courses. In regard to the courses in which games are most frequently applied [g], they were Software Engineering, Introduction to Programming, and Computational Thinking. Other courses such as Data Structure and Computer Networking are also mentioned, but with much less frequency.

Regarding the most taught programming languages with the support of games, we had, in order of relevance: Java, C#, Visual Basic, and Python.

The use of games for teaching was mainly carried out as workshops for high school, as support for curricular subjects of higher education courses in Computer Science, and as extra-class courses for the general public. However, the primary target audience of the studies was students of higher education courses in Computer Science, followed by high school students.

The review (d) identified that three strategies were applied in the use of games to support teaching Computing: Use of games for teaching programming, Teaching programming based on game programming, and Gamification for teaching programming.

Finally, a survey was also made concerning the educational institutions linked to the authors of the articles found by the systematic reviews as a way of obtaining an overview of where games were being used to support the teaching of subjects related to Computer Science. It was found that the institutions are mostly public and that all regions of Brazil have researchers working with this theme. In order of precedence, the Northeast and South have more works published on the theme (31% each), followed by the Southeast (27%), and in a lower percentage, the North (8%) and Central-West (3%).

## IV. Conclusion

After the first Do-It application, it was possible to identify some aspects. One of the first observations is that students have better developed the ability to differentiate reviews from systematic mappings. In previous classes, because the explanation relied on the exposition of contents, learning did not become situated. As reported in Step 4 of the Do-It method, which appears in Section 2, by making students search for systematic reviews, the professor of the course established an opportunity to make them think why and in what they differ from the mappings. As it was explained by [9]: “Systematic mapping was developed as a need for a method to describe the literature across a broad subject of interest. Systematic mapping does not attempt to answer a specific question as do systematic reviews, but instead collates, describes and catalogues available evidence”.

As they read the articles, discussions about the difference between mappings and systematic reviews could be constantly established during classes. As well as to add more information. For example, what primary and secondary studies are about. Because of QP2, students were encouraged to think about the QPs contained in the systematic reviews, aiming to make them reflect on various aspects, such as if they were well-formulated, and even, if what the authors labeled as systematic reviews could be considered correct, stemming from the students' perspective. It is a starting point for practicing the students' argumentative thinking, and they can be organized in groups to discuss questions proposed by the professor.

It was also observed that because of the need to collaborate within a relatively large team (24 people), the professor can also establish a space to expose many skills, including *soft skills*, that need to exist for the project to reach a result, as it is the case of resolving conflicts raised by some students. Another relevant point emerged from the experience: students were encouraged to realize how their judgments, which were subjective and sometimes guided by technical inexperience, led to the introduction of bias in the decisions they made when including or excluding studies. Thus, the professor can use this opportunity to explain that the validity of the evidence from an SM is influenced by the presence of multiple reviewers throughout the process, and preferably one with more *expertise* in the area, and they can be organized to resolve conflicts raised in the evaluations.

At other moments when the PAC course was taught, teams of up to three students were formed. Each received a research question, which guided the decisions in SM. However, due to the diversity of themes, it was not possible to establish productive classes in which the discussions could solve the different obstacles that the teams faced, for example, and even give way to carry out more dense questions. Using the same QP was the guiding thread to establish rhythm and synchrony in the discussions. Apparently, the experience reported here established circumstances for the students to find meaning for some decisions they make and to contextualize the information given to them. This pedagogical construction is in line with a situated learning proposal. For [3], "to situate means to locate people's thoughts and actions in time and space". For [5], "thought and action acquire meaning only in the circumstances in which they occur".

At the end of the course, students were voluntarily invited to evaluate the method. Of those who responded, all reported a positive experience with the approach regarding their learning about the content, but many pointed out the desire to have used solely Parsifal. However, in previous experiences, the non-use of shared spreadsheets resulted in some problems. First, it was difficult to control who was updating the data on the platform. Then, the way Parsifal provides the extracted data does not facilitate the analysis, especially for beginners. The students evaluated negatively aspects related to the work in groups because, not all of them, that is to say, but a few students could not meet the deadlines for the tasks. Thus, the visualization of the data was undermined since it was partial most of the time, which postponed the extraction step. Some subsequent mapping steps needed to be postponed. That aspect seems to have frustrated the students who fulfilled their tasks within the stipulated time.

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