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An Analysis of Systematic Reviews On Active Learning in The Context of Computer Programming Instruction and Learning

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Abstract

A systematic literature analysis was done to analyse and evaluate the methodologies, educational techniques, applications, contributions, and implementation issues presented in this research. The objective of the review was to identify the research that examine the different pedagogical strategies used to foster active learning in the context of teaching and learning computer programming. The given text does not provide any context or information. The literature indicates that teachers have not achieved the desired level of success in teaching programming, leading to high percentages of student failure and dropout. There has been extensive debate about the pros and cons of implementing active learning teaching methods in this specific context. Methods This review evaluated all publications between 2014 and 2019 that discussed the relationship between active learning and computer programming instruction and learning. The analysis included works discovered in WOS, SCOPUS, ScienceDirect, and the ACM Digital Library. The selection procedure was driven by criteria that involved evaluating the quality of the studies and assuring their alignment with the research goals. Involvement This study contributes to an overview of the current state of affairs by detailing the research papers that establish connections between different active learning pedagogical methodologies and the instruction and acquisition of computer programming skills. Outcome The findings revealed that the methods employed in the studies primarily involved intervention, educational experimentation, or the development of a tool, instrument, or methodology. The lipped classroom methodology has gained significant renown through research. Implementing active learning pedagogical methodologies results in more student acceptance and positive feedback, which motivates them to improve the learning process, learning outcomes, and student performance. However, the instructor must invest more work and effort to effectively arrange and execute the teaching and learning process. The contributions observed in the computer programming teaching and learning process originate from research conducted mostly in university settings. The main objective of this research is to ascertain whether these contributions can be replicated in other educational settings. Research on the implementation of active learning pedagogical techniques in computer programming has shown significant benefits. These techniques can effectively enhance the teaching and learning process, serving as a viable alternative that reduces programming failures. Recommendations for Professionals. We suggest that educators reconsider their conventional methods of instructing computer programming, employing pedagogical techniques of active learning to enhance student learning outcomes, considering the historical difficulty

students have faced in the teaching and learning of computer programming. We recommend that additional scholars examine the correlation between the difficulties faced by students and the subject matter, as well as the obstacles encountered by teachers in the process of teaching and learning programming. This is especially important when considering traditional instructional approaches. Impact on the Community This study enhances previous comprehensive evaluations of the literature, namely those that establish a connection between active learning and programming education and learning settings. This article aims to provide a framework for active learning researchers, with the intention of promoting more study on the issue and facilitating its development and exploration.

Keywords: computer programming, active learning, teaching/learning, teaching methodologies, systematic review

Introduction

Because of the significant impact that computers have on society, there has been a significant focus placed on the development of students' programming skills. One of the most important aspects of a well-rounded education is affording students the opportunity to learn and practise computer programming abilities. According to the findings of research conducted by a number of experts in the field, it has been established that teachers frequently face difficulties while attempting to instruct students in coding efficiently. These conclusions have been established in a number of research, such as the ones conducted by Benedsen and Caspersen (2007), Gomes and Mendes (2014), McGettrick and colleagues (2005), Simon and colleagues (2019), Sleeman (1986), and Watson and Li (2014). The issues that are linked with teaching and learning programmes have deep-seated origins because of the wide variety of situations and individuals that are involved. According to a number of studies (Bosse & Gerosa, 2016; Gomes & Mendes, 2007; Medeiros et al., 2019; Qian & Lehman, 2017; Robins et al., 2003), students frequently struggle with a variety of issues, including but not limited to the following: reading and interpreting information; developing logical reasoning; effectively solving problems; having insufficient knowledge in mathematics; adopting improper study habits; lacking motivation; lacking persistence; or lacking commitment. One of the potential reasons for the difficulty that students have in learning to code could be traced to the difficulties that teachers themselves face in properly teaching their methods. This is something that ought to be acknowledged as an essential component of any discussion concerning this topic. When compared to the conventional method of teaching, which consists of lectures and labs, the research carried out by Vihavainen et al. (2014) has demonstrated that educational interventions have the potential to boost programming pass rates by roughly 33 percent. In order to investigate the impact that different interventions have on the percentage of students who successfully complete programming courses, the researchers carried out a comprehensive review of publications that detailed alternate instructional methods for beginning programming classes. Multiple areas have expressed scepticism over the efficacy of the traditional lecture-based approach to

education, which is the most popular pedagogical style that is utilised in classrooms all over the world, across all grade levels, and in all learning situations. It has been argued by some that the problem with traditional methods of instruction is that they force students to only take information without actively participating in the process of their own education. Considering that the content is of an abstract character, there is a greater possibility that it will be forgotten over the course of time. There has been a significant amount of research conducted in the field of education that covers both the positive and negative aspects of active learning (Freeman et al., 2014; Michael, 2006). This learning paradigm is, without a doubt, a substantial departure from the conventional manner of conducting instruction through lectures. In order to achieve the goal of actively engaging students in the learning process, it is necessary to encourage them to make use of the knowledge they have received, to apply advanced cognitive skills, and to critically evaluate their learning experiences in order to develop unique insights. According to Bonwell and Eison (1991) and Richardson (2008), it makes use of a wide variety of instructional strategies, methods, and approaches in order to achieve this goal.

For the purpose of this systematic review, the primary objective was to discover papers that investigate the several pedagogical practices (methodologies, tactics, and approaches) that promote active learning within the framework of programming education. The purpose of the review was to investigate and characterise the many approaches, instructional tactics, applications, contributions, and documented difficulties that were present in the particular environment that was being referred to. Several studies, including those carried out by Borges et al. (2018), Luxton-Reilly et al. (2018), Medeiros et al. (2019), Pears et al. (2007), Qian & Lehman (2017), and Robins et al. (2003), have provided evidence that the topic of learning and teaching computer programming has been thoroughly studied in the academic literature. In the studies that were described before, instructional methods and tools are discussed to a certain extent; however, the primary focus of these research is on the more comprehensive aspects of programming education. The topics that fall under this category include learning competencies, problems, and barriers related to programming. This study analyses the process of educating and acquiring programming skills from the perspective of numerous active learning pedagogical techniques. Taking into consideration the information that has been supplied, we believe that the study is relevant since it investigates this process. The potential of the study to produce an accurate representation of the current state of research in the subject is the key reason for the significance of the study.

Background

Due to the widespread use of computers in today's culture, there has been a substantial increase in the amount of emphasis that has been paid to teaching kids how to code. Providing pupils with numerous opportunities to refine their skills in the programming language should be a component of an all-encompassing education that includes the teaching of coding to kids. Studies that were carried out by professionals

in the sector have shown that educators commonly encounter challenges while attempting to teach pupils the skill of coding in an efficient manner. Other investigations, such as those carried out by Benedsen and Caspersen (2007), Gomes and Mendes (2014), McGettrick and colleagues (2005), Simon and colleagues (2019), Sleeman (1986), and Watson and Li (2014), have provided evidence that supports these conclusions. The problems that are associated with educational programmes occur as a consequence of elements that are deeply rooted and are the result of a diverse range of circumstances and individuals involved. There have been a number of studies that have shown that students frequently struggle in areas such as reading comprehension, logical reasoning, problem-solving proficiency, insufficient mathematical aptitude, formation of poor study habits, lack of motivation, lack of persistence, and lack of commitment to their academic pursuits (Bosse & Gerosa, 2016; Gomes & Mendes, 2007; Medeiros et al., 2019; Qian & Lehman, 2017; Robins et al., 2003). These are just some of the areas that have been shown to be problematic for students. It is possible that the difficulty that the pupils are experiencing in learning coding are a result of the teacher's own issues in successfully presenting their methodology.

While we are talking about this subject, it is very necessary to admit that this is an important component. The findings of a study that was carried out by Vihavainen and colleagues (2014) have demonstrated that educational interventions have the potential to improve programming pass rates by roughly 33 percent when compared to the conventional instructional approaches that involve lectures and laboratories. A systematic evaluation of the current literature was carried out by the researchers in order to determine the many approaches that might be taken while instructing introductory computer science classes. The goal was to determine the extent to which different interventions had an effect on the percentage of students who were able to successfully finish the course material. Traditional lecture-based instruction is the most common method of instruction used in schools all over the world, regardless of the grade level or the environment in which the educational institution is located. Nevertheless, concerns have been expressed about the effectiveness of this technique across a variety of fields of study. One of the criticisms that might be levelled against traditional methods of instruction is that they prevent students from actively participating in activities that go beyond what is known as passive information collection.

The content is of an abstract character, which increases the likelihood that it will be forgotten at some point in the future. In the field of education, the advantages and disadvantages of active learning have been the subject of several studies, including those conducted by Freeman et al. (2014) and Michael (2006), to name just two examples among the majority of these studies. This learning paradigm represents, without a shadow of a doubt, a total break from the traditional approach of instruction, which is based on lectures. In order to cultivate a profound level of student engagement, it is of the utmost importance that we encourage them to actively use the knowledge they have received, make use of their advanced cognitive skills, and

critically assess their own learning experiences in order to come up with novel points of view. This is something that can be accomplished, according to Bonwell and Eison (1991) and Richardson (2008), by utilising a wide variety of educational tactics, methods, and approaches. his systematic review's major purpose was to discover publications that study the various pedagogical practices (methodologies, tactics, and approaches) that encourage active learning in the field of computer science education. Finding these articles was the primary objective of this review. In the context of the indicated environment, the purpose of the review was to examine and explain the many strategies, instructional methods, applications, contributions, and problems that were reported. The academic literature on the subject of learning and teaching computer programming is extensive, as demonstrated by the numerous studies that have been conducted on the subject. These studies include Borges et al. (2018), Luxton-Reilly et al. (2018), Medeiros et al. (2019), Pears et al. (2007), Qian & Lehman (2017), and Robins et al. (2003). There is a brief discussion of teaching approaches and tools in the studies that have been included; however, the primary focus of these research is on the more general aspects of programming education. Competencies in learning, learning challenges, and obstacles to learning programming are all included in this field of study. The purpose of this study is to analyse the process of teaching and learning programming from the point of view of a number of different active learning pedagogical strategies. The fact that the study explores this process leads us to conclude that it is pertinent, given the information that have been provided. The capability of this study to accurately portray the current status of research in the field is one of the most important reasons for the significance of this study.

Method

The recommendations for conducting systematic literature reviews that were established by Kitchenham (2012) were utilised in the process of conducting this review. In order to analyse and characterise the methodology, educational strategies, applications, contributions, and difficulties that were covered in the research, the purpose of this study was to conduct the research. This research aims to discover and assess articles that were published between 2014 and 2019 that investigate the relationship between various active learning pedagogical strategies and the design of teaching and learning programmes. The time period covered by this research is from 2014 to 2019. For the purpose of determining whether or not the created search phrase was enough, a number of experiments were carried out across a variety of databases. It was determined, on the basis of the findings of the testing, that the search phrase that was selected was suitable for the purpose of locating papers that fulfilled the requirements of this investigation. The search engines conducted the search using the following databases as parameters: Web of Science - Core Collection (Clarivate Analytics), Scopus (Elsevier), ScienceDirect (Elsevier), and ACM Digital Library. The search phrase that is displayed in Figure 1 was executed automatically by the search engines. There were three fields in the search query: the title, the keywords, and the abstract. The content type was specified as an article, and the publication date range

was set between 2014 and 2019. During the search that was conducted on September 21, 2020, a total of 335 studes were discovered within the databases that were referred to. The process of selecting the research that would be included in the foundation or documentary corpus for evaluation started as soon as the studies were retrieved. In light of this, redundant research, totaling 83, were initially disregarded in this investigation. After that, the researchers conducted a painstaking analysis of the titles, abstracts, and keywords of the remaining 252 papers, making certain that they strictly adhered to the criteria that were stated for inclusion and exclusion. Consequently, in order to carry out systematic reviews, it is essential to evaluate the quality of the research that has been done in the past. As a result, the articles that were chosen were evaluated in order to assess their level of quality. In order to identify and discard research that had weak methodology, preliminary findings, or low scientific quality, a quality evaluation was carried out. As a result, Figure 1 illustrates the formulation of seven questions, which were derived from the model presented by Dybå and Dingsøyr (2008), with the purpose of evaluating the quality of the research that was incorporated into this review.

The research works that were selected in advance on the basis of particular criteria were subjected to a comprehensive analysis in order to provide responses to the questions that were issued. When determining the weights of the questions, the following criteria are taken into consideration: The selected study is considered to be in compliance with the specified requirement if it has a value of 1. When the chosen study receives a score of 0.5, it suggests that the reporting is unsatisfactory, while a score of 0 indicates that the study does not report at all.Unfortunately, the investigation does not meet the requirements that were provided. According to the evaluation, the final result for each study was determined by calculating the quality assessment questions based on the results of the evaluation. For the goal of determining whether or not the research for the current evaluation is appropriate in terms of its objectives, methodology, results, reliability, and relevance, the questions that are included in the quality assessment are designed to facilitate this determination. As a consequence of this, it was decided that a minimum score of four was required for the research to be eligible for acceptance as the threshold requirement for the studies that served as the basis for this study. By utilising a collaborative spreadsheet, a single researcher was able to identify and share the papers that comprise the documentary corpus of the review. This was done in order to speed the process of acquiring relevant material for research inquiries. Following that, the results were checked by the other researcher who had been responsible for the data extraction.

Implementation of The Protocol and Discussion of Results

An initial discovery of 335 publications was made by employing the strategy that was suggested for the purpose of locating relevant material. Following the elimination of 83 studies that were no longer relevant, the remaining 252 studies were subjected to further examination. Out of the 252 pieces of research that were examined, 179 papers were disregarded because they did not satisfy the particular criteria that were used to

determine whether or not they should be included. There were a total of forty pre-selected research left after 212 studies were eliminated from consideration. There were 33 studies that were able to satisfy at least one of the criteria for exclusion.

After that, the selected studies were reviewed for their quality by assessing their objectives, methodology, and results, as well as their reliability and relevance to the review's objectives. This was done in order to determine the overall quality of the research. In addition, papers that were found to have deficiencies in their methodology, early findings, or scientific quality were subsequently discarded after being detected. Taking into consideration the dates on which these studies were published in conferences and journals that were subjected to peer review, it is plausible to anticipate that the pre-selected study would obtain positive assessments, with an average score of six points. As a consequence of this, just two of the studies that were selected in advance were deemed to be undesirable due to the fact that their quality score was lower than 4. As a result, the foundation of this review is comprised of 38 papers that were pre-determined and had accomplished a minimum quality score of four. These papers satisfied the criteria that were established for selection. The 38 studies are broken down into its component parts and explained in great depth in Appendix A. Appendix B contains an assessment of the quality of the research. When it comes to the application of the systematic literature review technique that was described earlier, it is essential to take note that the researchers demonstrated a significant level of agreement throughout the entire process. When it came to the techniques for selecting candidates and evaluating their quality, there were differences that were less than ten percent.

During the selection process, some examples of these distinctions can include instances that are related to the exclusion criterion (EC3). This criterion especially relates to research groups or authors who have conducted studies using the same data. There are instances in which the particular active learning strategies that were utilised in a study might not have been entirely transparent, which may prompt one of the researchers to contemplate the possibility of omitting or classifying those studies according to specified criteria. One of the other researchers, on the other hand, took a position that was contrary. The varying scores that were assigned to the assessments were the cause of the inconsistencies that were found in the evaluation of the quality of the study. The upshot of this was the organisation of conferences for the purpose of discussing and, if necessary, reevaluating the many studies that were carried out during the process of quality assessment and selection. In order to address any inconsistencies that may have arisen as a result of the separate analyses that were carried out by the two investigators for each research project, this was done. Following this, there will be a discussion that centres on the research subjects that were used as the foundation for this evaluation.

Contributions and Difficulties Reported in Using Pedagogical Techniques For Active Learning (Rq4)

The implementation of pedagogical methodologies for active learning in complicated research involves numerous contributions and challenges, which provide outcomes with broad applicability. The objective of the forthcoming recordings is to classify these contributions and the challenges that the authors have encountered about the subject matter of the review. The research contributions that formed the foundation for this examination on the use of active learning methodologies in programming education are outlined in Table 4, displayed below.In the area of teaching and learning programmes, Table 4 demonstrates that more than sixty percent of the research establish a connection between the utilisation of active learning pedagogical approaches and increased student acceptance, positive feedback, better motivation, and greater satisfaction. In addition to that, it is important to highlight the documented contributions that are as follows: It has been found that the intervention improves the academic achievements or outcomes of students (n = 16), that it stimulates their inquisitiveness, involvement, or involvement (n = 13), and that it fosters the formation of interpersonal skills, which are competencies associated to cooperation and communication (n = 8). The outcomes of this study are supported by the evidence presented by Andres (2017), which demonstrates that active teaching is positively connected with the academic performance of students as well as their desire to learn. Freeman et al. (2014) report results from regular classrooms that have been empirically confirmed. These results demonstrate that students have a preference for active learning as an educational style when it comes to pleasure. In their article, O'Flaherty and Phillips (2015) suggest that there is a substantial amount of circumstantial evidence that supports the success of the reversed technique in promoting happiness among both staff and students, as well as in improving academic attainment.

Implications

For the purpose of locating and analysing research that demonstrates a variety of active learning pedagogical methodologies in the field of teaching and learning computer programming, a complete literature review was carried out. The employment of active learning pedagogical strategies, according to a study of the data from the research that were included in this review, promotes student acceptance and positive feedback, which ultimately leads to greater motivation and satisfaction. In the process of teaching and learning programming, this, in turn, improves the learning experience, the learning outcomes, and the performance of the students. The results of the meta-analysis that Freeman et al. (2014) conducted on 225 publications that were published before to 2010 compared the performance of undergraduate students majoring in STEM subjects who participated in active learning to those who attended traditional lectures. When taken along with the failure rates, the findings of this research provide credence to the contributions that were discussed before. According to the findings of Freeman and colleagues, they found that students who took classes that consisted of traditional lectures had a failure rate that was 1.5 times higher than students who took classes that included active learning. Furthermore, the participants in the latter group

experienced an increase of approximately 6% in their average exam scores as a direct result of the active learning components. When it comes to the success of any learning process, motivation is absolutely necessary. However, if students do not have sufficient motivation, it is possible that they will not develop advanced cognitive talents and skills, such as programming, which requires knowledge in a variety of fields. Gomes and Mendes (2014) present empirical evidence to support the statement that a significant number of novice programmers lose their motivation as a result of the intrinsic difficulties that are associated with learning programming. According to the findings of Duffany (2015), a sizeable percentage of students demonstrate a lack of interest in learning the material that is presented in basic programming classes. There are some students who are only concerned with earning a passing grade, while there are others who are more concerned with merely passing the course. It's possible that their below-average performance is to blame for this divergence in priority.An additional finding related to the use of the active learning strategy known as the Flipped Classroom in the field of programming education.

Over the past few months, there has been a notable increase in the number of people seeking this treatment. It is said by Giannakos et al. (2014) that the introduction of the flipped classroom teaching technique has six primary benefits: it helps to cultivate a positive attitude, it enhances student involvement, it encourages more conversation, it facilitates collaborative learning, and it assists in the development of improved study habits. In general, the benefits of active learning that are reported in the current study are relatively comparable to the advantages that Giannakos et al. (2014) highlighted in relation to the utilisation of the flipped classroom technique. According to the findings of the research, we recommend that teachers reevaluate their approach to teaching computer programming and use active learning pedagogical approaches in order to highlight the significant contributions that students make to their own learning. In the end, it is essential to keep in mind that this review, much like the systematic approach, is subject to a number of fundamental constraints. These include the limited scope of research that was examined as well as the potential biases that may have happened throughout the process of selecting, extracting, and analysing the studies. Additionally, the need that non-binary or non-objective responses be provided to a number of the specified research subjects imposes additional constraints on the processing of the data. Nevertheless, it is of the utmost importance to acknowledge that these limitations have been overcome in a manner that is consistent with the fundamental principles which underpin systematic reviews.

Conclusions

In the context of computer programming education and learning, the primary purpose of this research was to discover studies that show linkages between various pedagogical strategies that are used to enhance active learning. The purpose of this study was to categorise the methodology, instructional tactics, contributions, implementation issues, and approaches that were reported by these previously conducted studies. An exhaustive literature review covering the years 2014 through

2019 was carried out in order to accomplish this goal. The ACM Digital Library, Web of Science, SCOPUS, and ScienceDirect were among the prominent academic databases that were utilised in the process of conducting a comprehensive systematic review. A total of 335 studies were retrieved from these databases. The selection of the research was carried out in accordance with a predetermined assortment of criteria that served to steer the procedure. The criteria included an assessment of the quality of the studies as well as their conformity with the research inquiries under consideration. At first, there were 335 papers that were acquired. However, following rigorous examination, it was discovered that 297 of them were either duplicates or did not meet the minimum quality requirements that were established in the criteria for inclusion and removal. As a consequence of this, a total of 38 papers were selected to utilise as the basis for this review. According to the findings of the study of the papers that were chosen, the methods that link active learning and teaching/learning programming (RQ1) involve pedagogical intervention or experimentation as well as the development of a tool, instrument, or approach. In response to research question 2, it was discovered that programming instruction makes use of a wide variety of active learning pedagogical approaches. These approaches include a wide variety of methodologies, tactics, and approaches. On the other hand, academic research has concentrated a great deal of attention on the flipped classroom method, project-based learning, and peer instruction strategies. In the context of higher education, these instructional strategies are utilised to a significant degree (RQ3). Regarding the research on educational programming (RQ4), it has been noticed that the deployment of these techniques typically results in greater student acceptance and favourable feedback.

This is the case in most cases. Consequently, this results in an increase in their level of contentment and motivation to enhance the learning process, attain the intended learning outcomes, and improve student performance. In addition to this, it encourages students to be curious, to be engaged, and to build their interpersonal skills, which are skills that are linked to working together as a team and having proficient interaction. On the other hand, it is essential to acknowledge that the majority of the advancements that have been mentioned in the education of computer programming are the product of research that has been carried out in academic institutions. The objective is to ascertain whether or not these advantages are capable of being repeated in a variety of educational environments. According to studies, active learning pedagogical strategies for teaching and learning programming present a considerable problem since they need teachers to devote more time and effort to organising and implementing the teaching and learning process. This is a significant challenge. The implementation of these pedagogical tactics has the potential to significantly enhance the teaching and learning process, which is essential for lowering the number of unsuccessful attempts in the field of programming education. On the other hand, it is important to emphasise that the incorporation of active learning pedagogical strategies requires a higher degree of commitment and effort from the instructor in terms of planning and carrying out the

process of teaching and learning. In the end, we are confident that we have successfully completed the objective of this research, which was to identify and explain the many active learning approaches that are utilised in the training of computer programming. The purpose of this study is to contribute to the current body of systematic literature reviews by conducting an analysis of a wide variety of studies that point to a connection between active learning and programming expertise. The objective of this article is to give a fundamental framework for future study in the field, with the intention of enabling researchers who are interested in active learning to expand and increase their understanding of the subject matter. In the future, research should be conducted to investigate the benefits of employing a variety of instructional strategies to encourage active learning, as well as the costs that are connected with the extra mental work that is required by these computer programming learning methodologies. It is of the utmost importance to acknowledge that the analysis of how the inherent issues that instructors have in teaching and learning programming may result in difficulties with students and content, particularly in regard to the traditional teaching methods that they use, might create impediments.

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