E-Assessment in Computer Science Higher Education

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ABSTRACT

The increasing use of e-assessment methods for computer science in higher education has led to a growing body of research on this topic. In this systematic literature review, we discuss various assessment types such as true or false questions, essay questions, interactive questions and performance-based assessments, and explore instructors' perspectives on the challenges and opportunities of e-assessment from 86 studies relevant to e-assessment. The review reveals that e-assessment offers numerous advantages, such as efficient grading and automated feedback, but presents unique challenges, such as ensuring academic integrity and providing personalized feedback. We also identify several assessment types typically used in e-assessment, including multiple-choice questions, coding exercises, and peer assessments. Overall, the findings of this study indicate that e-assessment is currently a topic of significant interest in the field of computer science in higher education.

CCS CONCEPTS

• **Applied computing**; • **E-learning**;

KEYWORDS

E-assessment, Higher Education, Systematic Literature Review, Computer Science Education

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1 INTRODUCTION

In recent years, e-assessment has gained significant attention as an alternative to traditional paper-based assessment methods. E-assessment refers to the use of electronic tools and technology to facilitate the assessment of students' learning outcomes. The field of computer science has been particularly interested in e-assessment, as it aligns with the discipline's focus on technology and innovation [1].

The review will begin by discussing the various types of e-assessment used in computer science assignments, including online quizzes, programming assignments, and automated essay grading. It will then explore the perspectives of instructors on e-assessment, including their views on the effectiveness of e-assessment in promoting student learning and engagement. The review will also examine the advantages of e-assessment, such as the ability to provide immediate feedback to students and the potential for increased efficiency in grading. Additionally, the review will address the challenges associated with e-assessment, such as concerns about cheating and the need for effective software tools. By synthesizing the literature on e-assessment in computer science, we hope to provide a comprehensive understanding of the current state of research in this field and identify future research directions.

Overall, this systematic literature review aims to provide a comprehensive analysis of the use of e-assessment in computer science assignments. By examining the types of e-assessment used, the perspectives of instructors, and the advantages and challenges associated with e-assessment, the review will contribute to a deeper understanding of this rapidly evolving field. We adopted the systematic literature review method proposed by Kitchenham to achieve our aim [2]. The strategy comprises of the following five steps: Define research topic, define search terms, select electronic resources, conduct a search, and match inclusion and exclusion criteria.

2 RELATED WORK

This article looks at how beginners learn computer programming in college courses. The authors read 60 research articles published in the past 10 years to learn about the best ways to teach programming. They found that most research focused on how to teach problem-solving and critical thinking, but not on things like what to teach or how to test students. They made a list of the most important topics to teach and suggested areas for future research This article provides an analysis and synthesis of existing research on introductory programming courses (IPC) in higher education. The article focuses on the acquisition of skills required for learning to program, such as problem-solving, design techniques, and critical thinking.

The research community has addressed the challenges faced by novice programmers through curriculum improvisations, pedagogical methods, cognitive aspects, supporting tools, and assessment design. The article reviews nearly 60 research articles published in the last ten years, selected through a systematic filtering process. The main findings reveal that "solution proposal" and "evaluation research" are the two main types of research adopted by these studies. Pedagogy, language choice, and student performance analysis are the most frequently addressed aspects of IPC, whereas curriculum content, assessment design, and teaching/learning through tools are less frequently addressed. The article presents a taxonomy of IPC based on the studied literature and offers general considerations and future research directions for practitioners and researchers in this area [3].

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This article discusses the benefits of using assessment tools for programming assignments in computing education. However, researchers and instructors are often unaware of the existing tools and either do not use them or re-implement them. To address this issue, the authors conducted a systematic literature review to collect and evaluate evidence about tools that assist in the assessment of programming assignments. The results of the study identify subjects for further research and characteristics of assessment tools that could help instructors select tools for their programming courses. [4].

This article focuses on e-assessment, which is the use of information and communication technologies (ICT) to prepare and administer assessments. The authors note that while e-assessment can make the assessment process easier in some ways, it also presents certain challenges. The article presents a framework for e-assessment from a student perspective, based on a study conducted over one academic year in two different mathematics courses for undergraduate informatics students. The study involved collecting and analyzing 631 students' responses to questionnaires administered three times throughout the year. The authors used a three-step factor analysis to identify four factors that make up the student perspective on e-assessment: transparency and fairness of assessment, formative and summative assessment and feedback, meaningful use of technology in assessment, and difficulty of learning outcomes. Overall, the students had a positive view of e-assessment and appreciated the student-centered approach that aligned all teaching and learning elements with assessment. The article uses keywords such as e-assessment, student perspective, mathematical education, assessment fairness, feedback, technology-enhanced learning, and face-to-face assessment [5].

This article discusses the impact of the COVID-19 pandemic on the world of education, specifically in terms of the shift towards online evaluation. The authors note that online evaluation had been marginal in most prestigious universities until now, but has become more prevalent due to the pandemic. The study compares the academic achievement of the last cohort that performed classroom assessment with the first group that was graded for an official degree using synchronous online evaluation. The study also measures the self-assessment of students in the second group using three different indicators: stress, difficulty, and fairness. The study involved 919 students, and the results indicate that online assessment resulted in grades that were 10% higher while enjoying the same degree of validity and reliability as traditional in-person assessments. The study also found that stress and difficulty levels were similar to on-site experiences, and students perceived the results to be fair. The authors conclude that online evaluation, when proctored, provides the same guarantees as traditional in-person assessments, with the added bonus of certain advantages that support their continued use, especially in degrees with many students from different locations [6].

The four papers were chosen because they address different aspects of computer programming education and assessment. The first article presents an analysis of existing research on introductory programming courses and offers a taxonomy of IPC based on the studied literature, providing practitioners and researchers with general considerations and future research directions. The second paper discusses the benefits of using assessment tools for programming assignments in computing education and provides evidence about characteristics of assessment tools that could help instructors select tools for their programming courses. The third article focuses on e-assessment and presents a framework for e-assessment from a student perspective based on a study conducted over one academic year in two different mathematics courses for undergraduate informatics students. The fourth paper examines the impact of the COVID-19 pandemic on the world of education, specifically in terms of the shift towards online evaluation, comparing the academic achievement of the last cohort that performed classroom assessment with the first group that was graded for an official degree using synchronous online evaluation. Overall, these papers offer insights into different aspects of computer programming education and assessment, highlighting the challenges and opportunities in this field.

3 METHODOLOGY

In order to conduct a comprehensive and rigorous literature review on e-assessment in computer science assignments, it was necessary to carefully plan and execute each step of the review process. This included developing a thorough search strategy, selecting appropriate search criteria, and establishing clear inclusion and exclusion criteria. In this methodology section, we will provide a detailed description of our approach to planning and executing the review, including a discussion of our search strategy, search criteria, and the results of our search. We will also outline our inclusion and exclusion criteria and describe how we selected relevant studies for inclusion in our review.

3.1 Planning the review

3.1.1 Review research aims and questions. The primary purpose of this study is to contribute to the small body of thorough reviews in the field of e-assessment research. According to evidence from prior study, the researchers have concentrated on a particular piece of the larger elements of -assessment. The primary objective of this research is to provide a complete overview of e-assessment methods, instructors' preferences, and e-assessment challenges and opportunities. In order to achieve these aims, this SLR addresses the following Research Questions (RQs):

RQ1: What are higher education instructors' most preferred methods for e-assessment in computer science assignments? (empirical studies).

RQ2: What are the recommended e-assessment types in the preceding literature?

RQ3: What are the challenges and opportunities of e-assessment in computer science assignments?

RQ4: What are the main impacts of e-assessment of computer science e-assessment on instructors?

3.1.2 Search strategy. This part develops a formal search approach for analysing all accessible empirical studies. The search included IEEE Xplore, ACM Digital Library, Springer and other journals and conferences. The search was conducted between January 2018 and January 2022. Afterwards, snowball was used to search and identify the relevant articles (snowballing). In addition, the next search string was used to find related papers to conduct this review:

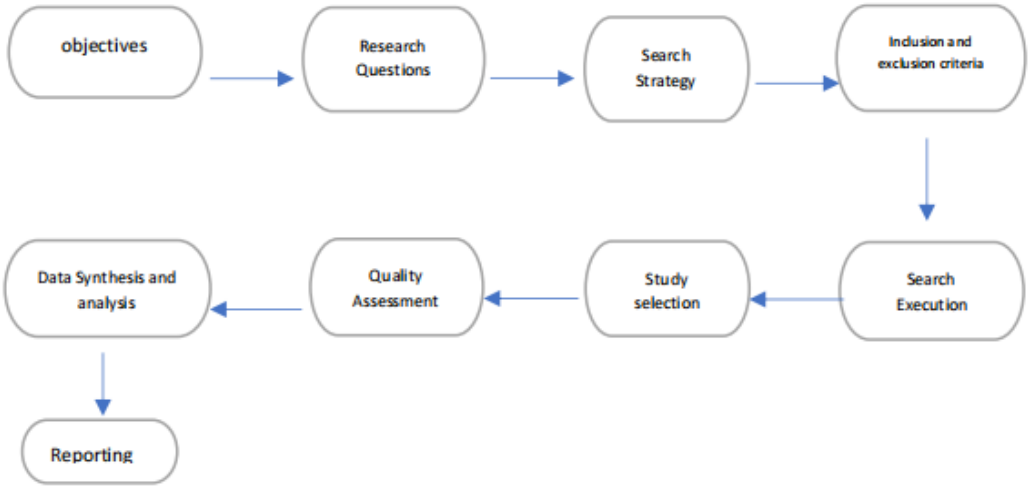

Figure 1: search strategy

Table 1: Search Criteria

Criteria	Definition
C1: is a search string relating to keywords that sugges special parameters for e-assessment relevant to this review's aims.	"e-assessment", "electronic assessment", "online assessment", " e-learning", "higher education", "online learning", "remote assessment", "online education", "remote learning", "e-education", "distance learning", "computer science assessment", "virtual assessment", "virtual education", "virtual learning".
C2: intends to gather all relevant publications by using an arrangement of search strings.	"assessment methods," "assessment types," "online assessment methods," " e-assessment methods ", "instructors preference," "instructors perception," "assessment preferences," "instructors' assessment performance," "instructors attitude," "instructors satisfaction," "e-assessment types", "e-assessment impacts", "online assessment challenges", "e-assessment challenges", online assessment obstacles", "e-assessment obstacles"," e-assessment opportunities", "online assessment opportunities", "academic performance".

("e-assessment" OR "electronic assessment") AND ("Higher Education"OR"Universities") AND ("Types"OR"Systems"OR"Methods") AND ("Challenges"OR"Obsticales"OR"impacts") AND ("Teaching"OR"Learning"OR"Instructors") AND ("Opportunities"OR"Advantages")

("e-assessment") OR ("electronic assessment") AND ("Higher Education") AND ("Types") AND ("Challenges") OR ("impacts") AND ("Instructors") AND ("Opportunities")

Fig. 1 outlines a systematic research approach consisting of eight steps. It begins with defining research objectives and formulating research questions. A search strategy is then developed, followed by establishing inclusion and exclusion criteria. The search is executed in selected databases, and studies are selected based on the criteria. Data synthesis involves extracting relevant information from selected studies. Finally, the findings are reported in a structured manner. This systematic process ensures a comprehensive and rigorous approach to conducting research.

3.2 Search criteria

This consists of the two sections listed below:

A search string included keywords that imply e-assessment.

Based on the information provided in table 1, we have chosen this particular search string because it includes a range of relevant keywords related to e-assessment and its applications in the context of higher education and online learning. These keywords cover various aspects of e-assessment, including its electronic and remote nature, as well as its relationship to e-learning, distance learning, and virtual education.

By using this search string, it is likely to find information on specific parameters and best practices for e-assessment, as well as any relevant case studies or research studies that relate to the use of e-assessment in higher education or online learning contexts. The inclusion of more specific keywords, such as "computer science assessment" and "virtual assessment," may help to further refine this study and uncover more targeted results.

Table 2: Study selection results

Phase	Process	Selection stage	IEEE	ACM	Springer	Others	Total
1	Search	Search String	1	21	1718	5	1745
2	Screening	Title	18	18	21,586	-	21622
3	Screening	Abstract	37	47,918	47,399	-	95354
4	Screening	Full text	766	48	1780	-	2594

3.3 Inclusion and exclusion criteria

Inclusion and exclusion criteria are predetermined standards used to determine which studies or articles will be included or excluded from a systematic review. These criteria are established at the outset of the review and based on the research questions and objectives of the study [7].

I1: Research papers written in English language are included.

I2: studies published between January 2018 and April 2022.

I3: studies pertaining to subjective aspects of the review.

I4: studies pertaining to selected databases.(ACM & IEEE & Springer)

E1: Research articles without abstract

E2: non-English language publications.

E3: papers that deal with special issues or are written for specific conferences or workshops.

E4: Papers that do not include e-assessment as their primary focus

E5: publications with five pages or less.

4 SEARCH RESULTS

This section illustrates the study selection results and outlines the search strategy used to identify relevant studies, and the number of articles screened. Then, there is a classification of the selected studies into four sections which are, reference of article, channel, published year and type of research. We provide readers with a clear understanding of how the final sample of studies was chosen for the analysis.

4.1 Study search and selection

4.1.1 Study selection results. Table 2 presents the findings of a systematic review that followed a rigorous and transparent process for selecting and evaluating research studies on a particular topic. The table shows the number of studies identified and selected in each phase of the review process, as well as the number of studies from different academic publishers. The table reveals that the majority of the studies identified were from Springer, while IEEE and ACM had a smaller number of studies. No studies were found from other sources. The results indicate that the majority of the studies were identified in the abstract screening phase, with a total of 95,354 studies screened, and only a small percentage of studies were screened in the full-text phase.

4.1.2 Classification of articles. https://pure.soton.ac.uk/admin/files/120402728/A_classification_of_paper_.csv

The link provides information about various research studies published between 2018 and 2023, including their reference, channel, published year, and type of research. The studies cover a range of topics and fields, and they include systematic literature reviews, state-of-the-art reviews, experimental research, empirical studies, case studies, and a comparison study. Data on techniques, contributions, validation methods, discoveries, and limitations were stored in spreadsheets, and research synthesis was conducted according to a structured procedure for data extraction and synthesis, including study title, author(s), primary objectives, methodology, data analysis, validation techniques, limitations, publisher, and publication year.

5 RESULTS AND DISCUSSION

The results and discussion will address each of the research questions:

5.1 RQ1: What are higher education instructors' most preferred methods for e-assessment in computer science assignments?(empirical studies)

The 86 papers that have been chosen via the search process examine e-assessment from a variety of vantage points. The key findings are there are a variety of e-assessment methods that higher education instructors use for computer science assignments, and preferences can vary depending on the instructor's teaching style, course goals, and the learning outcomes they hope to achieve [8]. Some commonly used e-assessment methods in computer science assignments include:

Automated coding assessments can save instructors time and provide objective feedback to every student based on the same criteria. This is particularly beneficial for courses with large enrollment. However, automated feedback can be limited to predefined criteria, which may result in a lack of personalized feedback for students [9]. To address this limitation, instructors can supplement automated assessment with manual feedback. Over-reliance on automated assessment can lead to missed opportunities for personalized feedback and overlook other important aspects of the student's work [10].

Multiple-choice questions provide an efficient way to assess a broad range of knowledge and reduce subjective bias [11]. However, they can only assess limited skills and may be guessed, which can make results less accurate. They also cannot assess higher-order thinking skills, which may limit their usefulness in certain contexts [12].

Short answer questions are commonly used to assess knowledge recall and understanding of concepts. While they can be manually graded, some e-assessment systems offer automated grading using natural language processing [13]. However, the limited space for

responses may lead to a lack of clarity or accuracy, particularly for questions that require in-depth or nuanced answers. Additionally, the narrow response format may not capture the complexity of interdisciplinary topics, limiting the ability to provide a comprehensive answer [14].

5.2 RQ2 What are the recommended e-assessment types in the preceding literature?

Electronic assessments, or e-assessments, have become increasingly popular in recent years due to their convenience, efficiency, and cost-effectiveness [15]. The following are some of the recommended e-assessment types that have been identified in the literature:

True/false questions are a quick and easy e-assessment type to grade automatically, useful for assessing recall and basic concepts [13]. However, they may not assess higher-order thinking skills and are more susceptible to guessing, limiting their accuracy [16].

Essay questions require longer, detailed responses and are useful for assessing higher-order thinking skills [17]. They can be flexible in assessing a wide range of subjects, but they are time-consuming to grade manually and may be more subjective than other types of questions ([18]; [19])

5.3 RQ3: What are the challenges and opportunities of e-assessment in computer science assignments?

Based on the most recent prior research, e-assessment difficulties may be categorized as follows: E-assessment in computer science assignments offers a range of challenges and opportunities, including:

5.3.1 Challenges. E-assessment offers an opportunity for innovation and development of new technologies to improve the learning experience for students and increase access to assessment ((Doğan et al., 2020); [1]). However, it relies heavily on technology, which can create technical and security challenges, potentially resulting in unequal access to assessment opportunities and privacy concerns [20].

E-assessment increases the risk of cheating and plagiarism, and can be susceptible to technical issues [21]. This may require proctoring or monitoring to ensure academic integrity, which can create logistical challenges for institutions and be uncomfortable for students. Additionally, e-assessment may require the use of online platforms, which can make it challenging to verify identity and easier for students to cheat.

5.3.2 Opportunities. E-assessment can save time by automating grading and providing flexibility for students to complete assessments [11]. It can also offer detailed data on student performance to inform teaching practices and ensure standardization in the assessment process [22].

Immediate feedback in e-assessment reinforces learning, personalizes feedback based on strengths and weaknesses, and helps identify areas for improvement [23]. It also motivates students to continue learning and saves time for educators by automating certain feedback processes [17].

5.4 RQ4: What are the main impacts of e-assessment of computer science e-assessment on instructors?

The problems, beliefs, and behavioral patterns associated with e-assessment might have an effect on the quality of the learning results [24]. E-assessment of computer science assignments has several impacts on instructors, including:

E-assessment automates grading, feedback, and record-keeping, reducing instructors' workload and allowing them to focus on teaching [25]. It also provides immediate and detailed feedback to students, helping them identify areas for improvement [20]. Additionally, specialized software can automate grading for multiple-choice questions and programming assignments, checking for correct syntax and functionality [26].

E-assessment provides instructors with tools for detailed and timely feedback, but there are challenges in providing effective feedback [27]. Automated feedback systems can provide immediate and detailed feedback to help students learn from mistakes, while rubrics and peer feedback can supplement instructors' feedback ([28]; [29]. Instructors can also use multimedia feedback, such as video or audio recordings, to provide engaging and effective feedback to students [29].

6 CONCLUSION

In conclusion, our systematic literature review on e-assessment in computer science assignments has provided a comprehensive overview of the various assessment types used in e-assessment, instructors' perspectives on the advantages and challenges of e-assessment. Our review has identified several advantages of e-assessment, such as efficient grading and automated feedback, but also highlighted some unique challenges, such as ensuring academic integrity and providing personalized feedback. We also identified several assessment types used in e-assessment, including multiple-choice questions, coding exercises, and peer assessments. Overall, our review provides valuable insights for instructors and researchers on the use of e-assessment in computer science assignments and identifies key research directions for future studies.

E-assessment is getting more popular in computer science assignments, as it offers benefits like efficient grading and automated feedback. However, e-assessment also has challenges, such as ensuring academic integrity and giving personalized feedback. The field of e-assessment is changing quickly, with new technologies and methods appearing regularly. This means that instructors and researchers need to keep up-to-date to ensure they use the most effective methods. This review helps the field of e-assessment and points to key areas for future research. As technology advances, it will be exciting to see how e-assessment develops and how it can enhance learning for students while maintaining academic integrity.

7 LIMITATIONS AND FUTURE WORK

This study has been conducted with a thorough methodology that has addressed a very specific set of research questions. However, the study still contains certain limitations. Firstly, our review may be limited by the quality and quantity of the existing literature on this topic, as there may be biases in the publication of research and

limitations in the methodologies used. Additionally, we may have missed relevant studies that were not included in our search terms or databases. Finally, our review only focuses on e-assessment in computer science assignments, which may limit the generalizability of our findings to other fields or subjects.

Future research can address the limitations of this study in several ways. Firstly, a meta-analysis could be conducted to synthesize the existing literature on e-assessment in computer science assignments and overcome limitations in individual studies. Secondly, expanding the scope of the review to other fields or subjects can help determine the generalizability of the findings. Thirdly, exploring the perceptions and experiences of students and instructors with e-assessment in more depth can provide a better understanding of its benefits and challenges from their perspectives. Finally, developing and testing new e-assessment tools and methods to address the challenges identified in this review can improve the effectiveness and efficiency of e-assessment.

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