Board 64: Work-In-Progress: A Scoping Review of Technology Acceptance and Adoption among Engineering Students

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A Scoping Review of Technology Acceptance and Adoption; Engineering Students' Perspective

Introduction

Technological advancements have significantly facilitated a dynamic shift in developmental processes across various fields, including education. Technological innovations are developed and adopted to facilitate formal education on the premise that they would improve student learning outcomes. Dawson, et al. [1] indicate that adopting technological innovations in higher education significantly impacts the quality of learning delivery, student engagement, and academic accomplishments. To meet the complex and dynamic demands of the 21st century, stakeholders of engineering education have also been exploring and adopting instructional technologies to improve the teaching and learning experience in engineering education. To develop technical competencies in engineering students, integrating diverse educational technologies such as educational games, mobile learning tools, and virtual reality technology is important [2], evidenced by the extensive breadth of research that has investigated how these technologies can be effectively designed to suit intended objectives.

As large investments continue to be made in educational technologies for engineering classrooms, it becomes imperative to investigate factors contributing to their successful integration for learning. This need has led to recent research focused on understanding the behavioral intention of students to use technology for their intended purpose, stemming from the idea that the success of any innovation lies in its end users' (learners) disposition [3]. Several models and theories have thus been adopted, modified, and validated to assess influencing factors for students' acceptance behavior in technology-enhanced learning environments [4].

Although considerable studies on students' technology acceptance have been conducted within the engineering classroom, there has been an overlooked effort to synthesize existing research and inform researchers, instructors, and other relevant stakeholders about the current state of research. Such an understanding serves an informative and strategic role in advancing technological innovations for engineering education. It offers insights into what has been done, what has been successful, and where we should direct our efforts in the educational technology landscape thus guiding future research and decision-making efforts. Our study addresses this gap by conducting a scoping review on technology adoption and acceptance by engineering students.

In this study, we identify and synthesize existing literature that examines engineering students' acceptance and adoption of technology within and outside the classroom by performing a scoping review. A scoping review is an approach to assessing the breadth and depth of a field by summarizing the existing range of evidence [5]. Major reasons for carrying out a scoping review include; rapid review to examine the range, extent, and nature of research activity, preliminary mapping to determine the value of conducting a systematic review, to summarize and disseminate research findings, and to identify gaps by concluding existing literature [6]. Our study's purpose aligns with the third and fourth reasons as we intend to carry out a scoping review to summarize, draw conclusions, and identify research gaps in the existing literature on engineering students' technology acceptance and adoption.

Considering this, we address the following research questions,

> What factors influence the adoption and acceptance of educational technologies by engineering students?
>
> What are future research directions that may advance the acceptance and adoption of educational technologies by engineering students?

Search and Synthesis Method

The scoping review in this study is conducted using the method checklist of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Review (PRISMA-ScR).

Defining the eligibility criteria: Technical documents written in English, including peer-reviewed journals and conference proceedings, that discuss the acceptance and adoption of educational technology in engineering education are included in this review. To capture the extent of the literature, there was no limit placed on publication date.

Determining the information source: The advanced search feature of the University of Georgia library website was used to conduct a literature search. To identify potentially relevant articles, search results were filtered to include the following databases: ERIC, Social Sciences Citation Index, Science Citation Index Expanded, APA PsycInfo, Education Research Complete, Academic Search Complete, IEEE Xplore Digital Library, Directory of Open Access Journals, MEDLINE with Full Text, ScienceDirect, Science & Technology Collection.

Designing search strategy: Our search strategy was based on the combination of phrases related to our study's objectives and research questions. Specifically, we used the following Boolean phrase search query:

(accept OR implement* OR adopt* OR intent*) AND (innovat* OR technolog*) AND (tertiary OR "higher education" OR universit*) AND (student*) AND (engineer*) AND (learn*)*

Identifying the relevant documents: Our literature search, conducted on October 13th, 2023, returned 3,531 articles. These articles were screened in two phases, based on their titles and abstracts, and the selection criteria identified in **Figure 1.** Finally, we identified 56 articles that met our inclusion criteria and were subjected to full-text review and analysis.

Reviewing the full manuscripts: In this step, we reviewed the full text of the relevant studies to extract information that helps address our research questions and study objectives. We collected two sets of information in this step. The first set captures basic publication features such as publication type, publication year, and study country. The second set of information delves into the main content of the articles to capture their contribution to the existing body of knowledge in terms of purpose, technology type, student-related barriers, and behavioral intents.

Synthesizing the extracted information: At this stage, we synthesize the extracted data to provide a coherent summary of the research landscape in identifying knowledge gaps, common limitations, and potential directions for future scholarly research.

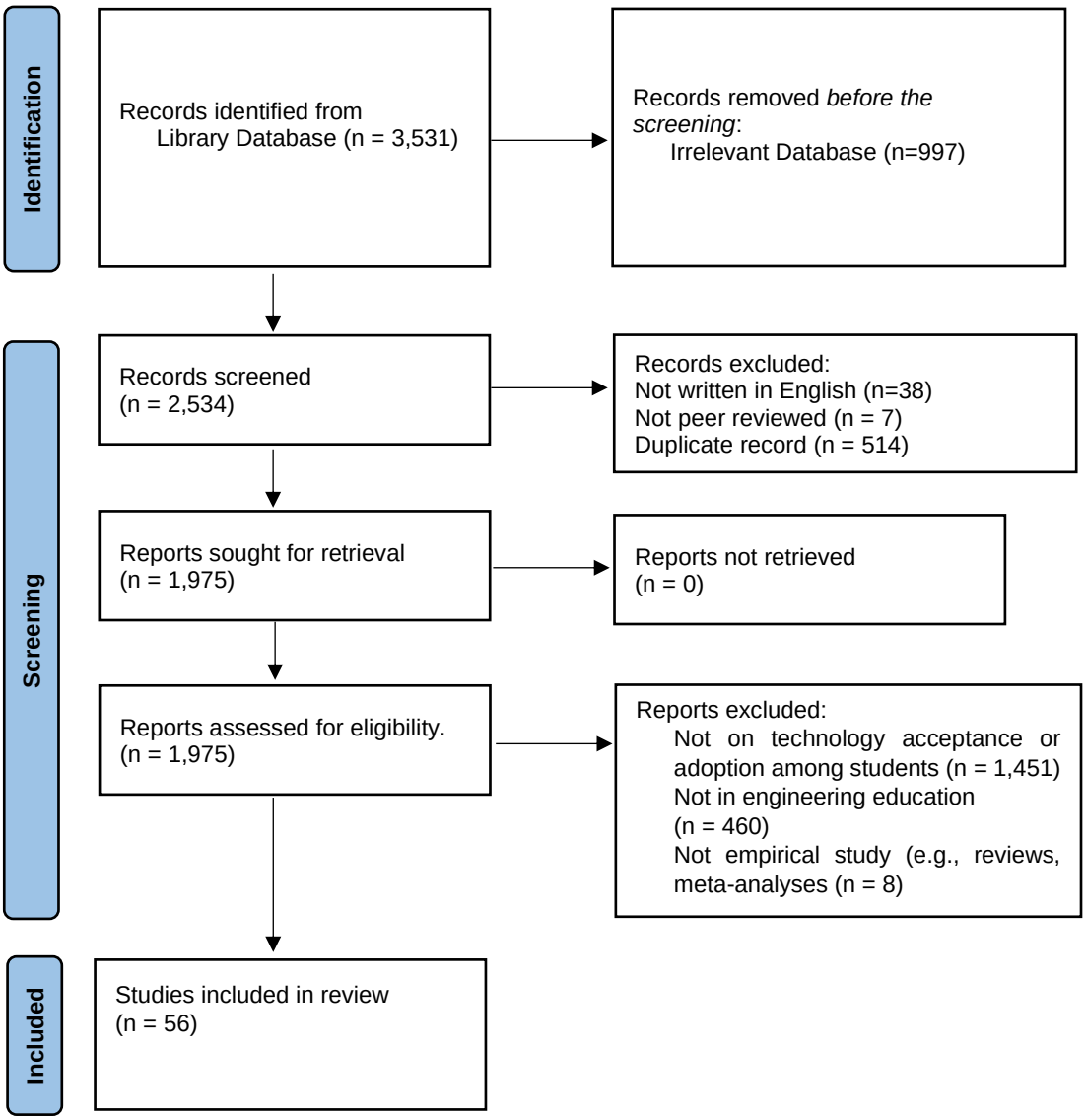

Figure 1: Flow Diagram for Scoping Review

Preliminary Results and Discussion

We extracted a wide range of data from relevant publications identified for our study and presented an overview of the synthesized information in line with our research questions in the sections below.

Publication Distribution by Year and Type

Articles in our study had publication years ranging between 2003 and 2023, with a majority published within the last decade. The sudden jump in 2020 (Figure 2a) is attributed to the COVID-19 pandemic which saw an increased adoption of educational technologies for teaching. The observed increase in publications from 2019 shows the attractive trend of technology acceptance research [7] in engineering education within the teaching and learning context. Before 2019, we infer that a greater focus was placed on integrating technologies into the teaching and learning process without a specific focus on their acceptance by students. Figure 1a below shows the number of publications across the years for identified relevant publications. In publication type, most identified studies were published in journal

outlets with a limited amount in conference proceedings (Figure 2b). This could be because our study was limited to empirical studies focused on engineering students' acceptance and adoption of educational technologies.

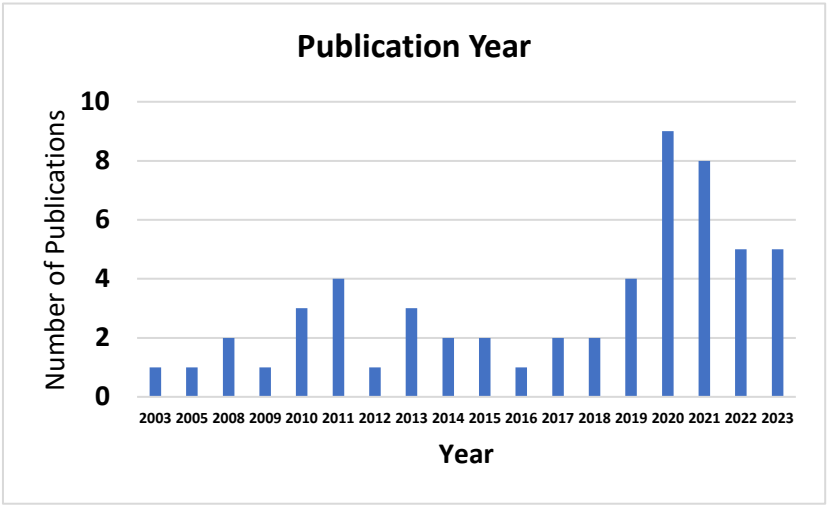

Figure 2a: Article Distribution based on Publication Year

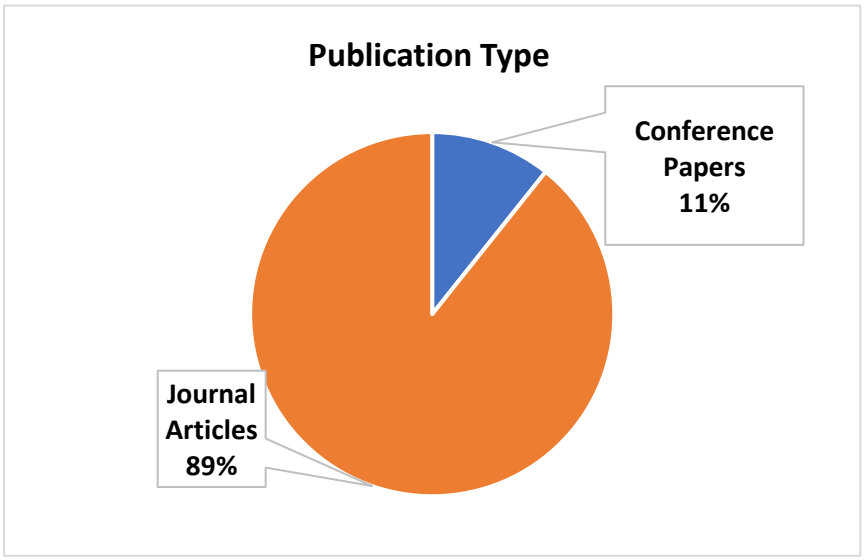

Figure 2b: Article Distribution based on Publication Type

Due to time constraints, we present findings, in line with our research questions, based on an in-depth analysis of 31 of the identified relevant studies.

Of the 29 studies that adopted a specific research design, the majority were quantitative (22), with others mixed method (4), qualitative (2), and multi-method (1). The most common instrument for measuring constructs of interest was questionnaires. There was no widely accepted questionnaire for measuring similar constructs of interests. Studies either developed questionnaire items based on operational definitions of constructs or adapted existing questionnaires to fit their context. Additionally, while many studies were conducted with undergraduates, they failed to specify the field of engineering in which their study was

conducted thus limiting the applicability and interpretation of their findings for multidisciplinary instructors and researchers.

Blended learning, E-learning, and mobile learning were the most frequently assessed forms of technology for student adoption and acceptance. This was a surprising finding as we had expected to find more research focused on computational tools specific to the field of engineering. The Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) were the most adopted technology models used in explaining the behavioral intention of students as observed by [4]. In response to calls for a technology acceptance model for game-related research [8], Hafiza Razami and Ibrahim [9] propose a digital educational game (DEG) model. The actor network, rogers' innovation diffusion, and expectation confirmation theory were theories used in combination with technology models.

Major barriers/challenges influencing the adoption of educational technologies by students for learning were technical difficulties [10, 11], uncertainty of instructors as to implementation expertise [12], and inadequate experience with technology type. The competition-based structure of educational games, previous gaming experience, and inadequate transfer of experience from entertainment-based games were also observed in [13, 14] to be barriers to the adoption and acceptance of an online educational game for engineering concepts.

In terms of scope, studies in our review could be categorized into 3 major groups; studies that focused on testing the predictive ability of an existing technology model as-is, studies that proposed modifications, justified by a research gap and context requirement, to existing technology models for predicting the behavioral intention of technology use, and studies that evaluated technologies by assessing learners experience with no predictive intent for usage. The first group consisted of 3 publications that were focused on assessing the level of acceptance of mobile learning, Learning Management Systems (LMS), and augmented reality technology among engineering students for learning due to a dearth of studies in the study country. These studies proposed moderators like gender, aesthetics, and information quality for the predictive ability of existing technology models.

The second group comprised 12 publications that proposed additional constructs like perceived satisfaction/enjoyment, social influence, ease of collaboration, resource availability, learning relevance and control, performance expectancy, effort expectancy, player experience, attractiveness, challenge, social interaction, feedback, concentration, immersion, facilitating conditions, hedonic motivation, attitude towards use, subjective norm, technology optimism, and technology innovativeness. However, constructs like player experience, attractiveness, challenge, social interaction, feedback, concentration, and immersion are yet to be validated. While constructs like performance expectancy, effort expectancy, social influence, and facilitating conditions had mixed results with inconsistency across study contexts revealing a need for additional research into the predictive factors of technology acceptance and adoption among engineering students in specific domains. Finally, factors like gender, age, cyber sickness, and educational level were observed to be valid moderators in this group.

The third group had 16 publications focused on understanding the perceptions of learners about technology implemented into their classroom instruction and the technology available

to them as students of an institution. Studies in this group shed light on the need to adequately understand the experiences of engineering students with varied technologies to measure their readiness against the successful implementation of technology for the new generation of learners[15, 16].

Future Directions

Based on our preliminary analysis, we propose the following directions for future research on technology acceptance and adoption among engineering students.

Technology acceptance and adoption research should be extended to domain-specific technology for engineering practice [17]. As the success of any technology depends on the end users [16], we must investigate learning technologies that characterize foundational engineering courses to ensure effective implementation in preparing engineering learners for future careers. Furthermore, there is a need to develop and make available validated instruments for measuring technology acceptance-related factors towards a standardized understanding of the literature.

Presently, we observed adoption and acceptance to be used interchangeably in most of the reviewed studies and propose that a clear distinction be made by researchers in their publications. This distinction enables instructors to identify literature relevant to their classroom or institutional phase, yielding positive impacts. In terms of environmental factors, a thick description of the study context should be provided to situate readers' understanding and interpretation of findings and improve transferability.

Conclusion

This work-in-progress paper describes the preliminary analysis of a scoping review being conducted to understand the scope of existing literature on technology acceptance and adoption among engineering students. We highlight factors influencing the acceptance and adoption of educational technologies among engineering students and propose potential future directions to enhance the existing body of knowledge. Upon completion of our study, we would set the stage for future scholarly work on the successful implementation of educational technologies for acceptance and adoption among engineering students.

References

[1] S. Dawson, L. Heathcote, and G. Poole, "Harnessing ICT potential: The adoption and analysis of ICT systems for enhancing the student learning experience," *International Journal of Educational Management,* vol. 24, no. 2, pp. 116-128, 2010.

[2] K. Cook-Chennault and I. Villanueva, "Exploring perspectives and experiences of diverse learners' acceptance of online educational engineering games as learning tools in the classroom," ed: IEEE, 2020, pp. 1-9.

[3] H. Taherdoost, "A review of technology acceptance and adoption models and theories," *Procedia manufacturing,* vol. 22, pp. 960-967, 2018.

[4] A. Granić, "Educational Technology Adoption: A systematic review," *Education and Information Technologies,* vol. 27, no. 7, pp. 9725-9744, 2022/08/01 2022, doi: 10.1007/s10639-022-10951-7.

[5] D. Levac, H. Colquhoun, and K. K. O'Brien, "Scoping studies: advancing the methodology," *Implementation Science,* vol. 5, no. 1, p. 69, 2010/09/20 2010, doi: 10.1186/1748-5908-5-69.
[6] H. Arksey and L. O'Malley, "Scoping studies: towards a methodological framework," *International Journal of Social Research Methodology,* vol. 8, no. 1, pp. 19-32, 2005/02/01 2005, doi: 10.1080/1364557032000119616.
[7] C. Gupta, V. Gupta, and A. Stachowiak, "Adoption of ICT-Based Teaching in Engineering: An Extended Technology Acceptance Model Perspective," *IEEE Access, Access, IEEE,* Periodical vol. 9, pp. 58652-58666, 01/01/ 2021, doi: 10.1109/ACCESS.2021.3072580.
[8] C. Udeozor, F. Russo-Abegão, and J. Glassey, "Perceptions and factors affecting the adoption of digital games for engineering education: a mixed-method research," *International Journal of Educational Technology in Higher Education,* Article vol. 20, no. 1, pp. 1-20, 2023, doi: 10.1186/s41239-022-00369-z.
[9] H. Hafiza Razami and R. Ibrahim, "Integration of Player Experience for the Acceptance Model of Science, Technology, Engineering and Mathematics Digital Educational Games," ed: IEEE, 2022, pp. 622-629.
[10] A. Chibisa and D. Mutambara, "An exploration of STEM students' and educators' behavioural intention to use mobile learning," *Journal of E-Learning & Knowledge Society,* Article vol. 18, no. 3, pp. 166-177, 2022, doi: 10.20368/1971-8829/1135622.
[11] B. Marks and J. Thomas, "Adoption of virtual reality technology in higher education: An evaluation of five teaching semesters in a purpose-designed laboratory," *Education and information technologies,* vol. 27, no. 1, pp. 1287-1305, 2022 2022, doi: doi:10.1007/s10639-021-10653-6.
[12] N. N. Kuzmina, E. G. Korotkova, and S. M. Kolova, "Implementing E-Learning in the System of Engineering Students Training," ed: IEEE, 2021, pp. 818-823.
[13] K. Cook-Chennault and I. Villanueva, *Exploring perspectives and experiences of diverse learners' acceptance of online educational engineering games as learning tools in the classroom*. IEEE, 2020, pp. 1-9.
[14] K. Cook-Chennault and I. Villanueva, *An initial exploration of the perspectives and experiences of diverse learners' acceptance of online educational engineering games as learning tools in the classroom*. IEEE, 2019, pp. 1-9.
[15] G. Naveh and A. Shelef, "Analyzing attitudes of students toward the use of technology for learning: simplicity is the key to successful implementation in higher education," *International Journal of Educational Management,* Article vol. 35, no. 2, pp. 382-393, 2021, doi: 10.1108/IJEM-04-2020-0204.
[16] A. Hanif, F. Q. Jamal, and N. Ahmed, "Behavioral Intention for Adopting Technology Enhanced Learning Initiatives in Universities," *Journal of Behavioural Sciences,* Article vol. 28, no. 1, pp. 88-104, 2018. [Online]. Available: https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=a9h&AN=132336742&site=eds-live&custid=uga1.
[17] M. D. Koretsky and A. J. Magana, "Using Technology to Enhance Learning and Engagement in Engineering," *Advances in Engineering Education,* 2019.