The Role of Simulation in Creating Project: A Literature Review

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Keywords: Simulation, Creating, Projects, Literature Review.

Abstract: The implementation of simulation in projects facilitates the examination, strategizing, and experimentation of solutions while circumventing the need for costly and specialized technical expertise. The purpose of this study is to examine the results of thinking and research on the use of simulation and its benefits in creating projects that have been published by Scopus over the past 10 years. This research is a literature review, with procedures consisting of four steps: namely, research design, filter methodology, online database search, inclusion & exclusion criteria, and data analysis. The findings from 15 scholarly articles indicate that simulation is employed in the domain of science education at a prevalence of 74%. Within the realm of education in engineering, the utilization rate of the aforementioned concept stands at 27%. In contrast, the utilization rate of said concept in education pertaining to health and management is 13% each. The incorporation of simulation into project-based learning has been found to be a highly efficacious approach for enhancing educational outcomes and fostering skill acquisition. Additional investigation is required to delve deeper into the results of the literature review. The limitations and shortcomings identified in the literature review are acknowledged by the researchers.

1 INTRODUCTION

In the realm of education, institutions of higher learning hold a pivotal position in facilitating progress and ought to actively participate in the attainment of educational objectives. The dynamic nature of technology necessitates that education must adjust to meet the evolving demands of learners (Abulrub et al., 2011). Furthermore, it is imperative to maintain regular updates of technology and educational support devices (He et al., 2019). The methodology utilized during instruction, along with the instructor's intentions, constitutes a multifaceted amalgamation that characterizes the approach to teaching and learning (Cao et al., 2019). Providing learners with exposure to authentic real-world problems and involving them in a thorough investigative process can facilitate the cultivation of proficient communication skills and interdisciplinary learning through the application of prior knowledge (Toledano-O'Farrill, 2019; Pan et al., 2019). To clarify, the aforementioned approach furnishes learners with prospects for practical learning and the acquisition of proficiencies such as collaborative work, analytical thinking, and numerical computation, which are deemed indispensable for optimal organizational performance (Sindre et al., 2018). As per the constructivism theory, learners have a tendency to establish links between newly acquired information and their pre-existing knowledge (Zadok, 2020).

Simulations are highly beneficial for learners as they offer tasks or projects that present challenges or problems that require resolution (Lee & Tsai, 2017). The process of incorporating simulation environments, scenarios, or models into project-based learning experiences is aimed at augmenting the learning process. Simulations are employed as instruments for the purpose of examining, strategizing, and evaluating remedies (De Oña & Lova, 2019). The approach being referred to in this statement fosters the acquisition of a range of competencies by students, including but not limited

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Widia, , Kaniawati, I. and Hasanah, L.
The Role of Simulation in Creating Project: A Literature Review.
DOI: 10.5220/0013422600004654
In *Proceedings of the 4th International Conference on Humanities Education, Law, and Social Science (ICHELS 2024)*, pages 700-707
ISBN: 978-989-758-752-8

to problem-solving, collaboration, communication, critical thinking, and creativity. The incorporation of simulations in projects enables the exploration of various possibilities without incurring substantial expenses or necessitating intricate technical proficiency (Eskrootchi & Oskrochi, 2010).

Several scholarly articles elucidate the utilization of simulations as a means to facilitate the achievement of project success, as per the aforementioned depiction. Hence, it is imperative to conduct a more comprehensive analysis of the publication patterns concerning simulations carried out by researchers across diverse projects. The objective of the author is to conduct an analysis of the ideas and research findings pertaining to simulations over the last decade, spanning multiple nations and academic disciplines, as documented in global scholarly publications. Considering the aforementioned, the writer presents a number of inquiries:

• Which disciplines have extensively explored the topic of simulations?

• Which types of simulation are frequently employed in project development?

• What are the benefits of simulations in the project creation of process?

2 METHODS

2.1 Research Design

The objective of this investigation is to conduct a comprehensive analysis of diverse literature sources pertaining to the function of simulations in the context of project advancement. The process of scrutinizing extant literature through the application of specific criteria is deemed a pivotal undertaking. The filter methodology has been employed in the design as it is considered the most effective approach for discerning research inquiries.

2.2 Data Search

A systematic search was performed to retrieve scholarly literature on simulations from various databases, including Scopus, Web of Science, Publish or Perish, ERIC, Wiley Online Library, and Google Scholar. The present study examined articles that were published in the past decade, specifically between 2013 and 2022, by utilizing the keywords "simulation" and "project." The search for data was executed in the month of May in the year 2023.

2.3 Inclusion and Exclusion Criteria

The research employs specific inclusion criteria, namely: (a) the articles utilized were published in 2014 or later, (b) the articles utilized are indexed in international journals, and (c) the articles utilized pertain to the topic of simulation-based teaching and learning. The criteria for exclusion are outlined as follows: The guidelines for article selection in this study are as follows: (a) articles written in languages other than English are prohibited; (b) articles utilized must be composed in globally recognized languages; and (c) articles utilized must remain within the scope of the field of education.

2.4 Data Analysis

The present study undertook a three-phase analysis of articles. The initial phase entailed scrutinizing 50 articles based on their titles and abstracts, which yielded a final selection of 30 articles. During the subsequent phase, the analysis was centered on the research objectives, methodologies, and findings, culminating in the production of 15 articles (as depicted in Figure 1).

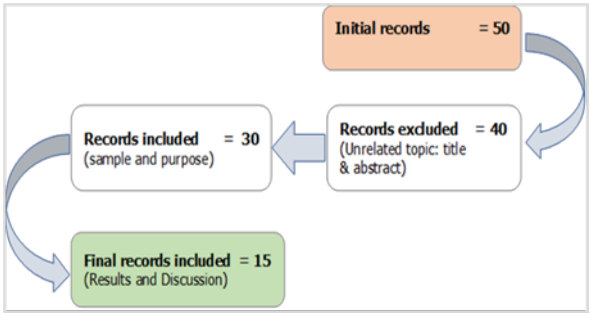

Figure 1: The process of analysis and selection of literature review articles.

After analyzing and identifying relevant articles based on predetermined criteria, the descriptive analysis was conducted with a focus on various aspects including authors, publication year, objectives, methods, and research findings. The objective of this descriptive analysis is to furnish a comprehensive outline of the prevalence of integrated simulation in project-based learning. The process entails engaging in reading activities with the aim of acquiring a broad comprehension of the subject matter. The authors conducted an analysis of research findings in specific sections of the selected articles.

3 RESULTS

In this study, the literature review comprised a selection of 15 articles that were deemed relevant to the research questions posed at the outset. Table 1 provides a comprehensive overview and comparative analysis of the chosen articles, encompassing the distribution of said articles with respect to authors, year of publication, research objectives, methodologies employed, and resultant findings.

Table 1: Descriptive data of the analyzed studies (N = 15).

Author (year)	Objective	Method	Effect
Bajow et al, (2022)	Analyze the success of a simulation-based strategy for chemical exposure prevention.	Mixmethods n = 41	The utilization of advanced simulations has the potential to augment the cognitive and practical proficiencies of individuals in effectively addressing incidents of mass chemical exposure (Bajow et al., 2022).
Chang et al., (2017).	Examine the process of resolving physics problems through the utilization of simulations, both individually and collaboratively.	Qualitative Squencial n = 30	Simulations that are based on collaboration have the potential to transform discussions into problem-solving endeavors. In contrast, simulations based on individual units exhibit a lower magnitude (Chang et al., 2017).
Jin & Durlofsky (2020)	Employing computational fluid dynamics (CFD) simulation to mitigate data loss and minimize errors.	Ekperiment n = 200	In general, the E2C ROM demonstrated a high degree of dependability in its prognostications, surpassing the current POD methodology in terms of disturbance management (Jin et al., 2020).
Yang et al. (2019)	This study involves a comparative analysis of flood simulations derived from five distinct global hydrological models (GHM) in conjunction with the Inter-Sectoral Impact Model Intercomparison Project 2a (ISIMIP2a).	Eksperiment	The global hydrological models (GHM) method yields favorable outcomes in regards to peak amplitude. The statement posits that the integration of traditional flood simulation methods with machine learning techniques could potentially enhance the reliability of flood risk evaluation (Yang et al., 2019).
Correia, et al. (2019)	Examine the utilization of simulation-based learning systems, specifically the PhET platform, in conjunction with the cognitive processing of chemical concepts.	case study n = 114	The simulation laboratory facilitates the visualization of gas behavior for students, while the system's design promotes comprehension of gas behavior at the submicroscopic level (Correia et al., 2019).
Dong et al. (2021)	This study aims to examine the level of uncertainty associated with the cost of generating wind energy by utilizing contemporary wind turbine simulations.	Meta analysis	The utilization of simulation techniques has the potential to decrease the expenses associated with the production of wind power. The sensitivity analysis indicated that the combined impact of the scale parameter, shape parameter, and air density on the total effect coefficient was positive (Dong et al., 2021).

Chung et al. (2013)	Conduct an examination of sites that pose a risk to human health or the environment through the utilization of specialized simulation software, specifically the Interactive Site Investigation Software (ISIS).	Qualitative n = 23	The Interactive Site Investigation Software (ISIS) is a computer program designed for interactive site investigation purposes. The aforementioned approach has a significant positive impact on students and is efficacious in enhancing their ability to manage intricate projects, bridging the gap between theoretical concepts and practical scenarios, and augmenting their proficiency in resolving complex problems (Chung et al., 2013).
Zwikael & Chih (2015)	The present study aims to evaluate the efficacy of simulation-based training (SBT) in the context of project management education.	Eksperimen n = 25	The utilization of Simulation-Based Training (SBT) has been shown to enhance the participants' declarative knowledge within the simulation and bolster their overall learning process. There exist multiple scenarios in which SBT proves to be a more efficacious approach for educating students in project management (Zwikael et al., 2015).
Crespo & Quiroz (2015)	This study aims to evaluate the effects and potential advantages of implementing virtual reality technology in the operation of the Mitsubishi Movemaster RV-M1 robot.	Eksperiment n = 10	The use of simulation technology enables the user to program individual joints of the robot and showcase various features of the robot in a virtual setting. These features may include animations, images, and textual information, which are a direct outcome of the developed features. The present software has the capability to perform a comparison between input sequences provided by the user and sequences generated by the computer, utilizing specific algorithms (Crespo et al., 2015).
Akkoyun (2017)	We are pleased to present a recently developed simulation software that has the capability to simulate natural stone mills, specifically designed for engineering students.	Qualitative	The favorable response received from students regarding the novel simulation software serves as a motivating factor for researchers to undertake additional projects. It also attests to the efficacy of the software in accomplishing its pedagogical objectives (Akkoyun, 2017).
Chakraborty & Elzark (2019)	Perform simulations of diverse machine concepts to facilitate the development of energy models that are more precise and effective.	Comparative Analysis	The XGBoost algorithm has demonstrated a high degree of precision in generating energy models. Furthermore, the inclusion of intermediate steps is deemed crucial in the development of both XGBoost and artificial neural network (ANN) models (Chakraborty & Elzarka, 2019).
Chaplin, et al. (2020)	Simulation plays a crucial role in the healthcare system, as it has the potential to enhance the quality of medical education by providing various applications.	Qualitative Survey	Research that utilizes emergency simulations can effectively identify factors that promote or hinder progress and establish agreement on key research topics. The initial phase involves formulating a research plan centered on simulation-based approaches tailored to the context of emergency medicine in Canada (Chaplin et al., 2020).
Allaire (2015)	Assess the impact of virtual patient simulation on the development of critical thinking skills among students.	Mixed Methods n= 31	The findings did not demonstrate a statistically significant rise in the average score. However, the students expressed that the utilization of virtual patients was a productive pedagogical approach in fostering critical thinking, problem-solving, and self-assurance in the clinical milieu (Allaire, 2015).

Li & Yang (2021).	The present study aims to evaluate the efficacy of the Base Station (BS) approach in comparison to the Deep Neural Network (DNN) method for problem-solving purposes. To achieve this objective, simulation techniques were employed.	Eksperiment n = 22	The findings of the simulation indicate that the employment of the simulation-assisted Deep Neural Network (DNN) approach offers benefits over the Base Station (BS) technique in addressing problems. This presents the proposed approach for addressing the issue of model mismatch between the training and testing datasets (Li et al., 2021).
Scholtz et al (2017)	The practical application of an enterprise resource planning (ERP) system has the potential to mitigate the cost and complexity associated with such tools.	Qualitative: Survey n = 50	Simulation-based learning and mobile learning (m-learning) are integral components of a broader and more extensive research endeavor that seeks to augment the acquisition of knowledge and skills related to Enterprise Resource Planning (ERP) systems in the context of higher education (Scholtz et al., 2017).

Information:
- E2C = Embed-to-control
- POD = Proper-orthogonal-decomposition
- ROM = Reduced-order modelling
- n = Number of research samples

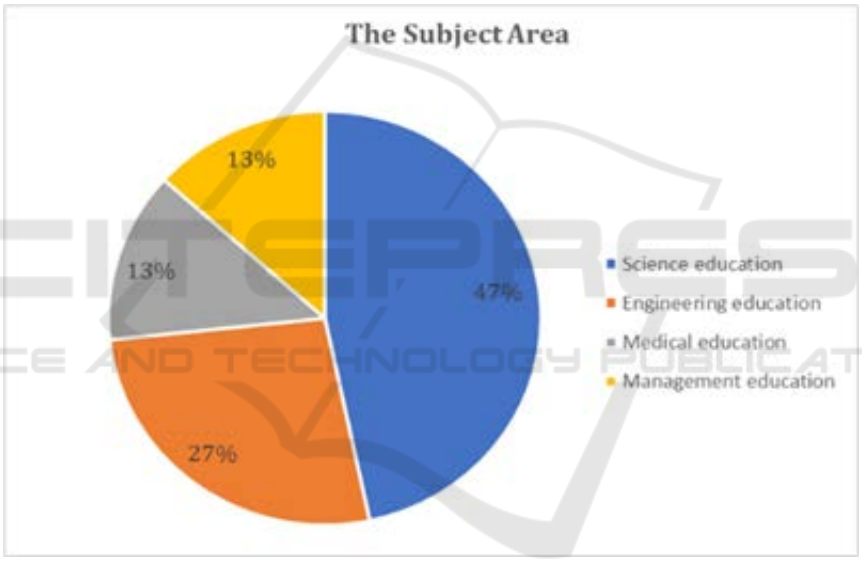

Figure 2: Distribution of articles by subject area in education.

3.1 Distribution of Simulated in the Subject Area

The literature review comprises 15 articles published within the last decade (2013-2022), as depicted in Figure 2. These articles cover diverse subject areas and educational disciplines. The preponderance of articles pertained to the domain of science education, comprising 7 articles, trailed by engineering education with 4 articles, medical education with 2 articles, and management education with 2 articles.

3.2 Distributed Simulation in Terms of Publication Year

Regarding the temporal distribution of simulation-related articles analyzed in the literature review spanning the period of the last decade (2013-2022), as illustrated in Figure 3, it was observed that three articles were published in 2015, 2017, and 2019, two articles were published in 2020 and 2021, one article each in 2013 and 2022, and no articles were published in 2014, 2016, and 2018. The current research suggests that there is a relatively low volume of publications within the last ten years. This implies that the incorporation of simulation in educational and pedagogical pursuits is not a prominent topic.

3.3 The Benefits of Simulation in the Project

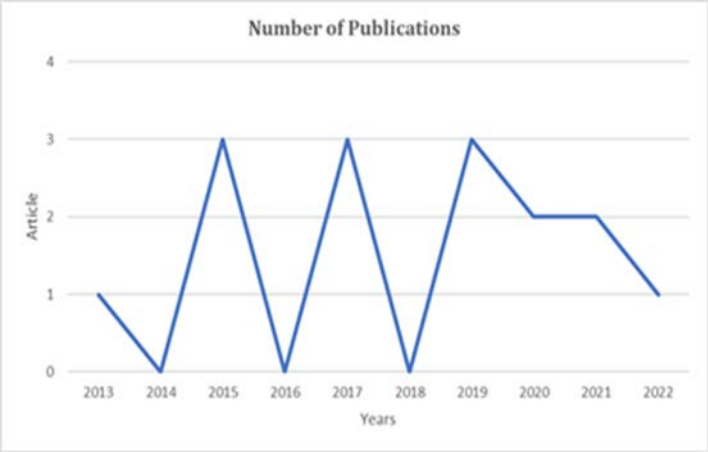

Figure 3: Distribution of articles in terms of publication year.

Table 2: Simulation utilization data in project creation.

Benefits of Simulation		Descriptions
Simulation in creation of project	1.	These simulate real-world chemical exposure incidents where participants practice sorting and treating patients.
	2.	The computer simulations for facilitating collaborative problem-solving learning.
	3.	The simulation offers a powerful combination of speed, accuracy, and adaptability, especially in scenarios where real-time or large-scale optimization is required.
	4.	These simulations offer a comprehensive and improved approach to global flood risk assessment, enabling better preparedness for climate-induced changes in flooding patterns.
	5	The ability to manipulate variables in the simulation, observe changes dynamically, and promote active experimentation and deeper learning through trial and error.
	6.	By simulating hazardous waste site investigations, students practiced applying engineering principles in realistic, controlled environments, improving their preparedness for real-world projects.
	7.	The simulation to improve training efficiency, accessibility, interactivity, and accuracy in robotic programming,
	8.	The simulation offers an interactive and effective way to teach complex industrial processes, leading to improved understanding and positive student experiences.
	9.	That virtual patient simulations are a promising tool for enhancing critical thinking, problem-solving, and confidence in clinical practice.
	10.	The using simulation-based learning includes accessibility, ease of use, experiential learning, improved content presentation, and flexibility, which collectively enhance the effectiveness of learning in higher education.

4 DISCUSSION

In response to the initial research inquiry concerning the domains in which simulation is implemented in projects, the examination of 15 articles through a literature review reveals that simulation is utilized 74% in the realm of science education, 27% in engineering education, and 13% in both medical education and management education. Simulation is employed in each of these fields to address the problems or challenges specific to each. Simulation is a widely used technique in the scientific field. Simulation is a key technology of Industry 4.0 to support the development of planning and exploration models to optimize decision-making, design, and operation of complex systems (Scholtz et al., 2017). Its primary purpose is to minimize losses and data errors that may arise during implementation (Jin et al., 2020). The utilization of a particular project model can potentially improve its efficacy (Yang et al., 2019). Similar principles are applicable to other domains of education, including but not limited to medicine, engineering, and management.

In response to the second research inquiry pertaining to the prevalent simulation techniques employed in project development, the examination of 15 scholarly articles reveals that simulation is employed in diverse modes of instruction, encompassing virtual reality, models, software, and virtual patients (Chung et al., 2013; Allaire, 2015; Li et al., 2021). Simulation is utilized as a means to replicate real-world scenarios or settings that are challenging or costly to replicate in the tangible realm (Crespo et al., 2015). Simulation, within the realm of education, encompasses various forms such as computer simulation, virtual simulation, physical simulation, and game-based simulation. Simulations offer a secure and regulated setting for students to engage in experimentation, decision-making, and skill-building (Crespo et al., 2015).

In relation to the third research inquiry, assert that the utilization of simulation has the potential to facilitate the successful completion of projects by users (Crespo et al., 2015). The implementation of simulation techniques has been shown to effectively mitigate expenses, optimize resource allocation, and minimize potential hazards, including accidents and safety-related issues (Bajow et al., 2022: Dong et al., 2021). Simulation allows experimentation with different approaches to completing a project without having to be on site, which can result in a better understanding of the process, lower costs, shorter durations, and quality (Scholtz et al., 2017). This framework aims to help teams design holistically to create a quality project overall (Scholtz et al., 2017). Project-based simulations facilitate the process of acquiring new knowledge through self-directed learning and collaborative problem-solving (Chang et al., 2017). The utilization of simulations is based on a problem-centered learning methodology and aims to cultivate a range of proficiencies such as critical analysis, resolution of complex issues, self-assurance, and efficient strategizing (Chung et al., 2013; Allaire, 2015; Li et al., 2021). Additionally, extant research has demonstrated that simulation projects elicit contentment among students with regards to their involvement and acquisition of knowledge. Simulations can improve students' skills and confidence and prepare them for real situations (Chang et al., 2017).

The utilization of simulation in project-based learning has been deemed essential for showcasing enhancements in educational outcomes, as per the results of the literature review encompassing 15 international articles (Chaplin et al., 2020). Hence, the integration of simulation with project-based learning is recommended. The process entails the incorporation of simulation environments, scenarios, or models into project-based learning endeavors with the aim of augmenting the learning process. The incorporation of simulation in project-based learning can provide students with the opportunity to confront authentic challenges, comprehend the consequences of their choices, and enhance their comprehension of the subject matter being instructed. The selection of simulation modality ought to be congruent with the academic level, contextual setting, and content domain.

5 CONCLUSION

Optimizing learning through projects involving simulation requires careful consideration of the suitable simulation type that aligns with the subject matter, environment, and level of instruction. The present study presents the outcomes of the literature review on the application of simulation in project-based learning. (a) The application of simulation is widespread in diverse educational domains, encompassing science, engineering, medicine, management, and other sectors. (b) Project development commonly employs simulation techniques such as virtual reality, models, modeling, software, and virtual patients. (c) The utilization of simulation in projects yields several favorable outcomes, such as cost and resource reduction, and risk mitigation, including accidents. (d) The

integration of simulation is also a crucial aspect to consider.

The limitations of this pepper is the present literature review's delineation of inclusion and exclusion criteria may not comprehensively explicate the function of simulation in the process of designing and executing projects. Furthermore, there exist certain variables that have not been extensively deliberated upon in the literature scrutinized during the course of this review. Given this constraint, the researcher recognizes the imperative of undertaking a comprehensive investigation into this issue.

6 AUTHOR CONTRIBUTIONS

Conceptualization, W. and I.K.; methodology, W. and I.K.; formal analysis, W.; data curation, I.K. and L.H; writing—review and editing, W., I.K. and L.H.; Submid and Correspondent, W. and I.K., All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGMENTS

The author would like to thank the promoter and co-promoter who have guided the author in completing this pepper.The author also wants to say thank you to Puslapdik Kemdikbudristek, LPDP who have fully financed the doctor's program with a financing scheme Beasiswa Pendidikan Indonesia (BPI) for the grant with a contract number: 01523/J5.2.3/BPI.06/9/2022.

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