3D environment approach to teaching and learning business process management concepts: a systematic literature review

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Abstract. *Although efficient process management is a factor that impacts the competitiveness of organizations, undergraduate students entering the employment market still have difficulties to understand and perform functions related to BPM, which indicates obstacles in teaching and learning these concepts. Using innovative approaches such as 3D environments can bring pedagogical resources to complement BPM training. This work performs a systematic literature review to investigate approaches using 3D environments in BPM courses and training to find their impact on learning and teaching. Studies suggest that 3D environments can positively affect the BPM teaching and learning process and impact student motivation, keeping them connected to the study material.*

1. Introduction

Business process management (BPM) is fundamental in organizations because a business process is what a company does whenever it delivers a product or provides a service [Dumas et al. 2013], such as the process of admitting new students to a graduate program that involves a sequence of several steps. BPM in organizations can directly influence the quality of products and services provided. Organizations are increasingly becoming process-oriented, as effective BPM brings competitive advantages in a globalized environment [Seethamraju 2010].

According to [Dumas et al. 2013], BPM has 6 phases in its life cycle, that is *process identification*, *process discovery*, *process analysis*, *process redesign*, *process implementation*, and *process monitoring and controlling*. In organizations, employees must be involved with the phases in the BPM life cycle and have deep knowledge about the processes they are inserted. Therefore, the search for qualified professionals with skills and experience in the different phases of the BPM life cycle has intensified [Seethamraju 2010, Saraswat et al. 2014, Leyer et al. 2019]. However, employers and professional associations highlight the inadequate capacity of undergraduates to manage processes, observing that they are not sufficiently prepared to work in customer-oriented environments and with processes linked to information technologies [Seethamraju 2010]. This lack of capacity and ability is related to the difficulties and challenges faced in teaching BPM concepts and in the development of teaching techniques and methodologies. [Hrabala et al. 2017] argue that the lack of trained and experienced instructors is a recurrent problem. They also claim a lack of pedagogical resources, such as textbooks or case studies, even in courses with a long tradition in teaching BPM. In addition, BPM courses are much more focused on theoretical activities, providing few possibilities for students to train their learning and practically improve their skills.

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With the development of new information and communication technologies, new opportunities and tools emerge for teaching and learning the most diverse disciplines and Knowledge domain (e.g., Virtual Learning Environments, digital games, animation content, virtual reality). It brings more possibilities for pedagogical resources in general and also can be applied to BPM. According to [Dalgarno and Lee 2010], educators and educational institutions at an international level perceive great potential in 3D environments for teaching and learning. The authors claim that students can explore virtual objects and structures, or even metaphorical representations of ideas, improving their involvement with learning activities. According to [Kluge and Riley 2008] these 3D environments offer very effective spaces for learning and can be generalized and applied in almost any discipline. The authors claim that 3D virtual environments provide a sense of presence to students, giving them an experience that other 2D media cannot. According to [Meadati and Akhnoukh 2021], students have distinct learning styles, and 3D environments offer an interactive 3D view, making students engaged and keep them focused on their learning development.

Based on the problems related to lack of BPM knowledge and skills of employees in organizations and considering the continuous development of new technologies in education, this study performs a systematic literature review (SLR) to investigate how 3D environments are being applied in disciplines and training in BPM. Furthermore, it shows the trends in using these environments, such as the most studied software, and the perceptions of students and teachers regarding the improvement or not of the teaching and learning using these environments as a pedagogical resource.

This work is organized as follows: Section 2 describes the methodology applied to perform the SLR protocol, such as the search string in the information sources and the criteria for inclusion and exclusion of studies. Section 3 is divided into three parts to answer each one of the research questions and to evidence how the studies use 3D virtual environments as a pedagogical resource in BPM teaching and learning. Section 4 presents the related works, and section 5 summarizes our findings.

2. Methodology

The methodology used in this work includes developing a SLR of the use of 3D environments in teaching and learning in BPM disciplines and courses. For this work, the guide designed by [Kitchenham and Charters 2007] was used, which has the steps to perform the SLR in software engineering. The SLR is a process composed of stages, which includes the planning of the protocol that will be applied, the execution of this protocol, performing the inclusion and exclusion of studies, and finally, the analysis of data and report of results obtained. In the planning stage, we search for existing SLR on 3D virtual environments for BPM teaching and learning. With the absence of a previous SLR, the protocol was planned for the execution stage, to answer the following research questions (RQ):

RQ1 How are researchers using 3D virtual environments for teaching and learning BPM? **RQ2** What phases of the BPM lifecycle are covered by 3D virtual environments? **RQ3** Does using 3D virtual environments help teach and learn BPM concepts, bringing better results or more motivation and engagement to students?

The search for studies that relate 3D virtual environments for teaching and learning BPM was performed on the sources ACM digital library[1], IEEE Xplore[2], Science Direct[3], and Scopus[4]. The general purpose of our SLR was to investigate what methodologies and approaches are being used for BPM teaching and learning. We verified through reading the abstracts and by the frequent reference to the IBM INNOV8 tool that there is a trend in using 3D virtual environments to transfer knowledge of BPM concepts, mainly in games format. Thus, we used a comprehensive search string in these databases. So that it was possible to reach studies related to education and after including those that use teaching and learning methods supported by 3D environments:

Search String: (BPM OR "Business processes") AND (education OR teaching OR learning) AND (method OR technique OR approach)

After using the search string, the following exclusion criteria (EC) were applied: **EC1** The paper is not written in English; **EC2** The paper is not in computer science, Engineering, Business, Management, and Accounting area; **EC3** The paper has less than four pages; **EC4** The paper is duplicated.

The last step in the execution of the research protocol is applying the inclusion criteria (IC): **IC1** Does the article present any proposal for BPM teaching/learning through 3D virtual environments? **IC1.1** Analyze the title and keywords (in some cases, abstract); **IC1.2** Analysis of the abstract (in some cases, conclusion); **IC1.3** Analysis of the conclusion (in some cases, methodology or full text to confirm the relationship with the researched topic). After using the exclusion and inclusion criteria, the selected studies are used in data analysis so that it is possible to answer the research questions proposed in the SLR.

The SLR started in June 2020 with the planning stage and research by pre-existing SLRs related to 3D environments for BPM teaching and learning. Then, applied the protocol, search, and analysis of the studies to be included. The search string was reapplied in the databases in June 2021, to ensure that new studies, if they emerged, would be included in the SLR so that it is updated.The analysis step of the data extracted from the work obtained is presented in chapter 3.

3. Data Analysis

Through the search string used in the selected databases, we obtained 2940 papers (68 from ACM, 109 from Science Direct, 361 from IEEE, and 2402 from Scopus). Still, to check if any related work was not captured by the databases, combinations of keywords were performed in the search field of Google Scholar[5], adding another 8 studies that could contain relevant information for the present work. In the end, 2948 studies were obtained in this first stage, adding the result of each database, with no additional filter using. Afterward, we applied the exclusion criteria, and 2087 studies remained to be submitted to the step of inclusion criteria application. Finally, 14 articles were included for complete reading and analysis. They have information related to the use of 3D

[1]https://dl.acm.org
[2]https://ieeexplore.ieee.org
[3]https://www.sciencedirect.com/
[4]https://www.scopus.com
[5]https://scholar.google.com/

environments for teaching and learning BPM and can answer the research questions. Figure 1 shows the protocol application process and the numerical results obtained.

Through reading these studies, we realized that there was a tendency to use 3D environments in game-based approaches. At the same time, other works did not have this aspect but simulated a 3D environment with BPM teaching and learning purpose. Thus, they were divided into two categories in the present study: game-based learning and simulation in 3D virtual environments. The studies included in game-based learning are [Roodt and Joubert 2009], [Lawler and Joseph 2009], [Bulander 2010], [Joubert and Roodt 2010], [Ribeiro et al. 2012], [Nkhoma et al. 2014], [Grace and Cohen 2016], [Lang et al. 2016], [Pavaloiu 2016]. The studies classified as simulation-based learning are [Madhavan et al. 2002], [Weichhart et al. 2014], [Aysolmaz et al. 2016], [Leyer et al. 2019], [Leyer et al. 2021].

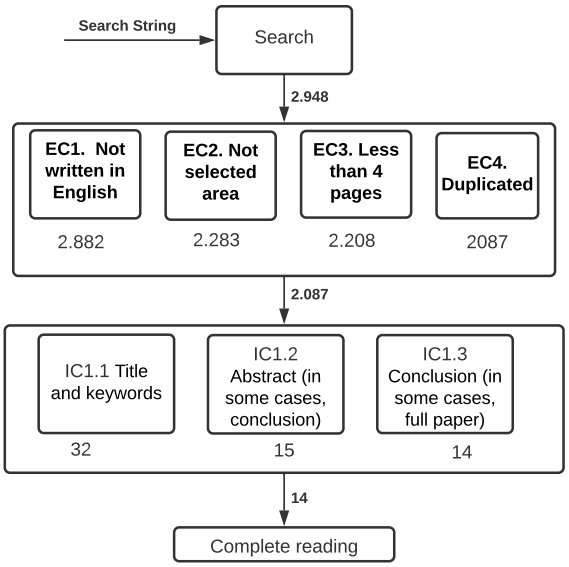

Figure 1. Literature review protocol application

3.1. Answering research question 1 (RQ1)

The first research question corresponds to how 3D virtual environments are used to teach and learn in BPM. The studies related to this question can be categorized as game-based or simulation-based. According to [Lang et al. 2016], the objective of serious games is to use aspects and concepts of video games, such as entertainment and interactivity, for educational purposes. The works that use serious games concepts for the teaching and learning in BPM, usually use the IBM INNOV8 tool, which, according to [Ribeiro et al. 2012], is a 3D game, where students can assume avatars within a virtual business environment. The tool's purpose is to introduce BPM concepts so that the student does not need to have prior knowledge. Another 3D environment used is ImPROVE, which, according to [Ribeiro et al. 2012], is a serious game developed for teaching business process modeling within a healthcare context.

The second category of 3D tools used in teaching and learning BPM are simulators that provide a 3D visualization of organizations and theoretical work environments where some processes occur. Unlike the other category, these tools are not considered games. According to [Leyer et al. 2019], it is possible to provide a way to represent real-life processes and submit students to more interactive training, enabling a better view of control flows within the process.

Thus, researchers are using 3D environments as a platform to simulate problems related to organizational processes. With these simulations, training becomes more interactive, and students can move through the activities of a complete process. Still, studies also point to the use of 3D serious games to simulate organizational environments. This approach is intended to keep students more engaged with learning in BPM, as it offers interactivity and entertainment, making learning more interesting for users of these 3D environments.

3.2. Answering research question 2 (RQ2)

The second research question deals with teaching and learning the phases of the BPM lifecycle. According to [The Object Management Group 2011] Business Process Model and Notation (BPMN) has become the de-facto standard for business processes diagrams, used in the process discovery phase of BPM lifecycle where the processes are modeled. Its first version was released in 2007 and is currently in version 2.0. The notation was cited or used by six selected studies in this SLR, mainly in works from 2016 onwards. This indicates the use of 3D environments for teaching and learning in the process discovery step and possibly in other subsequent phases of the BPM lifecycle, as in analysis and redesign.

The approach with tools based on simulation of organizational environments has been shown to be well developed and can be applied in all phases of the BPM lifecycle. The phases most benefited by this approach are process discovery, with all works indicating the possibility of coverage, and process analysis, with three studies indicating the possibility of teaching this phase through the 3D environment. As stated in [Weichhart et al. 2014], the approach is generic enough for teaching BPM in general. Thus, it is assumed that the environment created by the authors covers the concepts of any of the lifecycle phases. Also, [Leyer et al. 2021] argue that 3D environments can be recreated for different domains in industry and can be pretty comprehensive for teaching and learning BPM concepts.

On the other hand, 3D environments based on games proved to be diversified, but none of the works addresses activities in the process identification phase. The phases most benefited by this type of approach are process discovery, process analysis, and process redesign, with five or more studies indicating that it is possible to address them in courses and training through 3D virtual environments.

Figure 2 shows how many studies suggest using 3D environments for training each of the phases of the BPM lifecycle. The division of studies into two categories is maintained, demonstrating that simulation-based approaches are more distributed among the lifecycle phases. At the same time, those based on games are more focused on the discovery phase. Both are highly prevalent in the process discovery phase. Also, the process identification phase was not discussed by any of the game-based approaches.

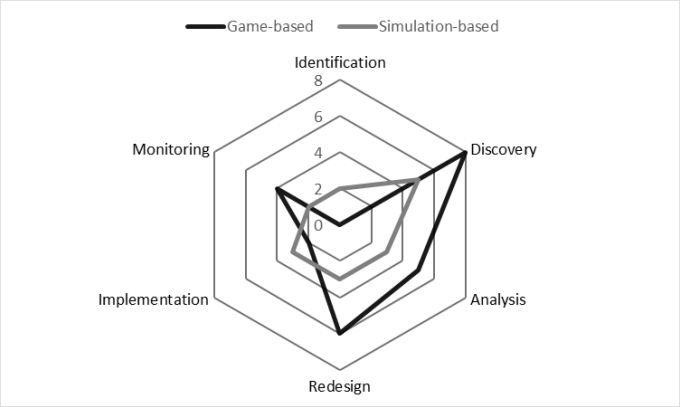

Figure 2. BPM life cycle teaching and learning in the studies

3.3. Answering research question 3 (RQ3)

In the work of [Leyer et al. 2019] the authors developed a 3D environment prototype for training that receives an XML file containing a BPMN file and automatically creates the process activities. The prototype was used with engineering students and in a master-level course on BPM, with the participation of 145 students, divided into two groups, where one group received the 3D prototype and the other a 2D representation of the process. When evaluated to remember the process, the group that used the 3D approach demonstrated better performance than the group that received the 2D visualization. The authors demonstrate that 3D virtual environments can be an innovative way of transferring knowledge, especially about the differences and definitions of BPM control flows, known as gateways. The study of [Leyer et al. 2021] applied a similar methodology with 60 undergraduate students in the business background. The authors also suggest an improvement in teaching using 3D environments compared to 2D representations.

According to [Roodt and Joubert 2009], students are more familiar with gaming technologies and, therefore, more comfortable using these tools for learning purposes. Although the authors did experimental research with a smaller number of students (15 graduate information system students), 100 percent indicated that they liked the approach. Still, this good receptivity of students to use 3D environments can be seen as a motivating factor for them and, consequently, keep them more willing to receive BPM content.

As stated in [Lang et al. 2016], the authors used the IBM INNOV8 to measure whether students showed improvements in the teaching and learning process through a 3D environment. The evaluation was carried out with 249 students of master level on Information System Design, who were divided into groups to use the platform for 90 minutes. The authors conclude from their experiment that serious games are helpful as pedagogical resources combined with other theoretical materials. Furthermore, these environments allow students to learn and develop new skills by performing different roles in game simulations.

In their experiment [Nkhoma et al. 2014] also used INNOV8 with 60 undergraduate students. The authors state that students demonstrate a favorable attitude towards using the 3D environment, mainly due to the continuous feedback during the learning process. Through questionnaires containing 14 closed questions and one optional open-ended question, the authors concluded that the game had positive impacts on learning.

In the work of [Lawler and Joseph 2009] the authors used INNOV8 with 39 graduate students in an information systems course and, in the end, applied a perception survey. According to the authors, students noticed an improvement in teaching with the 3D environment compared to materials such as books. However, students' perception of using INNOV8 to improve creativity, critical thinking, and problem-solving skills is no higher than conducting discussions and reports on proposed projects.

According to [Pavaloiu 2016], using game-based 3D simulation provides good results for teaching because students create strong connections with the content. His experiment with 41 master-level students showed strong adherence to the approach and positive perception about improvement in strategic thinking, decision making, real-time business management, and proactive thinking.

As stated in [Bulander 2010], the use of serious games, such as INNOV8, offers an opportunity to enrich learning processes. According to the author, the gamified environment simulates real-life scenarios and serves as a didactic resource for teaching BPM modeling. Although the author forms a discussion more focused on games, this study was included in the present work because it uses a 3D tool for game simulation in teaching BPM concepts. Likewise, the work of the authors [Joubert and Roodt 2010] was included. Both studies were performed through experiments with students, the first with high school students (aged 17 to 18 years). The second was achieved with higher education students from a course in BPM.

In their experiment [Joubert and Roodt 2010] perform questions on a scale of 1 to 5, where 5 means that the student entirely agrees with the suggested statement. One of the questions indicates that the students learned something with the innov8 tool, and the average of the answers was 3.78. When students are asked if they gained a better understanding of BPM, the average responses were 3.61. According to the authors, the averages indicate that students' knowledge of BPM has improved.

In [Aysolmaz et al. 2016] the authors present a 3D environment for teaching and learning BPM and demonstrate the possibility of using the tool. The authors argue that mapping real-world concepts to process model elements is challenging. A 3D environment can facilitate understanding through the visualization of the office environment, where the processes are performed. Also, [Weichhart et al. 2014] do not present experiments with students but address the use of a 3D world called Open Wonderland to create the application in learning and teaching. The approach developed is sufficiently generic to be used to teach the complete BPM lifecycle once its purpose is to be applied to educate BPM in general.

Some factors related to the advantages of using 3D approaches that can impact the improvement of the teaching process can also be discussed. According to [Madhavan et al. 2002], the use of 3D strategies offers an experience with situations similar to those of real-life that students should model. This type of training in BPM courses helps to bridge the gap between industry needs and classroom case studies. Also, it can positively impact students' motivation, making them more interested in learning the contents of the subjects.

According to [Leyer et al. 2019], virtual environments represent an alternative related to scalability in problems that arise with the growth of organizations, such as the

increasing number of employees or their geographic diversity. Furthermore, they represent a low financial cost since it is necessary to create and enable the training environment once, and it can be applied as many times as required to many students.

4. Related Works

We found only one SLR that deals with aspects related to teaching and learning BPM concepts, authored by [Leitão et al. 2021]. This study is recent, published in January 2021, and is entitled "Serious Games in Business Process Management: A Systematic Literature Review". Its purpose is to answer the learning objectives and design characteristics of serious games in the BPM domain. It addresses two games included in our study (imProve and INNOV8) but, the research approaches and objectives are different.

Although both works verify the coverage of the BPM lifecycle by the pedagogical resources, this related work focuses only on serious games in digital and analog format. In contrast, the present work focuses on 3D virtual environments. In addition, the study by [Leitão et al. 2021] groups the phases of the BPM lifecycle two by two in the analysis. It can make it challenging to assess which phases have less or greater focus, which is one of the goals of our SLR.

Also, the work of [Leitão et al. 2021] analyzes games in terms of their design characteristics, checking if it is a competitive game, whether it has a richer narrative, or the game's mode (digital or analog). Our SLR explores how the pedagogical resources with 3D characteristics (not just games) are used for teaching and learning in BPM courses and training. Also, if this approach focused on 3D tools help to improve the involvement and motivation of students, providing a better exchange of knowledge about BPM concepts.

5. Conclusion

In this work, we performed a SLR to investigate the approaches of 3D environments in courses and training in BPM. Two approaches were identified as more recurrent in the literature: one based on simulation of organizational environments and the other based on serious games. It was found that most studies related to games use the IBM INNOV8 software to introduce BPM concepts and then validate the use of this approach through the students' perceptions. Also, the studies demonstrate that both approaches are mainly applied in the early phases of the BPM lifecycle. Almost all studies cover the process discovery phase.

Furthermore, in the studies experiments, groups of students who used a 3D approach demonstrated better learning performance than groups that received a 2D view of the processes. Although one of the studies indicates that the use of 3D environments was not considered better than conducting discussions and reports on projects, all studies conclude that they are helpful as pedagogical resources and can be combined with other theoretical materials. Some studies indicate that students are more familiar with gaming technologies and, therefore, more comfortable using these tools for teaching and learning purposes. This familiarity can affect these students' motivation and positively impact strategic thinking, decision making, real-time business management, and proactive thinking.

Also, we present some advantages such as scalability for organizational environments with many employees or geographical diversification. The reduction of training costs was also pointed out, as the 3D environment developed can be used several times without generating significant additional costs.

As a limitation of our SLR, some work may not have been included as it does not describe the 3D feature of the tool used for education. Also, this work only includes studies published until June 2021. In addition, the number of studies that relate the use of 3D environments in BPM education is reduced. Although studies point to improved BPM teaching and learning, not all authors presented experiments with students.

This study offers relevant data for future works, such as creating pedagogical resources using 3D tools. We observe a lack of pedagogical resources related to the 3D environment in some phases of the BPM lifecycle, such as process identification. It brings an opportunity to create tools to support these phases. In addition, we suggest the inclusion of 3D environments in BPM education and a reformulation of the BPM courses curriculum in future works.

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