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VIRTUAL AND AUGMENTED REALITY IN PRODUCTION ENGINEERING

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Abstract: **Augmented Reality is a combination of a real and a computer-generated or virtual world. It is achieved by augmenting computer-generated images on real world. It is of four types namely marker based, marker less, projection based and superimposition based augmented reality. It has many applications in the real world. AR is used in various fields such as medical, education, manufacturing, robotics and entertainment. Augmented reality comes under the field of mixed reality. It can be considered as an inverse reflection of Virtual Reality. They both have certain similarities and differences. This paper gives information about Augmented Reality and how it started. It analyses various types of augmented reality, its applications and its advantages and disadvantages. This paper also gives us knowledge regarding those major threats that augmented reality will face in the near future and about its current and future applications. It gives us a comparison between the two related topics, Augmented reality and Virtual reality. The following paper also helps us know about the effect of Augmented Reality on the human life.**

Keywords: **Systematic literature review. Engineering. Teaching methodology. Virtual reality. Augmented reality.**

I. INTRODUCTION

The application of technologies in the teaching-learning processes is increasingly common. One of the current strategies is the use of virtual and augmented reality, which generates a learning condition in a virtual environment and provides the enhancing cognitive performance of the students. This article presents a review of the literature on the application of technologies for engineering education and in production engineering application gaps and impacts on competitiveness.

According to Kaliská (2012), learning processes can occur in many ways, such as practicing, listening, visualizing, and discussing. Each teacher varies their teaching methods, choosing discussions, demonstrations, exercises.

Gil (2010) explains that the approach that interconnects students and teachers in the process of more significant interaction is cognitivist. The cognitivist approach has, as its primary objective, to privilege mental processes and cognitive skills. The contents should be tailored to students' experiences, and methodologies need to be selected so that they can learn by doing. The teacher does not assume a central position; the student is the one who should be focused on being the center of the learning process, thinking, and building their knowledge.

Borges & Alencar (2014) mention that active methodologies are a way to develop the learning-learning process. Teachers use them to conduct a situation as real as possible, providing critical training for students in several areas of learning formation. This type of methodology favors the student's autonomy, arousing curiosity, attitude, and stimulating individual (or group) decision-making regarding the topics covered in the classroom.

Educational tools applied in support of active teaching methodologies are virtual and augmented reality. According to Latta & Oberg (1994), virtual reality is a process of interaction between man and machine, which is simulated in a realistic environment, creating an opportunity for involvement and communication between them. Augmented reality, according to Raja & Calvo (2017), is the projection of virtual devices into a real environment generating the opportunity for interaction and visualization by man.

Virtual and augmented reality are multisensory technologies that use multimedia, computer graphics, image processing, and other resources to create totally or partially artificial environments.

The virtual world has three essential characteristics related to immersion, interaction, and involvement. In Table 1 are shown examples of the features of the virtual world.

Schlemmer & Backes (2014) point out that those experiences with virtual reality bring new sensations, offering an environment very close to reality. Such digital technologies contribute to the concepts of presence and immersion, acting with interaction, and acting directly on students' cognitive issues, essential concepts for the teaching-learning process.

II. MATERIALS AND METHODS

The method used for development was the systematic literature review. The systematic literature review has the role of analyzing and develop theories through extensive research in the existing literature.

Dresch et al. (2015) explain that the systematic literature review is secondary studies that seek to understand, structure, and evaluate primary studies, answering actual research questions, identifying gaps in the literature, and synthesizing reports of the results.

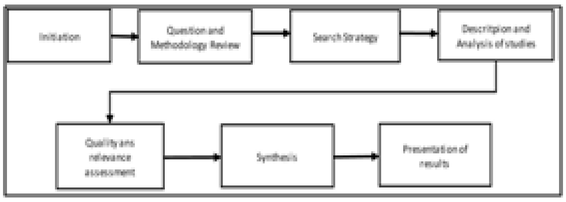
For the systematic literature review was selected the model proposed by Gough & Thomas (2012), whose steps are detailed in Figure 1.

Search strategy. It is necessary to define what to look for, where to search, how to minimize propensity, which studies to consider, and the extent of the search (Dresch et al., 2015).

In defining what to look for, the activity was organized into three steps. The first was to understand the historical behavior of publications dealing with teaching methodologies that apply virtual or augmented reality. This analysis was

performed using the Web of Science databases to explore the relevance of the theme and its growth. The search terms used were: (teach * and method *) and (“virtual reali” or “augmented reali *” or “virtual world” or “real virtual *” or “VR” or “AR”). Data collection was the period from 2000 to 2018 because at that time, the applications of technologies such as virtual reality and augmented reality increased. The indicators extracted were:

- The number of publications per year;
- The publications area;
- The evolution of publications by research area.



In the second step, related publications, teaching methodologies in engineering that used virtual or augmented reality technology as a teaching-learning strategy. Searches were realized in keywords, title, and abstract in the Scopus and Web of Science databases. The search terms combined were: (teach* and method*) and (“virtual reali*” “or” augmented reali* “or” virtual world “or” virtual real*”) and (“engineer*”). The research period covers from 2004 to the present day. The results of these searches and the inclusion and exclusion criteria of the collected data were applied.

The definition of the mentioned bases was because they have indexation with the most significant number of high impact factors and relevant journals.

It was used the model proposed in Figure 2 for the description and analysis of the papers.

The criteria for exclusion of the studies were:

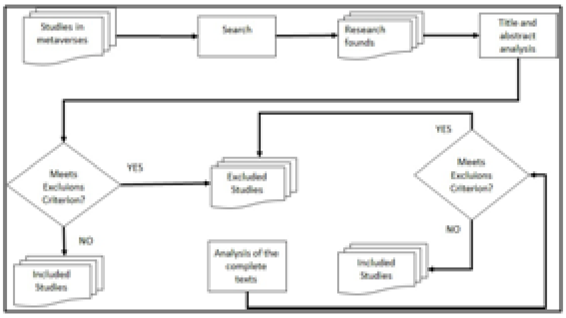
1) Exclusion of repeated papers, because it was analyzed two databases;

2) Exclusion of paper that didn’t contain at least one of the following terms in their title: students, methodology, method, teaching, learning, simulation software, virtual reality, augmented reality, virtual world, AR (augmented reality), VR (virtual reality), engineering, virtual simulation, virtual lab, education, digital environment, virtual 3D, 3D, virtual platform, virtual simulator;

3) Exclusion of papers, after it was analyzed the abstract, did not broach the teaching methodology related to virtual reality or augmented reality;

4) Exclusion of publications that did not have full texts available in the databases;

5) Exclusion of the articles that were not about teaching in engineering areas, with an application to virtual and/ or augmented reality



III. RESULTS AND DISCUSSION

This section presents the evolution of the results on the researched theme, its application in engineering, and future researches analysis of this application in production engineering.

It is possible to perceive the quantitative evolution of research on the execution of virtual environments in the teaching-learning processes. The application of these environments currently occurs in several research areas. This perception connects with what Kaliská (2012) says about how human beings can learn in many different ways, and technology is one of them.

Libâneo (1994), Gil (2010), and Schlemmer & Backes (2014) relate this evolution. These authors emphasize that the educational processes must compromise with the cognitive question because the cognitive processes of teaching develop students’ learning through the development of activities. The augmented and virtual reality bring conditions of immersion, interaction, and involvement, providing a much more interactive environment and student skills development. This consensus explains the growth of research on the subject, showing its relevance. It is a new trend according to the understanding

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that the students can learn in various ways, that cognition is fundamental in the learning process, and that augmented and virtual reality act on the cognitive issue. The application of these technologies in teaching is growing. It covers many areas of research, and it is one of the ways used to develop cognition and bring the student very close to a real environment, making it easier to understand theoretical concepts.

When evaluating the practice of virtual and/or augmented reality in engineering, we notice a certain level of stability of publications, highlighting the areas of civil and mechanical engineering, both of which use virtual and augmented reality.

One finding is that the application occurs in several engineering-related subjects, generating significant learning process results in the evaluated publications. Valdez et al. (2014) and Braga (2001) support this understanding, emphasizing that virtual environments are multidisciplinary and applicable to teaching-learning processes, and produce the development of knowledge.

Practically all engineers use such technologies to support teaching-learning processes, but they scarcely explore their tools' immersion, interaction, and involvement characteristics. However, according to Schlemmer & Backes (2014), this application directly affects cognitive issues and is essential in the teaching-learning process. The implementation of these technologies, taking into account their characteristics, would generate a much more interactive environment, providing a realistic environment much closer to the ideal for student learning.

It is perceived as a shy use of virtual and/or augmented reality in teaching-learning processes when evaluated the application in production engineering. It is found as themes of publications layout and production flow, analysis wastes of the production system, and supply chain management. Only one publication brings the practice of immersion in virtual reality when observing the characteristics of research applications in production engineering. However, all have the use of interaction and involvement with the developed environment.

The document developed by AssociaçãoBrasileira de Engenharia de Produção (2003), about the curricular guidelines of production engineering, shows that many areas of study still do not use virtual and/or augmented reality as a tool to support the teaching-learning processes. However, when used, the impact of the teaching-learning process or satisfaction of the students is not measured.

Virtual or augmented reality application models could be developed for other issues related to production engineering, such as Production Systems Management, Production Planning, and Control, Material Handling, Production Simulation, Production Management. Productive Processes, Metrological Quality Organization, Work Organization, Accident Risk Analysis and Prevention, Work Safety, Product and Process Ergonomics, among others, including applications dealing with supply chain, productive flow, production wastes, and lean manufacturing, with different approaches and characteristics of the four articles evaluated in this research.

Based on the understanding that the use of virtual reality and augmented reality in teaching-learning processes, there is a tendency of application. When analyzing the notes of the areas of production engineering that could use the application, it appears that there are many application opportunities, and their non-use generates some impacts.

One of the impacts is the less attractive and very theoretical teaching-learning processes, failing to transmit to students all the necessary knowledge for the development of production engineering themes. This is because the traditional approach to teaching is focused on the teacher, with the student as an onlooker in the teaching-learning process. However, the cognitive approach genuinely addresses the interaction between subject and object. In this approach, the student should be allowed to conduct research based on trial and error, analysis, and problem-solving.

The second impact is that students leave with learning gaps. These deficiencies often may not be resolved during professional development, causing loss of competitiveness of the production engineer in their professional performance. These gaps are noticed when Laseinde et al. (2016) mentions that without the application of virtual reality, 25% of the students retained knowledge. This index increased to 80% retention with the use of virtual reality.

The third impact is the inability of organizations to use all the concepts proposed by production engineering because professionals arrive with knowledge gaps. This impact makes organizations lose competitiveness, become more vulnerable to the market, and expose medium- and long-term sustainability risks. There are opportunities to apply these concepts within organizations in training, simulations, and other applications.

Based on the impacts seen in production engineering, it is stated that generating teaching-learning processes that form the student more completely, without gaps, potentially impact organizational competition at times when they enter the job market, due to the improvement of the learning and satisfaction rates of students who use it in the teaching environment. Therefore, the application of teaching approaches that use virtual or augmented reality in production engineering would yield results, making the subject relevant for discussion.

IV. CONCLUSION

This research shows that the application of virtual reality and augmented reality in teaching-learning processes increased significantly in the analyzed period. Virtual environments are now available for students from several areas of expertise.

When approached in the context of engineering, it can be seen that the application of virtual and augmented reality tools is diversified, acting in several engineering areas, primarily civil and mechanical engineering. It is noteworthy that the application occurs extremely broadly, in various subjects, such as physics, electronic circuits, fluid mechanics, among others.

Another important conclusion is that, in all the studied cases, the execution of virtual or augmented reality in support of engineering teaching-learning processes improved the learning index, showing that the application of technologies is relevant to these results and acts cognitively on students, accelerating the learning process.

In production engineering, there are still few publications on the subject, but the existing ones bring application examples, whose results are satisfactory.

It is worth noticing that there are many opportunities to implement this type of technology for teaching in production engineering. This use help students understand the concepts of production engineering and their functionality, generating more competitive professionals to work in the market, making organizations more competitive from the complete knowledge of production engineers.

In the analysis of qualitative texts, it was noticed that the application applied in the areas of the supply chain, productive flow, production wastes and lean manufacturing tools.

From the applications, it was noticed other opportunities for future research. For example, virtual reality or augmented reality can be used to measure the performance of the teaching-learning process or the satisfaction of students in production engineering. Also, in the areas of Production Systems Management, Production Planning and Control, Material Handling, Production Simulation, Productive Process Management, Quality Metrological Organization, Work Organization, Accident Risk Analysis and Prevention, Work Safety, Product and Process Ergonomics.

Other future research opportunities are related to the characteristics of the application of virtual reality and augmented reality, such as, didactic-pedagogical characteristics, educational strategies, environments, tools, cases of success and failure and application barriers.

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