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# AUGMENTED REALITY IN HIGHER EDUCATION INSTITUTIONS: A STUDY ON THE APPLICABILITY OF THE EVALUATION MODEL OF EDUCATIONAL APPROACHES IN MOBILE AUGMENTED REALITY (MAREEA)

*A REALIDADE AUMENTADA EM INSTITUIÇÕES DE ENSINO SUPERIOR: UM ESTUDO SOBRE A APLICABILIDADE DO MODELO DE AVALIAÇÃO DE ABORDAGENS EDUCACIONAIS EM REALIDADE AUMENTADA MÓVEL (MAREEA)*

*REALIDAD AUMENTADA EN INSTITUCIONES DE ENSEÑANZA SUPERIOR: ESTUDIO SOBRE LA APLICABILIDAD DEL MODELO DE EVALUACIÓN DE ENFOQUES EDUCATIVOS EN REALIDAD AUMENTADA MÓVIL (MAREEA)*

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**PALAVRAS-CHAVE**: *Realidade aumentada; Instituições de Ensino Superior; Modelo de Avaliação de Abordagens Educacionais em Realidade Aumentada Móvel (MAREEA).*
**PALABRAS CLAVE:** *Realidad aumentada; Instituciones de Educación Superior; Modelo de Evaluación de Enfoques Educativos en Realidad Aumentada Móvil (MAREEA).*

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## ABSTRACT

The present article aims to conduct an analysis on Augmented Reality (AR) as an enabling technology in Higher Education Institutions (HEI) and the applicability of the for the Evaluation Model of Educational Approaches in Mobile Augmented Reality (MAREEA) to improve the evaluative quality of Teaching. The research method has a qualitative approach, and the objective is exploratory, developed from a bibliographic and theoretical-conceptual study based on a survey of research in bibliographic sources for analysis and discussion. The MAREEA model has four evaluation factors, namely: usability, engagement, motivation and active learning. Usability refers to how intuitive it is for users to learn how to use and interact with a certain product, that is, how simple it is for a person to use a certain system. Some studies developed applying MAREEA in HEIs have presented an important advance in research on the subject, especially in the mediation process, cognitive development and improvement of learning techniques. It was observed that AR has been applied to the process of improvement and refinement of educational projects, particularly in technological education, social education, and inclusive education.

## RESUMO

*O presente artigo tem como objetivo analisar a Realidade Aumentada (RA) como tecnologia habilitadora nas Instituições de Ensino Superior (IES) e a aplicabilidade do Modelo de Avaliação de Abordagens Educacionais em Realidade Aumentada Móvel (MAREEA) para a melhoria da qualidade avaliativa de ensino. Trata-se de um método de pesquisa qualitativo, cujo objetivo de pesquisa é exploratório, desenvolvido a partir de um estudo bibliográfico e teórico-conceitual com base em um levantamento de uma pesquisa em fontes bibliográficas para análise e discussão. O modelo MAREEA possui quatro fatores de avaliação, quais sejam: usabilidade; engajamento; motivação; e aprendizagem ativa. A usabilidade se refere ao quão intuitivo é para os usuários aprenderem a utilizar e interagir com um certo produto, ou seja, o quão simples é para uma pessoa utilizar um determinado sistema. Alguns estudos desenvolvidos aplicando o MAREEA em IES têm apresentado um avanço significativo nas pesquisas sobre o tema, principalmente no processo de mediação, desenvolvimento cognitivo e aperfeiçoamento das técnicas de aprendizagem. Observou-se que a RA vem sendo aplicada para o aprimoramento dos projetos de fomento à educação, principalmente na educação tecnológica, educação social e educação inclusiva.*

## RESUMEN

*El presente artículo pretende realizar un análisis sobre la Realidad Aumentada (RA) como tecnología habilitadora en Instituciones de Educación Superior (IES) y la aplicabilidad del Modelo de Evaluación de Enfoques Educativos en Realidad Aumentada Móvil (MAREEA) para mejorar la calidad evaluativa de la Docencia. Se trata de un método de investigación de enfoque cualitativo, cuyo objetivo de investigación es exploratorio desarrollado a partir de un estudio bibliográfico y teórico-conceptual basado en un relevamiento de investigaciones en fuentes bibliográficas para su análisis y discusión. El modelo MAREEA consta de cuatro factores de evaluación: usabilidad, compromiso, motivación y aprendizaje activo. La usabilidad se refiere a lo intuitivo que resulta para los usuarios aprender a utilizar e interactuar con un determinado producto, es decir lo sencillo que resulta para una persona utilizar un determinado sistema. Algunos estudios desarrollados aplicando MAREEA en IES han presentado un importante avance en la investigación sobre el tema, especialmente en el proceso de mediación, desarrollo cognitivo y mejora de las técnicas de aprendizaje. Se observó que la RA se ha aplicado al proceso de mejora y perfeccionamiento de proyectos para promover la educación, especialmente en la educación tecnológica, la educación social y la educación inclusiva.*

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## INTRODUCTION

The industrial emergence, which occurred with the development of the steam engine, was a major event that influenced the historical evolution of humanity. Since its inception to the present day, the industry has undergone major and relevant changes, which have interfered in the organization and development of society. From a historical point of view, industry was the most powerful factor in accelerating economic growth, exerting a great impact on the most varied sectors of the economy, according to Marson (2014), Sakurai and Zuchi (2018).

With the advancement of technology, which occurred over the years, remarkable facts happened that contributed enormously to the advancement of industrialization around the world, the so-called Industrial Revolutions. The First Industrial Revolution was characterized by the invention of steam powered machines. The Second Industrial Revolution was known for the development of industry in the post-war period, as well as for metallurgical, steel and chemical industries, enabling the modernization of production methods. The Third Industrial Revolution manifests itself as the height of the technological era, introducing innovations such as biotechnology, computerization and microelectronics in the production system, enabling more efficiency and adaptability for production. Finally, a new era of technology brings the Fourth Industrial Revolution, also known as Industry 4.0, which aims to bring the man-machine relationship even closer, as mentioned by Boettcher (2015), Venturelli (2017) and Cavalcante (2019).

The term Industry 4.0 was first mentioned in 2011, and is the result of a German government strategy project focused on technology. Industry 4.0 aims at connectivity, making the entire industrial system integrated and connected, from production to after-sales, and has as a prominent feature the use of the so-called enabling technologies: Big Data, Internet of Things, Robotics, Simulation, Artificial Intelligence, Cloud Computing and Augmented Reality, among others. These technologies provide more efficiency in the delivery of products and services, reduce the costs involved, in addition to allowing a more flexible and personalized production, as said by Khan and Turowski (2016), Venturelli (2017), Silveira and Lopes (2017), Sakurai and Zuchi (2018) and Magalhães and Vendramini (2018).

The enabling technologies resulting from the Fourth Industrial Revolution positively impact people's daily lives, and are present in the most diverse sectors of the economy, such as, for example, health, marketing, recruitment and selection and game development. Another growing application of these technologies is in the field of education (Schwab, 2019; Silva, 2018). According to Altoé et al. (2005), the use of technologies applied to education emerged in the United States, during World War II, with the creation of audiovisual equipment for the instruction of military specialists. But it was only in 1970 that the computer began to be used as a tool educational.

A tool resulting from Industry 4.0 that can bring benefits to the teaching and learning process is Augmented Reality (AR). It is a technology that allows mixing virtual objects with the real world, using computer vision techniques. This technology is capable of offering a new way of

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presenting content, increasing interaction between the student and the exposed content and improving their understanding (Azuma, 2006; Kirner & Tori, 2006; Araújo, 2009).

In this sense, this article aims to carry out an analysis on Augmented Reality (AR) as an enabling technology in Higher Education Institutions (HEIs) and the applicability of the Evaluation Model of Educational Approaches in Mobile Augmented Reality (MAREEA) for the improvement of the evaluative quality of Teaching. It is a research method with a qualitative approach, whose research objective is exploratory, developed from a bibliographic and theoretical-conceptual study, based on a survey of research in bibliographic sources for analysis and discussion. Furthermore, this research is characterized as a preliminary cut of a more complex study, which is in development in a master's thesis.

## AUGMENTED REALITY (AR)

The concept of Augmented Reality (AR) emerged through the researcher Ivan Sutherland, in the 1960s. At the time, Sutherland wrote an article that idealized the evolution of virtual reality and addressed its reflections in the real world, in addition, he also developed a helmet for Direct optical vision tracked to view 3D objects in real environment. However, it was only in the 1980s that the first AR project emerged, developed by the US Air Force. This project consisted of an airplane cockpit simulator with direct optical vision and mixed virtual elements with the user's physical environment (Kirner, 2008; Ribeiro & Zorzal, 2011).

AR is the aggregation of the physical and virtual environment in real time, through technology instruments. This aggregation happens through the execution of a program on a computer with a webcam, allowing the projection of virtual images in the real world (Fieb, 2016). For Kirner (2011) and Insley (2003), AR can be understood as complementing or improving the real field with virtual information (images that have movement and can be changed or relocated, spatial sounds, sensations related to touch, among others) created by computers in real time, properly positioned in 3D space and verified through technological devices. Due to the growing interest in the area of Virtual Reality, some concepts and their references were summarized (Chart 1).

 

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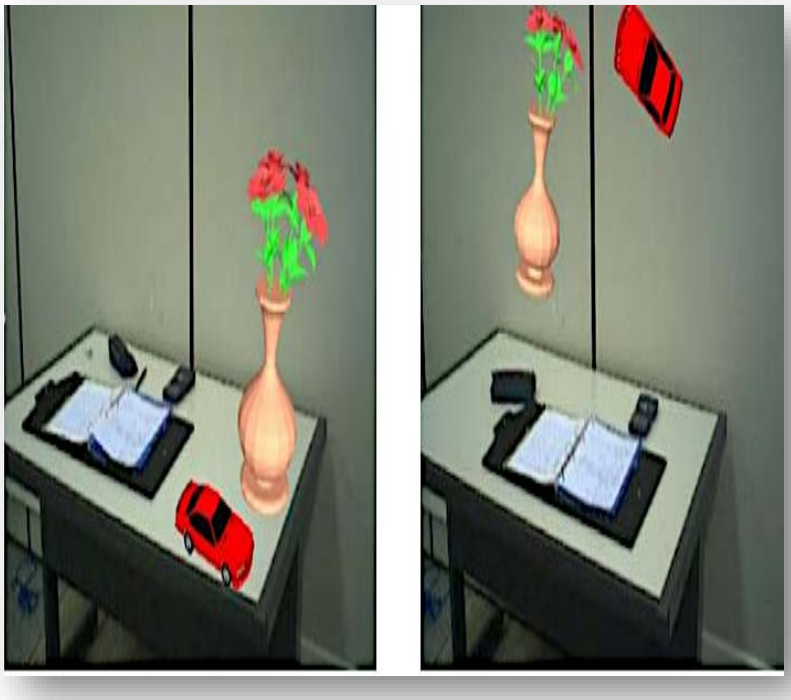
**Table 1.** Concepts of Augmented Reality

| Concept | Reference |
|---|---|
| It is a particularization of mixed reality, when the main environment is real or there is a predominance of the real; | Tori, Kirner e Siscouto (2006) |
| It is the enrichment of the real environment with virtual objects, using some technological device, working in real time. | Tori, Kirner e Siscouto (2006) |
| It is an improvement of the real world with text, images and virtual, computer generated objects. | Insley (2003) |
| It is the blending of real and virtual worlds at some point in the continuous reality / virtuality that connects completely real environments to completely virtual environments. | Milgran, (1994) |
| It is a system that fills the real world with virtual objects generated by computer, appearing to coexist in the same space and presenting the following properties: it combines real and virtual objects in the real environment; runs interactively in real time; organizes real and virtual objects among themselves; it applies not only to sight, but to all the senses, including hearing, touch, and smell. | Azuma (2011) |

Fonte: Authors, 2023.

Figure 1 shows an Augmented Reality scenario: there is a table and a binder from the real world combined with a cart and a potted plant from the virtual world, making the two environments coexist.

**Figure 1.** AR Scenario.



Source: Research record, 2006.

It is also possible to change the virtual objects inserted in the real environment using the hands or a device that works as a shovel, allowing the organization and adjustment of the mixed environment. This technology is promising and will bring positive changes in people's relationships, as it simplifies the formalization of ideas through the visualization and interaction of people with information (Kawashima, 2001; Galana & Silva, 2004; Santin, 2004).

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It is important to highlight that Augmented Reality is different from Virtual Reality (VR). In virtual reality, there is the immersion of the user, he is completely inserted in the synthetic environment, not being able to see the real world around him. It is a “replacement” of the real environment by the virtual one. In contrast, in Augmented Reality, the virtual environment is reproduced and superimposed on the real environment. AR allows the user to see the real world combined with objects from the virtual world (Bar-Zee & Lewis, 2016).

## Fundamentals of Augmented Reality

The main challenge of augmented reality is to make virtual objects appear to be part of the real world in order to integrate into this environment by creating the illusion of harmony. AR systems have the following characteristics (Tori, 2010; Azuma, 1997): (a) it mixes the real with the virtual, in a real environment; (b) real-time application; (c) 3D registration.

For this harmony to be achieved, it is necessary for an AR software to run on a computer with a webcam. Through computer vision and image processing techniques, it is possible to mix the real environment scene, captured by the webcam, with virtual objects produced by the computer. In addition, the AR software must enable user interaction with virtual objects and the interaction of real and virtual objects in real time (Kirner; Zorzal, 2005).

Still according to Tori, Kirner and Siscouto (2006) and Milgram (1994), Augmented Reality is a unique reality that exists between real and virtual environments. This relationship of realities can be understood as Mixed Reality (MR), a concept obtained through research by Milgram (1994) in his “Reality/Virtuality Continuum”, shown in Figure 2. For Tori, Kirner and Siscouto (2006), MR incorporates virtual elements to the real environment and vice versa, in order to complement the two environments.

It is possible to notice that Augmented Reality occurs when there is the introduction of virtual objects in the real world, maintaining the user's sense of presence in their natural physical environment, whereas Augmented Virtuality or Virtual Reality happens when real world users are introduced in the virtual environment. VR seeks to transport the user to the virtual environment.

AR can be divided into two classifications, based on the user's view, that is, how he sees the mixed world. In cases where the user sees the world mixed by directing the eyes to the real positions with optical or video scene, the AR is direct vision, also known as immersive. When the user sees the world mixed up through some device, such as a projector or monitor, not ordered with the real positions, Augmented Reality is indirect vision, also known as non-immersive (Tori; Kirner; & Siscouto, 2006).

Another well-known classification for AR systems is the classification based on the technology or device that is used. Thus, we have: direct optical vision; video-based direct viewing; monitor-based video viewing; optical projection vision (Milgram, 1994; Isdale, 2000).

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According to Thales Group (2016), Augmented Reality, which is usually better known in the world of games and entertainment, is arriving in the industrial environment. AR will be able to provide accurate and real-time data. There are several areas where its application will bring benefits, mainly the areas of teaching, learning and training, that will have to undergo a great evolution, considering the new forms of relationship between teacher, student and information (Tori, Kirner; & Siscouto, 2006).

AR has been applied in several areas, such as medicine, with surgery simulation, diagnosis and training, in the development of games applied to education and leisure and in marketing, exposing products as interaction elements (Moreira, 2012; Wanderley; Medeiros; & Silva; 2011).

## Augmented Reality in Education

For Klettemberg, Tori and Huanca (2021), AR is a technology that has been gaining ground and is of enormous importance for education. When analyzing publications of scientific articles on the use of AR in basic education, a growth in interest in the topic can be seen from 2012 onwards. That year, the first cloud AR application was launched (Blippar, 2012), simplifying and improving technology. In 2016, there was the launch of the first AR game that spread quickly and achieved great success: *Pokémon Go*, as shown in Figure 2. It was found by the authors that, after sharing Augmented Reality, there was a reduction in device prices. As of 2016, there is a greater number of publications that deal with AR applied to education.

This finding corroborates the statement by Tori and Hounsell (2018), in the sense that greater technological propagation and the reduction of device values are fundamental factors for the dissemination and consolidation of the use of AR in various sectors

An example of the implication of AR in education is the *Pokemon Go* (Figure 2). With the huge success of the game, another AR games have become popular, drawing attention from many areas, including education. *Pokémon Go* is a multimodal text in which students can interact outside the classroom and can be used to develop and explore academic literacy and reasoning skills within the classroom. In the game, children have the opportunity to develop notions of location, reading and critical thinking (Howell, 2017).

 

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**Figure 2**. Pokémon GO and AR


Source: Research record, 2022.

Regarding the demographic aspect, the Asian continent leads the number of publications of scientific articles on the use of AR in educational processes. However, this tool and the relationship with the field of education is being disseminated and studied worldwide. AR is present in all educational spheres and is available for all ages (basic, higher, technical education). The use of AR in education allows an innovative perspective that improves the quality of teaching. Students are interested in technology and feel motivated to learn. Despite the influence of negative aspects such as the low supply of devices and low investment by schools or government, motivational variables are strongly present, as AR allows learning in a playful and more interesting way. In addition, several areas of knowledge benefit from AR applications (Klettemberg; Tori; Huanca, 2021).

Stylianidou et al. (2020) argue about the importance of student engagement, motivation and participation in the learning process and claim that the use of Augmented Reality in educational contexts increases the levels of these three factors, which improves the level of student learning, including low-performing students. For Cardoso et al. (2014), AR makes the didactics of teaching more dynamic and enjoyable, thus providing a differentiation for the pedagogical contents.

Augmented Reality can enhance learning experiences by making 3D artificial objects available for students to interact with, which certainly increases the visual perception of the object under study. Students can analyze the 3D object from multiple perspectives for further understanding and comprehension (Chen et al., 2017; Arvanitis et al., 2007).

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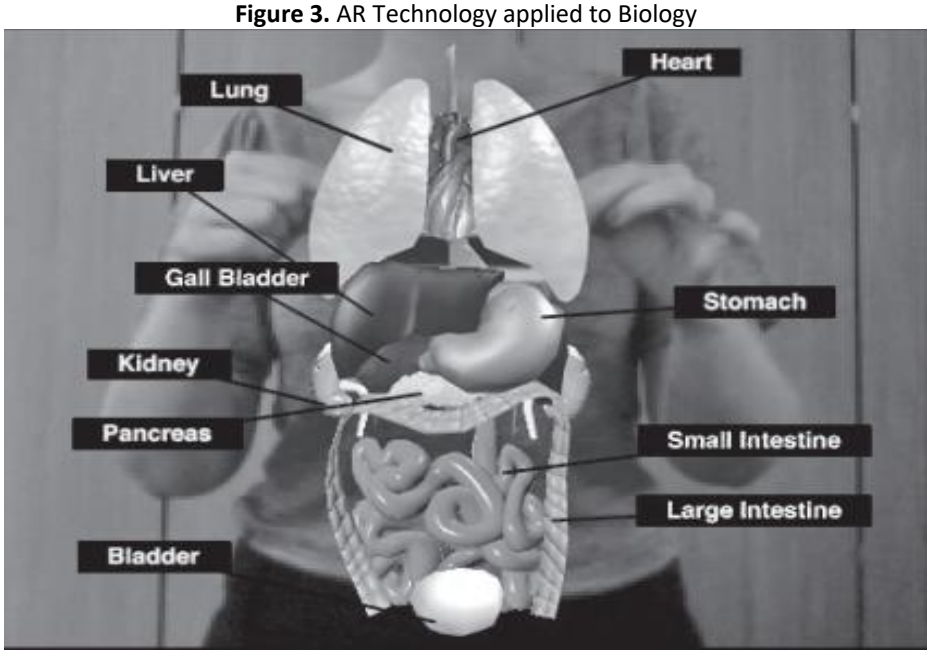
AR can be used in several areas of knowledge, such as for the study of anatomy and body structure in biology, the study of molecules in chemistry and even to review important events in history. An example of application is the fact that the Specialist Schools and Academies Trust (SSAT) found that teachers could use AR to show which organs make up the human body and how they look, all through the presentation of 3D computer-generated models in classrooms (real environment) (Lee, 2012) (Figure 3).

**Figure 3.** AR Technology applied to Biology




Source: Research record, 2022.

Kerwalla et al. (2006) cite an example of the application of AR in the study of astronomy that was divided into two parts: traditional teaching and Augmented Reality. In the traditional teaching phase, there was reading a physical book, verbal explanation about the solar system and a presentation using physical objects (for example, a tennis ball, a rope and a torch). In the AR phase, teachers and students used a mix of technologies (e.g. whiteboard, projector, web camera, AR block, and virtual 3D modeling package) to observe and manipulate a virtual 3D rotating earth to learn about the sun, earth, day and night (Wu et al., 2013). For Chang, Morreale and Medicherla (2010), an AR application called "3D Construction" was designed for teaching mathematics and geometry with three-dimensional models of geometric construction (Kaufmann, 2006; Kaufmann & Schmalstieg, 2002).

Through this application, teachers and students share a virtual space to work collaboratively in order to build geometric shapes, making it possible for users to superimpose images generated by the computer on the real environment.

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There is no doubting the numerous benefits of AR in education. Among these benefits, we can also highlight the reduction of anxiety in learning mathematics. According to a study carried out by Wangid, Rudyanto and Gunartati (2020), the application of an AR book in mathematics classes brings positive effects such as reducing anxiety, a problem that is often a barrier in the learning process. 3D visualization through AR and the use of media and innovations positively influence the reduction of students' anxiety (Klettemberg et al., 2021).

Based on the analysis of the literature, some dimensions and variables were verified about the theme "reality" in education. One can cite the quality of teaching that aims to evaluate the effectiveness of the application of the use of AR in education and has as a variable's adequacy to content, teaching methodology, physical resources and competence of teachers and staff. Other dimensions found in the literature emphasize investment in devices and training of the teaching staff. The first dimension mentioned has access to appropriate devices and the number of students per device as variables, while for the second it can be mentioned the existence of programs for training and qualification of teachers (Paulins, 2005; Klettemberg; Tori; & Huanca, 2021).

In addition to these dimensions, engagement and motivation of those involved in the educational process, active learning and student satisfaction were also found. Engagement has as variables the level of acceptability and involvement of teachers and students and how much they are interested in the educational process using AR, whereas in active learning it is evident in the literature, as variables, effectiveness, challenge and feedback. Finally, student satisfaction is the dimension that has expectations and perceptions as variables (Anderson; Fornell; Lehmann, 1992; Jacques; Preece & Carey, 1995; Hayes, 2001; Prince, 2004).

## RESEARCH METHODOLOGY

This is a bibliographical research, with a qualitative and exploratory approach, as it aims to gather information about the application of AR using the MAREEA model. The research was based on the theoretical-conceptual analysis of the themes that involve AR studies in education and the MAREEA model in Higher Education Institutions. The research process was carried out in two stages: (i) bibliographic survey in databases and (ii) selection of articles for discussion.

The databases consulted for the bibliographic survey were SciELO, CAPES Periodicals Portal, ERIC (Databases in Education) and digital and institutional repositories.

The following keywords were used for the collection: "Augmented Reality", "Higher Education Institutions" and "Evaluation Model of Educational Approaches in Mobile Augmented Reality". The temporality criterion was open and the languages were Portuguese, English and Spanish.

 

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## RESULTS AND DISCUSSION

### APPLICABILITY OF THE MAREEA MODEL IN HIGHER EDUCATION INSTITUTIONS: BRIEF DISCUSSION SCENARIO

Herpich et al. (2019) present an Evaluation Model of Mobile Augmented Reality Educational Approaches. This model aims to analyze the educational approaches in mobile Augmented Reality to measure the perception of quality with regard to the user experience and learning of users after interacting with such resources in the educational field. In other words, this model aims to evaluate the perception of quality in education considering the use of augmented reality through mobile devices.

The MAREEA model has four evaluation factors, namely: usability, engagement, motivation and active learning. Usability refers to how intuitive it is for users to learn to use and interact with a certain product, that is, how simple it is for a person to use a certain system. Engagement consists of the user's reaction in order to create an interaction that brings positive results such as improved attention, while motivation concerns people's goals and how effectively they are willing to pursue this goal. Active learning can be understood as any instructional model that actively involves individuals in the learning process; this model requires the performance of activities and makes the subjects think about what they are doing (Keller, 1987; Jacques; Preece; Carey, 1995; Preece 2001; Prince, 2004; Herpich et al., 2019).

The structure of the MAREEA model comprises a system that organizes the flow of analysis into two aspects: (i) quality factors and (ii) dimensions. This set of attributes constitutes a cyclical and feed backable assessment, in addition to being systemic, as it assesses the quality in different environments of the user's perception of learning (Herpich et al., 2019). DeVellis (2016) argues that the measurement instruments of the MAREEA model are the questionnaires, generally applied to observe the quality standards and evaluate the respective quality dimensions. All these quality factors for evaluating the use of AR in education defined in the MAREEA model and their consequences are proposed in Figure 4.

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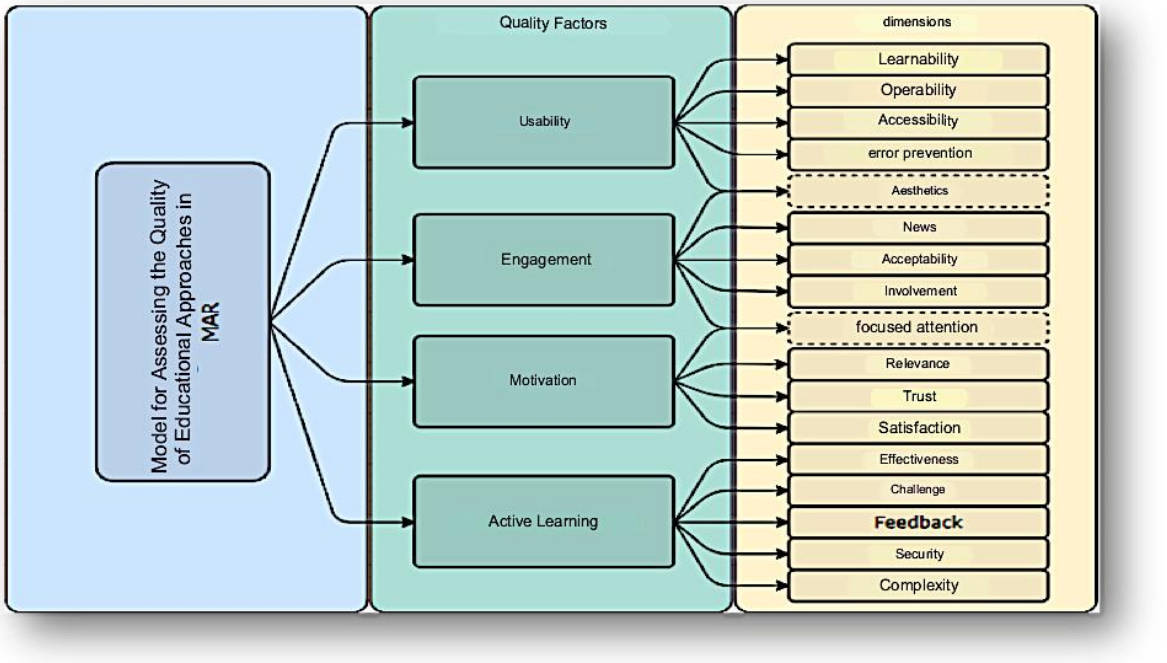
**Figure 4.** Structure of the MAREEA evaluation model




Source: Herpich et al. (2019).

Some studies developed applying MAREEA in HEIs have shown important advances in research on the subject, mainly in the mediation process, cognitive development and improvement of learning techniques. Below are some studies applied in HEIs in Brazil, focusing on multiple strategies for improving learning processes:

The study by Yaegashi (2017) observed MAREEA as an innovative pedagogical model aimed at disruptive educational environments. The study was applied in a private HEI, in face-to-face and online modality, through which it was possible to diagnose processes of improvement in the adaptation of actions for the evaluation of face-to-face and distance education courses. Yaegashi's research (2017) understood the MAREEA as a qualitative assessment instrument aimed at three aspects: sizing improvements throughout planning, engagement of the work team and understanding of motivational factors.

The research by Herpich et al. (2020) explored the evaluation of twenty-seven (27) students from a federal HEI, in which the feedback of improvements with the use of AR technology was analyzed from the dimensions of usability, engagement, motivation and learning. The study identified that the evaluation participants were able to improve the use of methodologies previously introduced by the institution, and the use of AR technological alternatives improved the pedagogical practice of teaching in the classroom, mainly by improving the interaction between student and teacher. Furthermore, in the study by Chang and Hwang (2018), whose learning method was based on the flipped classroom methodology, it was identified that the increment of processes with AR enhanced the development of applications and didactic activities in the classroom.

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The use of MAREEA contributes, above all, to identifying possibilities for long-term adjustments in AR applications in the classroom. As in the study by Pereira (2014), who applied Google Sketchup technology in initial classes of the Electrical Engineering course, demonstrating the facilitation in the visualization of geometric elements. For this study, an evaluation of improvements in student interaction and engagement was carried out, especially with students who did not have a basic command of technologies, making it possible to adjust the teaching practice. Likewise, Almeida and Santos (2015) developed an application of the Tales theorem through the Augmenters Author tool for students at a private university. The evaluation was directed towards a technical observation at three levels of analysis: challenge, feedback and usability.

## CONCLUSION

Studies on AR with application in Higher Education have been covering their analyzes for the processes of evaluating and understanding the usability of enabling tools and instruments that provide greater approximation with technological resources that enable the improvement in the teaching-learning process. In this sense, assessment methods are crucial mechanisms for observing the student's relationship with technology, in order to capture and understand how the applicability of an AR technology can effectively provide greater knowledge evolution in their academic practice in the classroom.

In academic terms, the research sought to discuss the use of AR in Higher Education Institutions, understanding the applicability of MAREEA to promote efficiency in the quality process in the evaluation of students regarding the usability and operationalization of AR. In addition, the research contributes to academic growth and to the strengthening of scientific knowledge, as well as highlighting the importance of applying theoretical knowledge of production engineering in the field of education.

In managerial terms, the research aimed to stimulate the interest of managers of Higher Education Institutions to increase the quality of their services through the application of technologies and innovations brought by industry 4.0.

It was observed that AR brings innovations that culminate in the improvement of the learning process, highlighting the importance of training students, teachers and technicians in the education sector, in addition to enabling a perception of expansion of social, technological and inclusive education. The MAREEA model, on the other hand, is a tool that has allowed the evaluation of quality dimensions in learning, based on learning experiences in educational environments and the applicability of mobile media resources combined with educational objects.

AR has proven to be a promising enabling technology in Higher Education Institutions, allowing the creation of more dynamic and interactive learning environments. In this context, the Evaluation Model object of this study presents itself as a useful tool for evaluating the quality of education mediated by AR.

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The model is composed of four evaluation factors: usability, engagement, motivation and active learning. Through the application of this model, research has shown that AR can contribute significantly to the cognitive development of students, as well as to the improvement of learning techniques.

It is worth mentioning that the application of AR in education does not replace the traditional teaching model, but complements it by enriching the learning environment. In addition, this tool has been used not only to improve technological education, but also other fields such as social education and inclusive education. This demonstrates its versatility and potential to be applied in different areas of knowledge.

AR emerges as an alternative capable of improving the quality of teaching, making it more attractive and interactive. The application of the MAREEA model, on the other hand, allows a more precise and systematic evaluation of the relevant aspects for the successful implementation of AR in HEIs. It is recommended to carry out research to verify how AR has contributed to improving the learning process.

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