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AUGMENTED DIDACTIC: AN INTERDISCIPLINARY APPROACH TO ASSESSING AUGMENTED REALITY IN LEARNING

DIDÁCTICA AUMENTADA: UN ENFOQUE INTERDISCIPLINARIO PARA EVALUAR LA REALIDAD AUMENTADA EN LOS PROCESOS DE APRENDIZAJE

DIDÁTICA AUMENTADA: UMA ABORDAGEM INTERDISCIPLINAR PARA AVALIAR A REALIDADE AUMENTADA NA APRENDIZAGEM

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Abstract

Augmented reality (AR) is a ground-breaking technology through which virtual elements, created with the help of computers or other devices, are inserted into a real environment, through a process of information overlapping that allows users to interact in real time with context-sensitive virtual information objects (Di Martino,2019). AR in didactics helps students to understand material and contents being studied, by facilitating their learning (Yildirn, 2018). AR helps students engage in learning contexts that become authentic real-world explorations by facilitating the observation of events that cannot be easily observed with the naked eye (Wu et al., 2013). This quantitative experimental research uses both conventional qr codes to support university teaching and innovative use of ArUco markers that allows student to view directly on their devices different manipulable models, whose purpose is to facilitate the inspection of what is represented. Specifically, we investigate the use of AR as a facilitator for the understanding of concrete concepts and inherently difficult-to-learn subjects belonging to faculties of humanities and technology. The added value of the research is the accessibility of the facilitator that is proposed with the use of a common smartphone. For a quantitative estimation of the effectiveness of the proposed method, a control group subjected to frontal teaching and an experimental group subjected to AR teaching will be evaluated.

Keywords: undergratuate, smartphone, qrcode, pedagogy, engineering.

Resumen

La realidad aumentada (AR) es una tecnología innovadora mediante la cual elementos virtuales, creados con la ayuda de computadoras u otros dispositivos, se insertan en un entorno real, mediante un proceso de superposición de información que permite a los usuarios interactuar en tiempo real con objetos virtuales sensibles al contexto. objetos de información (Di Martino, 2019). La RA en la enseñanza ayuda a los estudiantes a comprender los materiales y contenidos que se estudian, facilitando su aprendizaje (Yildirn, 2018). La RA ayuda a los estudiantes a participar en contextos de aprendizaje que se convierten en auténticas exploraciones del mundo real, facilitando la observación de eventos que no se pueden observar fácilmente a simple vista (Wu et al., 2013). Esta investigación experimental

cuantitativa utiliza tanto los códigos QR convencionales de apoyo a la docencia universitaria, como el uso innovador de los marcadores ArUco que permiten a los estudiantes visualizar diferentes modelos manipulables directamente en sus dispositivos, cuya finalidad es facilitar la inspección de lo representado. Específicamente, investigamos el uso de la RA como facilitador para la comprensión de conceptos concretos y temas intrínsecamente difíciles de aprender pertenecientes a las facultades de humanidades y tecnología. El valor agregado de la investigación es la accesibilidad del facilitador que se propone con el uso de un teléfono inteligente común. Para una estimación cuantitativa de la efectividad del método propuesto se evaluará un grupo de control sometido a docencia presencial y un grupo experimental sometido a docencia de RA.

Palabras-clave: estudiantes de grado, móviles inteligentes, qrcode, pedagogía, ingeniería.

Resumo

A realidade aumentada (AR) é uma tecnologia inovadora através da qual elementos virtuais, criados com a ajuda de computadores ou outros dispositivos, são inseridos num ambiente real, através de um processo de sobreposição de informações que permite aos utilizadores interagir em tempo real com o contexto. objetos de informação virtual sensível (Di Martino,2019). A RA na didática ajuda os alunos a compreender o material e os conteúdos que estão sendo estudados, facilitando seu aprendizado (Yildirn, 2018). A RA ajuda os alunos a envolverem-se em contextos de aprendizagem que se tornam autênticas explorações do mundo real, facilitando a observação de eventos que não podem ser facilmente observados a olho nu (Wu et al., 2013). Esta pesquisa experimental quantitativa utiliza tanto códigos QR convencionais para apoio ao ensino universitário quanto o uso inovador de marcadores ArUco que permite ao aluno visualizar diretamente em seus dispositivos diferentes modelos manipuláveis, cujo objetivo é facilitar a inspeção do que está representado. Especificamente, investigamos o uso da RA como facilitador para a compreensão de conceitos concretos e assuntos inerentemente difíceis de aprender pertencentes a faculdades de humanidades e tecnologia. A mais-valia da investigação é a acessibilidade do facilitador que se propõe com a utilização de um smartphone comum. Para uma estimativa quantitativa da eficácia do método proposto, serão avaliados um grupo controle submetido ao ensino frontal e um grupo experimental submetido ao ensino AR.

Palavras-chave: estudantes de licenciatura, smartphone, qrcode, pedagogia, engenharia.

INTRODUCTION

The current educational scenario feels the need to respond to the challenges given by digital evolution: innovation, in fact, is inserted as a link between teaching and learning processes, contributing to a constructivist perspective where meanings are born from experiences and interactions anchored to the cultural reality of students, and where the embodied perspective continues to be the framework of a new pedagogical didactic concept, which sees the body as the most natural side of learning (Gomez, 2009).

This research is an implementation of an already existing research (Lembo et al., 2023) that is born with the objective of investigating the impact of Augmented Reality (AR) conveyed through QR-code, which allows the student to exploit the motor execution of the gesture by manipulating the overwritten virtual object in physical reality contributing to the development of conceptual knowledge in an embodied cognition perspective (Duijzer, 2017).

The upgrade presented consists in the assessment of the impact of AR within a comparison between humanities and technological faculties: specifically, the reference sample relates to the Education Department and Engineering one. This research aims to evaluate the possible contribution of AR in the internalization of concrete but difficult-to-understand concepts, expanding the heterogeneity of the sample. Teamwork, which responds to the need for multi and inter-disciplinarity, reflects on the rigidity of the roles played by teachers in the creation of teaching methodologies. In fact the aim is to loosen the boundaries of these roles and allow the skills of each to become pervasive and transversal.

1 AUGMENTED REALITY IN DIDACTIC: AUGMENTED DIDACTIC

Augmented reality (AR) in the field of education is defined by the potential it offers, as it allows the student to live increased experiences, obtaining a high level of interaction with the set of notions that at that moment one wants to learn (Tomassoni, 2021). Recent applications of AR in the use of textbooks, which enhances their abilities (Cino, 2017; Filomia, 2019), suggest to reflect on the psychopedagogical potential that digital input could offer in the field of education (Diegmann, 2015; Niewint, 2019; Pancioroli & Macauda, 2018).

It is precisely the possibility of interaction with the concept to be acquired that has led us to rethink the mode of teaching, based on the dual need to find an anchor with the new predispositions and attitudes of students, who are now moving in the digital sphere, and to exploit the intrinsic potential of an Embodied Cognition approach in which the body is the necessary means that underlies the learning processes (Paloma-Gomez, 2016). We thought about how much the possibility of accessing the concept to be acquired in the context in which one is learning and even manipulating it, thus making oneself aware of an overall reality manageable according to one's needs, could favor the learning processes. Improving learning processes requires a more active participation of the student and a greater and more new awareness of what one is learning, an awareness that is returned much more by a notion taught through AR than by a mere two-dimensional image. The potential of AR also lies in the ability to engage multiple senses simultaneously, making the learning experience a global learning experience that takes place through the whole body. In this way, the AR responds in a functional way not only to the specificity and individuality of students, who are characterized by the presence of increasingly heterogeneous learning styles, but also to the educational needs of students with disabilities (Di Martino & Longo, 2019). To access augmented reality in an educational context, QR codes have been used, and specific markers called ArUco have been considered. These markers are most suitable for students' use due to their robustness in terms of rotation, trapezoidal or perspective distortion. Furthermore, ArUco markers are particularly effective even in conditions of low lighting, making augmented reality accessible anywhere and at any time, aligning with the research objective of ease of use. The markers also consider the position that the student assumes during the lesson, where the perpendicularity between the device and the physical support is not always guaranteed. In light of this, the choice of these markers resolves any difficulties and adequately fulfills the project's objectives.

2 AR, LEARNING AND MOTIVATION

The fundamental principles of motivation and learning transcend the differences that make each technology specific, from virtual reality to AR even to artificial intelligence (Keller, 2016). The research investigates how the reality of AR, integrated into the lessons provided to the students, can influence the motivational level of the latter creating a cascade positive influence on the learning processes. The motivation construct can be defined as multicomponent because it identifies four categories which determine the totality of the construct: "interest", "relevance", "expectation" and "results" (Keller, 1979). These categories show the complexity of the motivation, which is influenced by the levels of curiosity and interest related to the notional concept being learnt; the subject must also perceive the relevance of the information to the extent that it is consistent with objectives, learning styles and past experiences. The motivational construct also concerns the confidence and satisfaction perceived by the student regarding positive expectations for success. So, this construct rests on a complexity of sub-constructs which, in their interaction, contribute to determine the complexity of the whole motivational expression. In the theoretical landscape we have just described the AR fits perfectly, anchoring itself to all the sub-components that define the motivation: manipulating virtual objects overwritten in the physical reality of the student satisfies the levels of curiosity of the student. This technology makes learning processes more efficient during the presentation of content as it himself/herself requires greater interaction and involvement of students. AR, in fact, allows to overcome the limitations imposed by the current media used during lessons, such as slides, images or video files, making the teaching experience much more exciting and engaging (Tomassoni, 2021).

The interaction through AR, with the concept to be internalized, correlates with the new predispositions and attitudes of students, who are now moving in the digital sphere. One should think about how AR makes the presentation of content more effective by requiring more interaction and involvement of students. AR is one of the technologies with a significant impact in educational contexts, promoting a rereading of the fields of teaching, learning and research. In fact this technology allows to offer the student learning forms, not only theoretical, but rather, visual, manipulable and highly interactive, enriching the real world with the superimposition of digital data and the simulation of dynamic processes.

In the use of AR there is a greater accessibility of information, inherent in the concept to be learned, which allows the student to experience the concept, not only visually but also through the manipulation of it. The AR refers to an image that the student can explore from the inside, enlarge or shrink it, rotate it, moving his/her fingers on the screen, succeeding in grasping its relationships as a whole and improving and facilitating its understanding also through a more realistic and engaging approach. The augmented information is provided in a stratified way to allow the search for further meanings (Panciroli, 2018). It is based on a constructivist approach according to which the individual builds meanings through experiences and interactions, in the light of an anchorage and a resonance with the cultural reality of the individual. In the face of this, the use of the smartphone equipped with touch-screen emerges even more clearly, offering the possibility of

Scientific evidence shows that one of the dimensions most favored by the contribution of AR is the dimension of interactivity. It is precisely this dimension that is identified as one of the most important for fostering learning processes that can be declared meaningful. In fact, the objects that AR propose, do not suffer from the static and immobility of the most traditional teaching aids, but can move and animate in response to the actions of the user. The significance of the resulting learning stems from the improvement of memory capacities, which leads to longer retention of knowledge acquired through AR (Dünser, 2012). Moreover, the scientific community agrees in affirming that the AR, integrated with the teaching methods, improves the ability to explore, favors the absorption of new knowledge, increasing the motivational level and the emotional impact of the student (Liu, 2009). Taking advantage of the continuous use that the student already makes of the smartphone, it is proposed to give an educational cut to this use, asking the students to use the devices during the study sessions, which thus become highly interactive and engaging, by connecting the power of technology and the network in favor of a new and deeply dynamic communication in the transmission of content (Bidoia, 2016).

3 IMPLEMENTATION OF 3D MODELS

Multidisciplinarity has become necessary for the execution and realization of research. Considering the new pedagogical and didactic scenarios permeated by digital innovation, it is no longer possible to conceive and define a teaching methodology that is not the result of expertise from multiple fields. To meet the technical specifications of this project, it was necessary to create three-dimensional models of the human brain, highlighting the cerebral areas underlying emotional, mnemonic, linguistic, and motor processes, as well as three-dimensional models of thermodynamic state diagrams for studying phase transitions of real substances. The glTF format was chosen for the three-dimensional models as it was deemed most suitable for this purpose, as it allows for quick upload and download, speeding up the use of augmented reality and mitigating the risk of delivering cumbersome lessons that could negatively impact performance outcomes. These models aim to satisfy the investigation regarding the impact of augmented reality in an interdisciplinary approach: the intention is to compare the effect of augmented reality in humanities faculties and technological faculties.

For research purposes, HTML pages were created containing JavaScript code capable of activating the smartphone's camera and consequently providing a real and direct view of the surrounding physical environment. The functionality of the HTML pages is realized through the framing of the aforementioned ArUco markers, which anchor the three-dimensional reference system of the model to a vertex that needs to be called. In the design of the 3D models, pedagogical and neuroscientific perspectives were taken into account. The embodied approach supports the overcoming of the Cartesian mind-body dualism, giving the latter a new dignity and centrality in the learning processes. This implies the need to make the use of augmented reality globally experiential by equipping the models with features of scalability and rotatability, through touchscreen gestures that leverage the coordination between action and perception, and the execution of gestural motor actions that contribute to the development of conceptual knowledge from an embodied cognition perspective. This was made possible thanks to the use of the Aframe framework, a library that allows for model manipulation. The overlay of the 3D model onto the student's physical reality is closely related to greater involvement of the student, who becomes the protagonist of a highly emotionally impactful learning experience, positively influencing the internalization of concepts that find an anchoring with the reality in which the subject is immersed (Tomassoni, 2021).

4 RESEARCH PROJECT

4.1 RESEARCH HYPOTHESIS AND SAMPLE

The research hypothesis aims to determine if AR, conveyed through qr code, can implement the learning of concepts in the Education and Engineering, and if it can implement the learn motivation. This research is the continuation of a previous research that had begun to explore the use of this new teaching methodology. Since the previous research (Lembo et al., 2023) has given excellent results, we have gone deeper into the proposed teaching methodology, selecting a faculty with a totally opposite matrix, i.e. a faculty of science instead of humanities. The sample consists of 108 students, 90 of whom come from the Education Department and 18 from the Engineering Department.

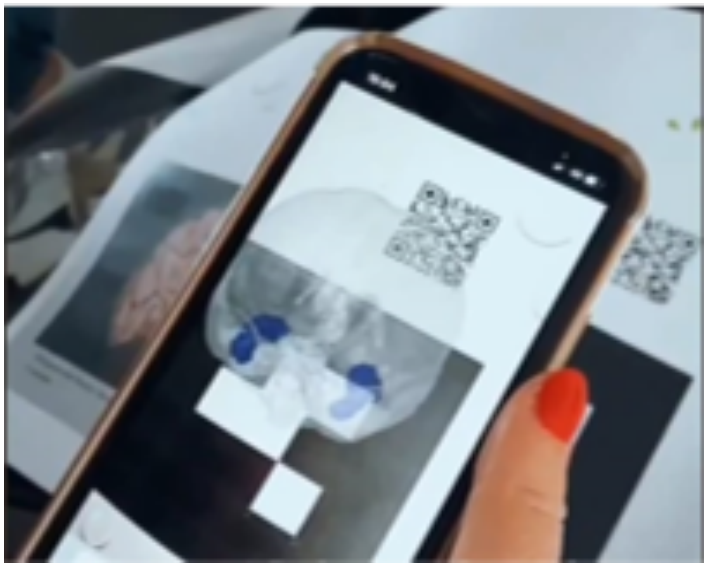
4.2 METHODS AND MATERIALS

The sample was randomly divided into two groups, an experimental group of 60 subjects and a control group of 58 subjects. The proposed teaching activity included the normal use of the didactic lesson, with frontal explanation and with multimedia support, such as slides and videos. In addition to this, the experimental group benefited from the use of AR. Specifically, AR was presented through qr code which, as in image 1, allowed to view and manipulate the notions presented in class. AR was therefore used both during the lesson, during the explanation phase, and during learning at home.

At an early stage of the trial, we administered the Rey Auditory Verbal Learning test (RAVLT), a mnemonic test used to exclude the presence of memory disorders within the sample. Then, at the end of the proposed teaching activity, we administered, both to the experimental group and to the control group, a spontaneous recall questionnaire aimed at investigating the level of memorization of the concepts explained. At the end, we administered AMOS, a study approach questionnaire, which analyzes the motivation to learn through 5 components: elaboration, organization, cognitive sensitivity, strategies and self-evaluation.

Figure 1

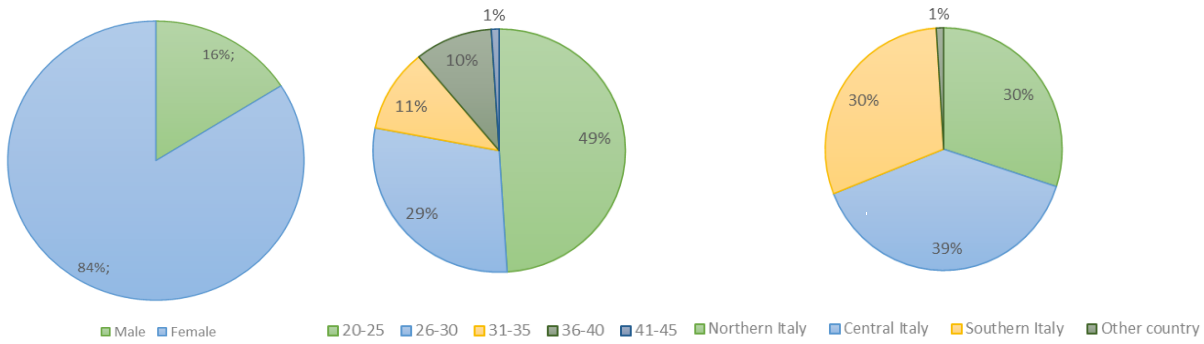
AR, via qr code, on smartphone



4.3 RESULTS AND DATA ANALYSIS

Graphs 1, 2 & 3

Sample gender, age ranger and origin

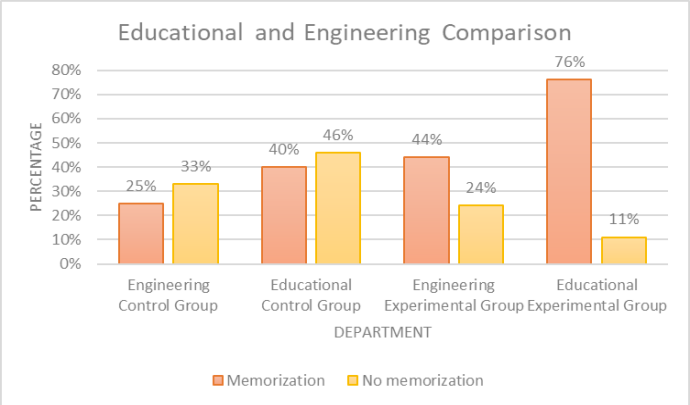


The sample, made of 108 students from the Education and Engineering Department, is composed of 84% females and 16% males. The age is quite heterogeneous, from 20 years to 45 years, with an average age of 26 years. The sample composed of students of the Niccolò Cusano University of Rome, has a heterogeneous origin from both the north, central and southern Italy. In the previous research (Lembo et al., 2023), the experimental group, belonging to the Education Department, had shown a 40% improvement in learning the selected notions (functioning and neural bases of emotions, memory, language and movement) thanks to AR and therefore it's now in our interest to understand if this effect can also affect other issues and other faculties. The lesson proposed at the engineering students concerned the notion of volume-temperature-pression of real substances. We have selected these topics for these two faculties because, from our preliminary study, they are rather complex topics to understand, which is why there is a need to find a more functional way of learning them.

As can be seen from Graph 4 the level of memorization of the concepts presented, in the control group, is very low.

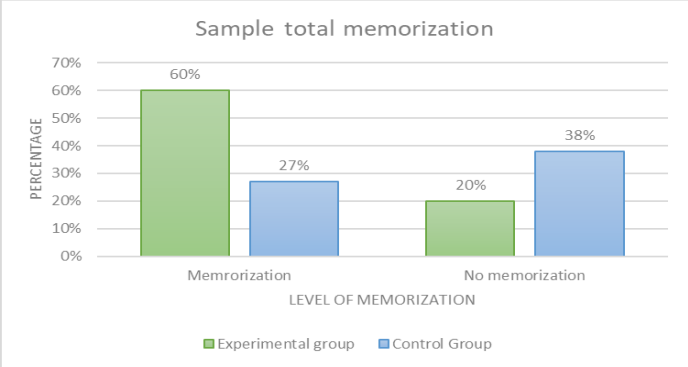
Graph 4

Department Comparison



Graph 5

Sample Memorization



The graph 4 shows that students of the Engineering Department also benefited from the use of Augmented Didactic: the control group shows a percentage of correct answers in 25% of the sample, while the experimental group in 4 4%, showing an improvement of 19%. Comparison with the Education Department shows that the improvement is a bit lower, since the experimental group of the latter responds correctly in 76% of cases. In Graph 5 there is the union of the two research that in general confirm how this new methodology is of effective benefit to the sample, resulting in a general memorization level of 60% compared to 27% of the control group, highlighting an improvement in the memorization of the concepts presented, thanks to the use of Augmented Didactic, of 33%. At this point, it becomes central to understand the actual validity of the experimentation presented. We therefore performed an independent sample T test to check if our hypothesis is null, i.e. that the averages between the two experimental groups were equal, could be confirmed or rejected. The results show a difference in the averages between the two samples of 11.2 points and the p value, less than 0.001, affirms that this difference is statistically significant, which is why we can reject the null hypothesis and confirm the alternative one, i.e. there are statistically significant differences between the two samples (see Table 1).

Table 1

Independent Sample T test

Independent sample T test

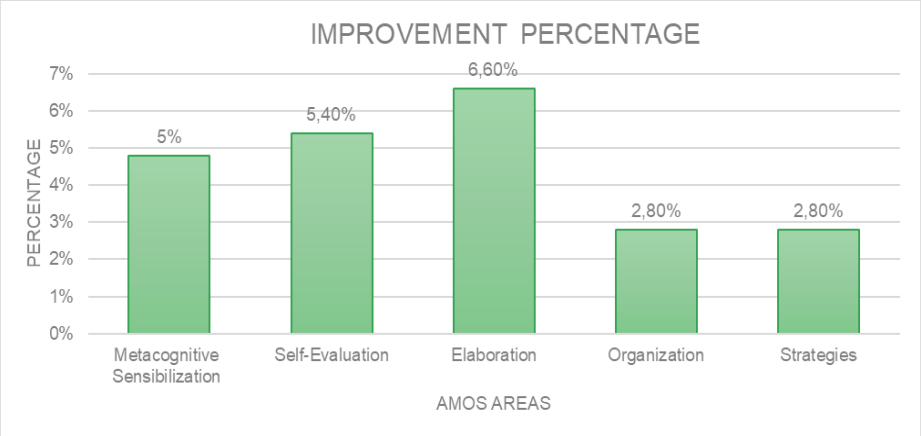
		Statistic	DoF	p value	Average difference	SD difference	Effect size	
A	t di Student	7.95	106	< .001	11.2	1.41	d di Cohen	1.54

Note. $H_a\ \mu_{\text{Augmented Didactic}} \neq \mu_{\text{Traditional Didactics}}$

The fact that the difference is statistically significant, however, is not necessarily associated with the fact that the effect is large enough to have any practical interest. To get this information we used the analysis of the effect size, through the Cohen d. This index reveals the percentage of overlap between the two distributions, according to an effect that can be small, medium, large or very large. The Cohen d resulting from our research turned out to be greater than 1.5, so the size of the effect ranks as very large, representing a 25% overlap between the two distributions. Finally, we analyzed the level of learning motivation of the two experimental groups. Our research showed an improvement in the level of motivation to learn, showing a 4% boost. In graph 7, there are in detail the different areas, where it is possible to see how the improvement has affected the elaboration component more.

Graph 7

AMOS



4.4 DISCUSSION

The research hypothesis aimed to understand whether the improvement previously found (Lembo et al., 2023) on a sample of students of Education Department, could also affect other realities and faculties. From the data analysis, it is evident that even the student of Engineering showed a clear improvement from the use of Augmented Didactic, although with a lower percentage of improvement. The notions selected to represent in AR were those found as most difficult to understand, which is why they were also quite difficult to represent, and therefore this factor may have influenced the level of learning. In addition, engineering students are more accustomed to the use of technology, and for this reason they have experienced in a lower percentage the wow effect experienced by the education student. Finally, there is a component that largely influences the learning of students, that is the way the lesson is conducted and the teacher's teaching mode. There are wide differences in the type of lectures and topics between the two faculties and the teachers selected to carry out the lessons had slightly different teaching styles. We did not request that these teachers use the same teaching style because the Augmented Didactic project is based on the idea that this teaching methodology is effective regardless of the faculties, the topics covered and the teaching styles of the teacher. In fact, despite differences, the total improvement experienced by the experimental group was 60% and the p value and the effect size confirm that this improvement is statistically significant.

With reference to the learn motivation to learn, the difference of only 4% can be attributed to several factors, such as the time when the test was administered (after several consecutive hours of lessons), or the fact that the Augmented Didactic lesson was a small parenthesis compared to a normal and traditional teaching method. This is why it may not have impacted too much on the level of motivation. Despite this, the area on which we notice a greater improvement is “Elaboration”, linked to the in-depth elaboration of the concepts studied. In line with our assumptions, this could suggest that students have experienced greater appreciation and awareness of the levels of processing and understanding of the themes.

CONCLUSIONS

In light of what emerged, the research hypothesis can be defined as confirmed because the use of AR in didactic, conveyed through Qr code, has led to a statistically significant improvement in learning in the two selected faculties, as well as an enhancement of learning motivation.

Considering what has emerged, it is necessary to continue the investigations that involve the use of AR, declining the latter in the fields of education. It is, therefore planned to expand the investigations on the subject by considering the different factors that support learning beyond motivation and in light of this bring the focus on the processes of memorization, perception and emotion, which in a synergistic way contribute overall to determine the cognitive process of learning. The awareness of the need for multidisciplinarity within the didactic contexts is maintained,

enhancing the possibility among teachers to internalize transversal skills that can make them skilled in rethinking and building teaching approaches, with the completeness conforming to the new learning styles of digital native students.

REFERENCES

Bidoia C. (2016). Erbario in movimento, la realtà aumentata. *SIe-L – Società Italiana di e-Learning*, 1

Cino L. (2017). Realtà aumentata nell'aula di lettere. *Bricks, 7*(1), 51-57

Di Martino V., & Longo L. (2019). Augmented reality to promote inclusive learning. *Form@re – Open Journal per la formazione in rete, 19*(1), 179-194.

Diegmann P., Schmidt-Kraepelin M., Van den Eynden S., & Basten D. (2015). Benefits of Augmented Reality in Educational Environments – A Systematic Literature Review. *Wirtschaftsinformatik Proceedings 2015/103*, 1542-1556

Filomia M. (2019). Augmented reality and textbooks: systematic review. *Form@re – Open Journal per la formazione in rete, 19*(1), 165-178.

Gomez Paloma F., Ascione A., Tafuri D. (2016) Embodied Cognition: the role of body in didactics. *Formazione & Insegnamento* XIV-1

Guglielmi G. (2017). Il Legionario "aumentato" – Un esercizio di lessico latino in "realtà aumentata". *Bricks. SIe-L – Società Italiana di e-Learning, 1,* 40-50.

Keller J., (2016). Motivation, Learning, and Technology: Applying the ARCS-V Motivation Model. *Participatory Educational Research (PER), 3*(2), pp. 1-13

Lembo L., Cipollone, E., Oliva, P., Monteleone, S. (2023), Augumented Didactic: wow effect for learning. Use of Augmented Didactic through qr code to enhance learning process in undergratues*, gsdjournal*, (printing)

Niewint J., Mori S., Naldini M., Benassi A., & Guasti L. (2019). IDeAL: A methodology for constructing artefacts and promoting transversal skills in the classroom*. Form@re – Open Journal per la formazione in rete*, *19*(1), 117-132.

Panciroli C., & Macauda A. (2018). Educazione al patrimonio e realtà aumentata: quali prospettive. *Italian journal of educational research, 11*(20), 47-62.

Tomassoni R. (2021), The instrumental function of "augmented reality" in the processes of representation, transmission and construction of knowledge. *MeTis, 11*(1).