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ORIGINAL RESEARCH ARTICLE

High school students' views on the use of metaverse in mathematics learning

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ABSTRACT

The introduction of information and communication technology (ICT) into the classroom has led to a new learning scenario based on educational innovation, in which mobile devices are used for teaching. In this study, the views of upper middle class students in a private educational institution in Mexico on the implementation of augmented reality teaching strategy based on metaverse mobile application are analyzed. The study is descriptive and survey based. Data retrieval is conducted using a clearly designed digital questionnaire. From August to December 2018, 192 first semester students who participated in the basic mathematics course participated in the course. The results show that compared with the previous academic year, the school recognition index has improved, and the affinity for the use of reality in the classroom has improved. When using the strategies mediated by these tools, the view of learning change is favorable. Therefore, it can be inferred that the application of augmented reality in mathematics teaching is of great help to students' performance.

Keywords: augmented reality; mobile learning; mathematics; innovation; learning strategies

1. Introduction

A frequent debate in the field of education focuses on whether mainstreaming information and communication technology (ICT) will improve students' learning. A variety of views can be found in this regard. Some of them show that technology is far from helping, but will reduce the quality of teaching practice[1,2]. Even those who claim that digital applications and devices help strengthen general and disciplinary capabilities and contribute to actively changing the teaching process[3–5].

In the field of mathematics, the position of ICT as an important factor for students to understand and master the topics of arithmetic and basic algebra can be determined[6–8], and it is pointed out that the teaching and use of ICT has led to the consolidation of classroom learning, It should also be noted that it is in this discipline that students most often seek help in virtual space to solve problems and strengthen their knowledge[9].

In this way, and recognizing that teachers play an important role in the application and effective use of digital technology[10,11]. These tools can be seen as capable of generating new learning styles that can go beyond those generated in traditional teaching practices, such as exhibition classes supported by the use of pens and blackboards, because

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digital device mediated learning acts as a cognitive amplifier[12].

2. Augmented reality in education

The emergence of augmented reality (AR) in school scenarios makes it easier for tablets and smartphones to promote innovative augmented reality based teaching strategies[13,14], which not only makes the teaching process dynamic, However, it helps to derive academic benefits from the mobile devices currently owned by almost all students and promotes the development of digital skills[15].

Recent studies have shown that the experience of AR in the classroom is related to academic success[16–18] and to the positive affinity of students to use AR applications in learning[19–21], Evaluate strategies for participating in training experience with high satisfaction, including simulated reality[22,23]. The main feature of this technology is real-time interaction with users through virtual images, regardless of education level, discipline and course content[24]. It is becoming an emerging and important tool in the teaching process mediated by information and communication technology[25,26].

The educational possibilities of AR are diverse because it can be used as a tool to simply present content related to students and as a tool to promote active and universal learning development[27]. Its interactive platforms are multiple and can use QR codes, images, 3D objects, GPS, etc.[28]. In any case, in the teaching process, AR can be regarded as a tool conducive to constructivist, situational and playful learning, involving students in school training[29].

Similarly, we believe that the experience design of AR intermediary can be shared with students in order to build learning objects from a collaborative[30,31], which enriches students' motivation to participate in their own knowledge generation.

However, it must be pointed out that AR has limitations, especially those related to the digital divide, that is, access to medium and high-end mobile devices, Internet connection of educational institutions, lack of digital literacy of teachers and the early development of students' educational digital knowledge, AR-based teaching strategies have great potential to improve learning by cultivating students' visual understanding of content[32], especially in the field of Mathematics[33].

With regard to the educational application of augmented reality, it was pointed out that this technology will have a significant impact as an interactive and three-dimensional content creation platform, which can be used in different disciplines and disciplines to improve divergent learning, while strengthening the technical capacity of students and teachers[34,35].

In addition, in the education level of bachilerato, Cabero and Barroso[36], they mentioned that various studies have been carried out on the experience of using this technology in learning, which better compresses complex concepts because it helps to decompose phenomena or processes into different stages[37,38]. It enables students to go up and down culture and enrich subject information in an interactive and dynamic way[39].

Therefore, AR strategy may improve students' participation in the teaching process, improve teachers' ability to build stimulating, immersive and destru/ctive l earning space, and enrich students' experience in solving conceptual and procedural problems through a deeper understanding of academic content.

3. Methodology

This study is a descriptive study, which uses quantitative methods to obtain postest information[40] through a systematic process and public opinion survey[41]. To this end, a collection tool called "using metaverse to develop high school students' Mathematics Learning" was made, which was provided to 267 subjects, of which 192 answered the questions.

The objectives of the study are from the perspective of students, understand whether the use of augmented reality helps to improve academic performance (compared with the previous academic year, the use rate and pass rate without the use of AR-related technical tools), to analyze students' affinity for the use of AR strategies in learning activities, to explore the potential of AR in improving mathematical ability.

3.1. Stage studio

AR's experience was developed in a study conducted in August and December 2018 to teach basic mathematics courses in secondary and higher education at a private educational institution in Mexico. In order to demonstrate the experience of AR, the learning object containing basic algebra developed by members of the academic community of the discipline is used as the strategy. The software chosen to design content is metaverse, which can develop content on the web platform and perform the AR experience through applications in the app store (Macos) and play store (Android) virtual stores.

Use AR content to force teachers to revise the curriculum plan to include the following activities to explain the reasons for using augmented reality as a teaching strategy in the first class and guide students on how to install applications on mobile devices, in the sixth class, students learn metaverse separately on the topic of basic algebra (significant products and factorization), about 30 minutes each time. Under the guidance of teachers, after the implementation of the experience, the application of information retrieval tools.

3.2. Instrument design

A tool consisting of 10 projects was produced and organized as follows: the first dimension puts forward open-ended questions (1–2) to understand students' views on the integration of AR experience into teaching; the second dimension (3–6) restores their views on the affinity of using metaverse as a learning tool; the third dimension (7–12) asks students' views on the application of strengthening mathematical ability. For the second and third dimensions, a Li Kert scale is used, including four alternative answers (completely disagree = 1, disagree = 2, agree = 3, fully agree = 4), because according to Mata[42], the reliability of such tools can increase with the number of these options, and unknown options are added to the possibility of answers, to force students to stand for or against each project[43].

3.3. Instrument verification and pilotage

The validation of the tool was carried out through the Delphi method developed for the educational research background of Cabero and Infante[44], which was simplified by George and Trujillo[45] into two stages. In these two stages, discipline experts first evaluate the clarity and relevance of the project, and then recommend improving the wording of each project.

The implementation of this method involved nine teachers from the Institute's educational institutions and scientific academic institutions. As a result, the wording of six items was adjusted and two items considered to be duplicate were deleted. Using this tool, 39 students were tested, and the Cronbach α coefficient of 0.873 was obtained. From the perspective of Pedroza[46], this coefficient is suitable for positive measurement. The item total correlation statistical program was also applied, and all items were retained, because if one item was deleted, the reliability of the instrument would not be increased.

3.4. Sample selection

For simple accessibility, intentional non probabilistic sampling is carried out. A total of 192 subjects and 267 qualified subjects aged between 14 and 16 participated in the basic mathematics course in the first semester of high school education.

The survey was conducted through a spreadsheet designed by Google gdrive in the last two

weeks of November 2018 (August to December).

4. Analysis and results

In order to process the collected data, the spreadsheet information matrix is exported to Microsoft Excel 365 Proplus software, and then the file is exported to professional software Minitab 18 to calculate and analyze the frequency, average value and standard deviation of each project.

In order to understand the results, **Table 1** lists the project analysis (items 1–2) related to students' arguments on integrating AR experience into teaching, as well as the comparison of pass rates in the previous academic year (without AR experience) and August December 2018 (if applicable).

Table 1. Approval and utilization indicators

School year	Approval	Unratified	Failure rate	Average account
January may 2018	171	32	18.71%	71
August to December 2018	261	6	2.21%	79

In the first method, the retrieved opinions can be associated with the lower failure rate (18.71% to 2.21%) and the increase in the average score of subjects (71% to 79%) shown in **Table 1**, and can be classified as positive, because the advantages of learning mathematics through AR outweigh the disadvantages:

> "It's cool (working with AR), you can use your smartphone to learn your partner, but don't browse the page again, but play some games to let you learn an exercise step by step" (It1, 71, Regina. R).

> "When the teacher asks you to solve a problem, for example, using an excellent product of an augmented reality application, you can leave, realize where your mistake is, then you correct the mistake (students quote feedback), and then when another (the next exercise) comes out, you will remember and do well" (It1, 14, Dayra. F).

While most of the views are in favour of recognizing the benefits of using AR teaching strategies, it is best for teachers to strengthen their expertise in technology trends and set up academic groups to coordinate the implementation of these strategies[47], as some views indicate areas of opportunity in this field:

> "When the teacher explains and guides you to solve problems, it will help you (teach strategies with AR), so if you practice on the phone, you will leave questions, you will despair, and you won't even learn" (It2, 83, Xavier. C).

The other thing that the teacher wants to teach you is to distract your students from their work.

Therefore, it must be pointed out that AR is not a comprehensive solution to overcome the low utilization of mathematics education because even the perception of innovative learning strategies can be diluted by continuous use in the classroom[18], or it may produce distracting, distracting and even addictive behavior[48]. In the following research, it is advisable to use other research methods to deepen the relationship between the failure rate and students' arguments

According to the research objectives, the students' affinity for metaverse is analyzed, and the total average of the four scores is 3.73. It can be seen from **Table 2** that the score exceeds the central value, which means that the affinity for using AR in learning activities is very high. It should be emphasized that the highest average value corresponds to the perception of higher learning motivation (item 3, M = 3.81). And the usefulness of AR mediated teaching strategies (item 6, M = 3.84) because students like activities using virtual games[33,49].

In this regard, the use of AR makes learning more attractive and satisfying[50,51], thereby deepening mathematical knowledge through the use of destructive techniques (item 4, M = 3.69). In terms of opinion dispersion, the perception of learning innovation is the highest (item 5, DS = 0.78), but this

is not important, but it provides a precedent for analyzing how to generate innovation related to AR based learning object design.

Table 2. Students' affinity for AR

Project	TD	D	A	TA	NS	M	DS
3. Learning by using augmented reality is motivated.	-	2	33	157	-	3.81	0.42
4. I think that by using metaverse, I can deepen my study of mathematical concepts and processes.	-	16	27	149	-	3.69	0.62
5. Participating in metaverse experience design is an innovative way to learn mathematics.	-	11	40	137	3	3.59	0.78
6. This is helpful for teachers to design classroom augmented reality strategies.	-	-	26	164	2	3.84	0.44

Finally, **Table 3** shows that students believe that augmented reality can actively mediate the formation of mathematical ability (general average = 3.32), and the emphasis on a higher average shows that when students have AR experience, they pay more attention to the classroom (item 7, M = 3.49) because they are more involved in building their own learning. It is also recognized that it is easier to remember the procedure for solving mathematical problems (item 9, M = 3.77) because it has the potential to generate knowledge in a practical and destructive way[36] and encourage learning (item 12, M = 3.34), so as to cooperate with students and adopt a positive and constructive approach[51].

In this dimension, the lowest average value and the highest dispersion of the whole instrument are given (item 8, M = 3.19, DS = 0.92; item 11, M = 3.31, DS = 0.90), indicating the opportunity to improve the experience of AR. It is worth mentioning that its usefulness in promoting cooperative activities (item 10, M = 2.80, DS = 1.02) means that, at least in the context of research, it is necessary to consider the idea of separating AR from cooperative activities, or develop teaching strategies to enable learners to use metaverse for a more meaningful cooperative process.

Table 3. Mathematical skill training

Project	TD	D	A	TA	NS	M	DS
7. Augmented reality requires me to pay more attention in class.	-	14	42	129	7	3.49	0.92
8. I think with augmented reality, it is possible to better learn the concepts explained by my teacher.	11	30	63	88	-	3.19	0.90
9. With augmented reality, I can more easily identify whether a mathematical process is right or wrong.	-	9	26	157	-	3.77	0.52
10. It is easier to use augmented reality for collaborative learning activities.	11	77	35	67	2	2.80	1.02
11. Using augmented reality technology to solve algebraic problems is easier to learn.	-	33	50	105	4	3.31	0.90
12. The mathematical process of using metaverse to solve problems is more dynamic.	-	20	78	92	2	3.34	0.75

5. Discussion

Through the analysis of the experience of using AR in middle school and higher education, it is certain that students are very interested in learning mathematics using interruptive applications, and will also have interest, satisfaction and motivation in the learning process, but how to design more effective teaching strategies to realize the assimilation of mathematical ability is still an open problem.

As shown in **Figure 1**, the perception of affinity exceeds AR mediated skill training. Similarly,

the dispersion of these dimensions is inversely proportional to each dimension, which shows that although the affinity for the use of such technologies has increased, efforts are still needed to improve teachers' awareness in order to establish a link between technical tools and instructional strategy design.

However, it must be emphasized that the introduction of AR may be relevant when students have mobile devices such as smartphones and tablets. Similarly, the immersive experience inherent in this technology must always be accompanied by teachers' classroom guidance to solve the tools and discipline problems of students.

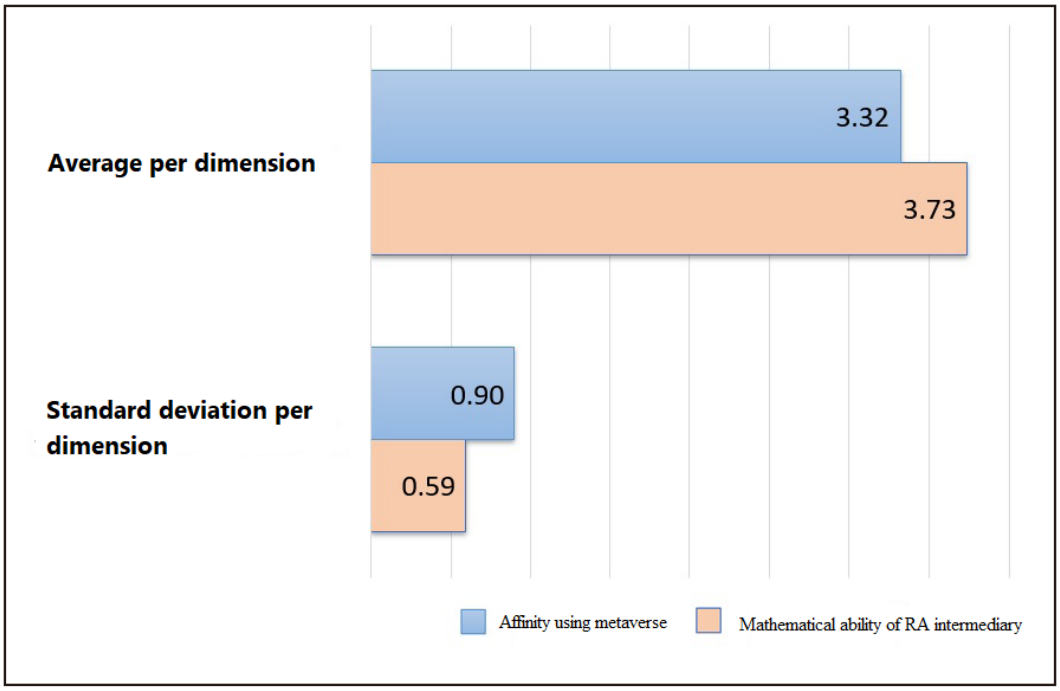

Figure 1. Comparison of mean and standard deviation of each research dimension.

It should also be considered that the application of emerging technologies such as AR in teaching requires teachers to acquire digital skills to ensure their effective use in order to achieve the learning identified in the curriculum objectives. Only when teachers take on the role of the main body of educational innovation and connect it with the knowledge of mathematics, can we truly realize the innovative reform of education.

Finally, it is worth noting that the limitation of this study lies in most quantitative research on the educational reality of students in secondary and higher education, which requires future research to supplement the research in terms of methods, Similarly, it must be clarified that the study was conducted in the educational context of a specific upper middle class school, so it is best to compare in a less privileged environment.

6. Conclusions

The conclusion of this study focuses on two aspects. The first is about the results obtained. In these two aspects, it must be pointed out that from the perspective of students, there is a good degree of acceptance when augmented reality is incorporated into the teaching process, which reaffirms the research results of Fernandes[52], Kim et al.[53], Garyet al.[54], Joe et al.[55] among other things.

On the other hand, students said that an important factor in the integration of AR into teaching is its ease of use. metaverse software allows dynamic interaction with three-dimensional images and learning experience. Similarly, when this experience is included, the motivation to learn mathematics will increase. This suggests that AR technology may be related to the curriculum plan in

senior high school. The results show that the introduction of AR not only contributes to mathematics learning, but also enables students to be exposed to motivated learning and play a positive role in discovering and constructing knowledge.

As a second point, it should be pointed out that we should design, develop, test and verify the tool of using metaverse to develop mathematics learning for senior high school students, making it a useful tool to collect students' affinity for AR and the formation of mathematics ability, In future research, it is necessary to compare the results of the methodological framework used in this study with other methodological experience.

Conflict of interest

The author declares no conflict of interest.

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