A proposed Mobile Augmented Reality framework for Hearing-Impaired Students

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ABSTRACT

Augmented reality (AR) promotes the human perception of the world by integrating real life with the virtual environment. With the unexpected increase in affordable mobile devices and the development of communications infrastructure, mobile augmented reality (MAR) applications are gaining popularity. It is very important to provide appropriate education for hearing-impaired and deaf students. Today, it seems that using traditional teaching methods alone is not enough to teach hearing-impaired students. This paper focuses on students with hearing impairment. Hearing impairment greatly affects the reception of information (oral and written) and the vocabulary proficiency of children. This paper aims to create a set of algorithms based on MAR for hearing-impaired students. The first algorithm deals with analyzing the needs of hearing-impaired students. A second algorithm helps them convert written words into expressive images. A third algorithm helps them learn matrices, in addition to another that helps them learn clock times. Finally, a fifth algorithm helps them distinguish between odd and even numbers. As a result, hearing-impaired students' academic achievement increases in comparison to ordinary students, and they do not feel deprived or less than other children.

Keywords*: Mobile augmented reality, hearing-impaired students, Proposed framework*

1. INTRODUCTION

Hearing impairment affects millions of people globally and is the fourth leading cause of disability globally. Current research has become a major problem all over the world and in Egypt and the Arab world. Hearing loss in general affects the activity of Life contact for children in school and affects the finances of people around the world [1].

Because of the increasing need and advancements in technology, augmented reality (AR) research is a topic that is always changing [2]. Augmented reality (AR) is a system or visualization technique that enhances the natural environment by integrating virtual objects that seem to share the same physical space as the real world [3]. AR provides the potential for designing effective learning experiences, combining virtual and real objects, providing real-time interaction, and presenting 3D objects, resulting in students having a sense of reality in an individual learning environment [4][5]

Several ways augmented reality, or AR, might improve education. It has been shown to improve students' academic performance, motivation, and engagement [6][7][8]. Due to the emergence of two popular mobile augmented reality development environments (ARKit from Apple and ARCore from Google), together with the mobility and accessibility of smartphones and tablets, mobile augmented reality is now widely available and accessible [9], smartphones and tablets promote social connections and teamwork [10][11] and encourage participation in learning activities [12][13].

MAR achieves the goals and requirements of individual self-learning. It provides an innovative educational space that eliminates the deprivation of hearing for people with hearing disabilities which leads to students acquiring greater skills and knowledge and equating them with ordinary students. Hearing impaired individuals are located in the category of individuals who need special education [14]. MAR applications and games immerse the hearing-impaired student into the world of studied information so that he/she can have an attractive and effective realistic experience instead of dealing with this information as static texts [15]. MAR technology supports the hearing-impaired

to participate because it combines fun and knowledge at the same time, and this will encourage them to discover more in the educational content.

MAR has been conceived as a new paradigm to immerse mobile users in the wonderful world of mixed reality[16]. In general, a MAR application has inputs (microphone, cameras, sensor, gyroscopes, and GPS), processing functions (registration, rendering, and interaction), and outputs (mobile screen, camera, and eye lens) as shown in Figure 1 [17].

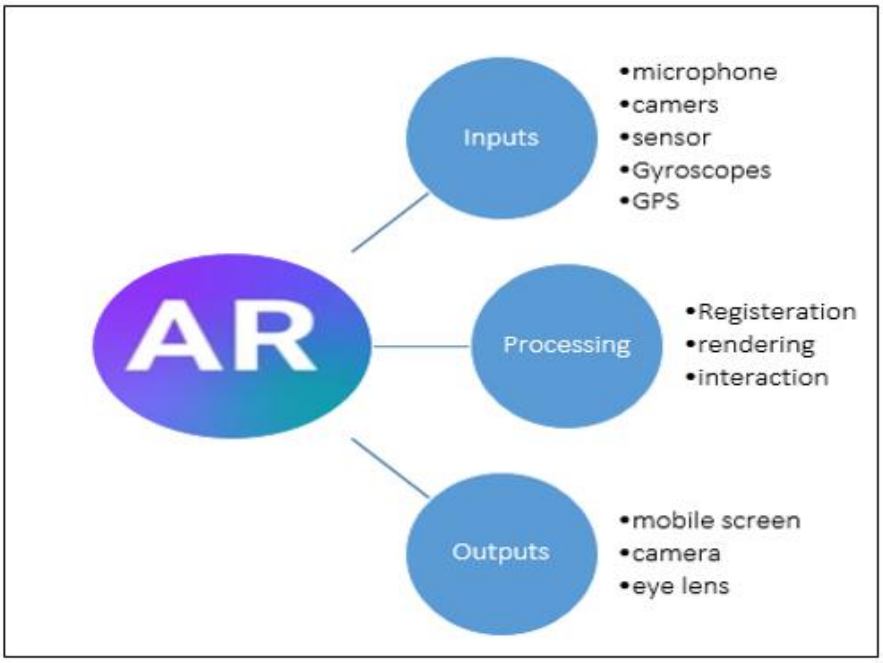

Figure 1. MAR components.

Online education platforms allow interaction between students and teachers in real-time using high-quality videos to replicate the classroom experience. MAR has excellent potential in such educational activities [15]. For example, it could use AR to help the hearing-impaired "hear" what the interlocutor may be saying to them and understand it without having to know how to read lips or the interlocutor's sign language by directing the person's speech next to his head intuitively and easily and interacting with it[18][19]. Table 1 compares AR and MAR[20][21].

Table 1. Differences between augmented reality and mobile augmented reality.

Property	Augmented reality	Mobile augmented reality
Mobility	Using augmented reality while moving is unrealistic.	The user can try it on the go, like the Google Glass application.
Processing	Devices are equipped with graphics processing units.	Mobile devices do not have enough computational power.
Energy consumption	It has high energy consumption.	It must be designed to reduce power consumption due to functions that drain batteries.
The shape of the device used in the operating environment	It requires a large screen.	It should be of a small size.
Operability	It works in a specific environment.	It works in unsuitable environments (works everywhere).

Deaf and hearing-impaired students prefer visual learning strategies, and this is particularly challenging in an environment where much information is presented exclusively by word of mouth [22]. Hearing-impaired students need to use assistive technology to participate in the class, such as a mobile phone to provide details of the content and do some activities and exercises [14]. Hearing impairment can cause delays in receiving educational materials, where students need a long time to absorb them, so this must be taken into account in terms of setting appropriate schedules for completing work for each student. Students with hearing loss appear isolated in the learning environment due to limited social contact and interaction with other students, which affects learning. Participation and interaction in educational programs may be limited [23]. We aim for the hearing-impaired to use mobile augmented reality as a greater opportunity for self-learning, assistance in learning through non-traditional educational media, and increased academic achievement. The rest of the paper is organized as follows: Section 2 highlights the motivation of the paper. In Section 3, related works are provided. Section 4 looks at the applicability of the paper to different educational materials. Sections 5 and 6 present a framework that helps the hearing-impaired learn through MAR. Section 7and 8 concludes the paper and makes suggestions for future work.

2. Paper Motivation

The current research is a response to some of the recommendations of conferences, such as the third international conference in Cairo under the title Creative Learning in the Digital Age in April 2016, which recommended the use of AR in education. Many technological systems are designed to help the deaf, such as supporting and developing reading and writing. Most of these systems focus on translating written language into sign language. This research studies the potential and capabilities of AR technology in improving the educational ability of the deaf and enhancing their academic achievement.

AR has a positive impact and potential in improving the educational abilities of students, especially those with disabilities, if properly designed and implemented. The problem of the current research was inferred through the results and recommendations of previous studies and scientific conferences in the field of education in general and dealing with the disabled, especially those with hearing impaired.

In addition to conducting interviews through some field visits to schools for the deaf and dumb, it was noticed that the teachers were not satisfied with the level of student achievement for several reasons, including that the sequence of the scientific subject is not suitable for the hearing-impaired and the deaf, and planning the curriculum was isolated from their needs and relied on the traditional approach in developing curricula and textbooks, in addition to not using computer applications in education.

3. Related Work

In this research, the use of MAR to educate students with hearing impairment is highlighted for several reasons. The primary benefit of AR is that it can be used by anyone including mentally and physically disabled individuals [24]. Several studies related to the development of the learning processes for students with hearing impairment have been conducted.

It aimed to design physical education learning products and applications that enable hearing-impaired and deaf students to perform movement tasks well and to increase students' motivation to do physical education learning through some animations [25].

Besides, teachers and student teachers can act as catalysts to accelerate the adoption and integration of any new technology in the educational process; therefore, teachers' and student teachers' attitudes and perceptions about mobile AR adoption and integration are very important. Nevertheless, their views have not been extensively investigated [26]. Despite all the aforementioned benefits of mobile AR, its educational use is still rather limited [9].

It focused on highlighting issues faced by deaf students in higher education during COVID-19 by providing a detailed analysis of the technological challenges that hinder their learning experience. This work called for the investigation of broader and more effective teaching and learning strategies for deaf and hard-of-hearing students so that they can benefit from a better online learning experience [26].

Moreover, it provided an overview of research on ICT as a support for students with hearing impairment in higher education settings. The findings showed a lack of research addressing the use of ICT for students with hearing impairment [27].

In addition to that one of the major problems in Latin America is that there are a large proportion of hearing-impaired children who do not receive proper education due to a lack of support from the government and a lack of technology. The suggestion was educational mobile applications for students whether they are hearing-impaired or not [28].Teachers are still hesitant to use mobile AR in their classroom practice [29].

In addition, it presented ways to provide psychological and educational support to children with hearing disabilities, as a result of proper education and upbringing [30].

Besides, the mathematics curriculum should be prepared for the disabled in the primary stage in the light of their characteristics, needs, and educational difficulties in teaching the subject from the point of view of their teachers [31].

Moreover, using educational aids by deaf teachers is not well covered, due to the teacher's lack of conviction in the feasibility of the existing means, due to their incompatibility with the capabilities of the deaf student [32].

It is important to provide appropriate education to hearing-impaired students by using modern technology that makes training for the hearing-impaired more beneficial [33].

Recent technological developments have led to mobile devices being used more frequently in education, mainly for children with disabilities or diverse educational needs [34].

Some previous studies focused on the use of mobile augmented reality with the hearing impaired, which helps to acquire skills and information better as a suitable environment for education and face many challenges and problems. With a few exceptions, mobile augmented reality technology has not yet been successfully applied in the classroom. Aside from a few rare experimental instances, mobile augmented reality technology has not yet been completely used in the educational system. In this paper, we have presented a proposed framework for mobile augmented reality for hearing-impaired students based on a set of algorithms that help raise the academic achievement of the hearing-impaired student.

4. Application of MAR in the Educational Context

The work of previous studies can be applied in the educational context of different subjects as follows:

- *Biology:* The application of AR technology contributes to the field of biology by presenting the structure of the organs of living organisms in detail, where the student can examine the parts of the body and how each of its organs works [35].
- *Chemistry*: AR technology can be provided for students to interact and understand amino acids and understand chemical structures in a simpler way [36].
- *Physics*: AR technology explains the different properties of objects and monitors the movement of the body and the amount of speed. The applications of AR technology can contribute to communicating abstract concepts to students and simulating natural phenomena and their interactions when they are not clear in real life [37].
- *Computer*: AR helps the novice learner perform complex tasks that make robots, connect networks, install internal parts of the computer, and clarify

the flow of data within computer parts and different networks [37].Learning computer-based subjects is challenging as they require many skills, techniques, and understanding among students. It required students to be critical in solving the problem. Students had problems learning computer science subjects due to teaching approaches and the course content [38].

- *Geography*: The geography subject contains many details about countries, cities, and geographical places that students must remember. By using AR technology, the content has become less complex, allowing the student to discover natural phenomena and advanced technology with flexibility [39].

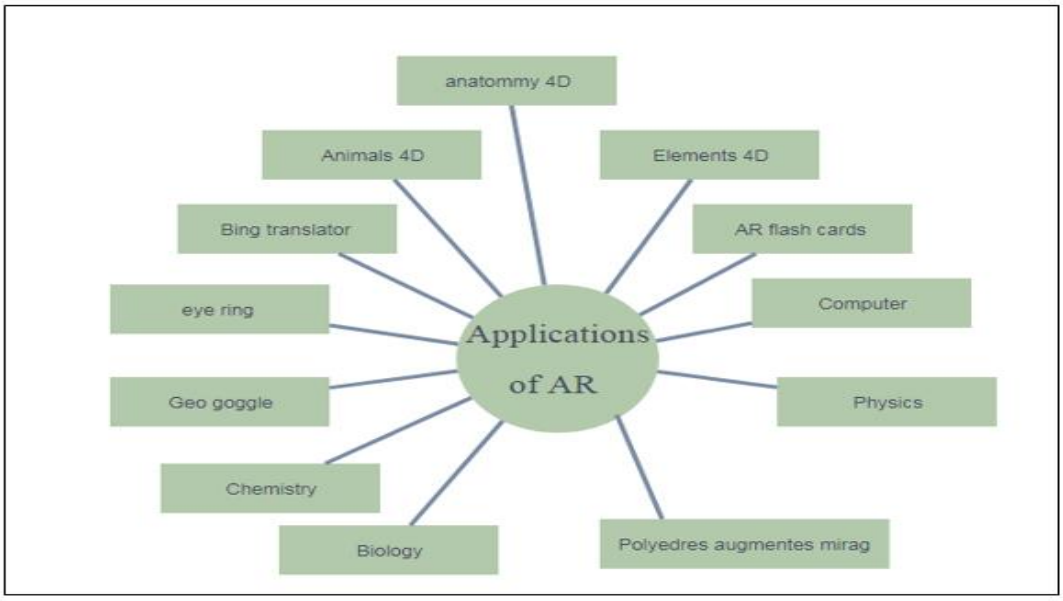

Figure 2. Applications of AR.

Online education platforms have allowed students to continue their education without interruption since the COVID-19 pandemic [40]. Students use mobile devices in the learning process through AR applications, which highlights that MAR is part of AR, achieving interactive learning that allows students to interact easily with the content anytime and anywhere [41]. These platforms have spread after their success in the COVID-19 pandemic as shown in Figure 2. The huge increase in the use of mobile phone technology with AR has led to the emergence of MAR, which combined the two concepts. The combination of AR and the mobile phone has led to the emergence of MAR, becoming more flexible and affordable.

5. The Proposed Framework

One of the technologies that have spread very quickly is MAR due to the great progress in technology. MAR has become a large part of the education process. It has helped the teacher explain information more efficiently and played a major role in motivating students to learn. AR increases student participation, understanding, and learning, which are essential elements for the success of the learning process [42]. Based on the great advantages and characteristics MAR presents, it has helped students with hearing impairment and deafness in their education and increased their academic achievement. Before MAR, there was a decrease in the level of academic achievement, which is due to the inappropriateness of the curricula and the teaching methods used to make them three grades less than ordinary students [43].

MAR works to achieve equality between the hearing-impaired student and the ordinary student by benefiting from its applications, facing life's problems, developing their social skills, and improving their communication with their colleagues. The main focus of this work was interaction design to improve learning and teaching as well as communication with MAR to reduce the communication gap between ordinary students and the hearing-impaired.

5.1 Analysis

The following are the steps of the first Algorithm that analyzes the needs of the hearing-impaired students:

- **First**, identify the educational problem.
- **Second**, identify the target group in terms of the educational stage, and make sure that the target group has hearing disabilities.
- **Third**, identify the causes of the problem.
- **Fourth**, provide the requirements and services needed by the hearing-impaired, such as sign language, the presence of an audiologist and a social worker, and the provision of some optical devices.
- **Fifth**, provide the classroom with the latest educational tools that suit their needs.
- **Sixth**, provide a comprehensive learning environment with tools suitable for students with hearing disabilities.
- After completing the application, the student can complete the learning process.

Algorithm 1: Analysis the needs of hearing- impaired students.

Step1: **Start**.
Step2: Determine the target group.
Step3: Determine whether the student is able to learn or not.
Step4: The teacher shows the student an AR program with a set of educational cards distinguish between odd and even numbers.
Step5: **If** the student can't learn **then** define the problem.
Step6: **If** the student able to learn **then** present him some exercises.
Step7: **If** the student answers the exercises presented to him, **then** the student may be able to answer any question.
Step8: Teacher present the student a test.
Step9: End.

Algorithm 1: The analysis of the needs of hearing-impaired students.

5.2 Design and Modeling

At this stage, the educational content that the hearing-impaired student is to be proficient in is collected, taking into account a simple and attractive design and the diversity in the use of multimedia elements, such as still and animated images, written texts, video clips, and various effects, as well as their use in displaying educational content for students with hearing impairment. The combination of these elements captures students' attention, explains the content, and presents learning objectives, which enhances the learning process.

The second Algorithm uses an AR program that helps the student understand the written words that he/she has difficulty with, turning them into expressive images, three-dimensional models, and drawings, for example.

Algorithm2: AR assists hearing-impaired students to transform written words into expressive images.

Step1: **Start**.
Step2: Select the topic.
Step3: Choose the terms that the student struggles to understand the main topic.
Step4: Convert terms (written words) into pictures.
Step5: Preparing a scenario (educational content) on terminology.
Step6: The teacher displays the student a lesson supported by an AR program that simulates reality by converting the written words in front of him into three-dimensional graphic models.
Step7: Teacher discussion the content with the student.
Step8: Teacher prepare a set of exercises and presenting them to the student.
Step9: **If** the student answers the exercises presented to him, **then** the student may be able to answer any question related to the topic.
Step 10: **Else** go to Step 6.
Step11: End.

Algorithm 2: AR assists hearing-impaired students to transform written words into expressive images.

In addition, the third Algorithm shows how to learn arrays. For example, the teacher presents the student with an AR program for a set of different arrays, through which he/she explains the terms of the correct array if it is complete. He/she shows the number of rows and columns and deduces the name of the array. If there is an empty space in it, then it is incorrect.

Algorithm 3: AR assists hearing-impaired students in learning arrays.

Step1: **Start**.
Step2: The teacher explains to the student the terms of the correct array.
Step3: The teacher provides the student with an enhanced digital book that presents array in AR program.
Step4: The teacher asks the student a question about the array**.**
Step5: The student makes sure that there are no blank spaces.
Step6: **If** the student finds an empty space**, then** it is not an array.
Step7: **If** the student does not find empty spaces, **then** it is an array.
Step8: The student determines the number of columns.
Step9: The student determines the number of rows.
Step10: The student mentions the name of the array.
Step11: **If** the student answers the question, **then** the student may be able to answer any question about array.
Step12: Else go to step 3.
Step13: End.

Algorithm 3: AR assists hearing-impaired students in learning arrays**.**

Moreover, the fourth Algorithm presents an AR program based on educational visual forms as an educational movie about learning time by recording wake-up times, sleeping times, visits, and daily tasks and assignments.

Algorithm4: AR assists hearing-impaired students in learning clock times.

Step1: **Start**.
Step2: Teacher records waking and sleeping times of hearing impaired student.
Step3: Teacher records times of daily tasks.
Step4: Teacher records the dates of official visits.
Step5: Teacher writes notes about the time.
Step6: The teacher presents to the student an AR program with various educational visual forms that shows a movie about time.
Step7: Teacher discusses with the student his observation about clock times.
Step8: **If** the student answers the exercises presented to him, **then** the student may be able to answer any question related to time.
Step9: Else go to Step 6
Step10: **End.**

Algorithm 4: AR assists hearing-impaired students in learning clock times.

The fifth Algorithm highlights how the teacher shows the student an AR program and flashcards to distinguish between odd and even numbers.

Algorithm5: AR assists hearing –impaired student in distinguishing odd and even numbers.

Step1: **Start**.
Step2: The teacher shows the student an AR program with a set of educational cards distinguish between odd and even numbers.
Step3: The student reads the number.
Step4: The student divides the number by two.
Step5: If a number is divisible by two, then it is even.
Step6: If the number is not divisible by two, it is odd
Step7: The teacher asks the student many questions about even and odd numbers.
Step8: If the student answers the teacher's questions about even and odd numbers, he knows the difference.
Step9: Else go to Step 2
Step10: **End.**

Algorithm 5: AR assists hearing-impaired students in distinguishing odd and even numbers.

5.3 Implementation

At this stage, it should be ensured that the teaching resources and specifications work well and are supported by animated and still images, video clips, and three-dimensional figures with the hearing-impaired student and that the teacher is ready to use these materials and ensure the availability of basic requirements and other aspects of support from a psychologist and sign language teacher. Determine the relevant audio or visual devices while providing the classroom with the latest educational means that suit the needs of the hearing-impaired student, which results in providing an appropriate educational environment that includes tools and is suitable for the class in a safe way in terms of classrooms, learning centers, scientific laboratories, or individual learning positions, as the learning environment must be comfortable and free from any annoying distractions such as vision problems.

- Ensure that the application is suitable to work on a smartphone.
- The application includes animated pictures to attract attention.
- Adjust the colors to attract attention.
- Increase the dynamic effects in the program.
- Add video clips that explain the content.
- Add instructional video clips explaining what is happening in sign language by the teacher.
- Conduct an exploratory experiment.
- Work by the app.

6. Experimental data and results

The sample consisted of 18 students from deaf and hard of hearing schools in the primary stage, some mathematical concepts and skills required to be developed for hearing-impaired students were addressed, which consisted in their final form of (5) five main skills, and (19) nineteen sub-skills. With the presentation of a set of algorithms based on MAR that help them convert written words into expressive images and others help them learn matrices, in addition to another algorithm that helps them learn the times of hours. Finally, another algorithm helps them distinguish between odd and even numbers.

6.1 Moderation of distribution

Moderation of distribution means that the data is free of outliers, or random, and that the data curve is moderate and resembles the shape of a bell. The researcher used the Shapiro-Wilk test because the sample size is less than 50. The null hypothesis of the test is that the sample follows the normal distribution. The following table shows the results of the Shapiro-Wilk test.

Table 2 Shapiro Wilk Test Results

Search tool	Number	Shapiro welk	Significance value
"Pre-test" test	18	0.931	0.200
"Post-test" test	18	0.924	0.155
observation Card (Before)	18	0.932	0.214
Observation card(dimensional)	18	0.946	0.373

It is clear from the previous table that the sample follows the normal distribution where all the values of the Shapiro Wilk test are not significant at the level of (0.05), and therefore the zero hypothesis is accepted. Thus, the validation of the hypotheses will be based on laboratory statistical tests.

6.2 Hypothesis Validity Test

1- Results related to the first hypothesis

The hypothesis states that "there are statistically significant differences between the averages of the experimental group students' scores in the pre- and post-measurements of the achievement test, in favor of the post-measurement."

To verify the validity of this hypothesis, the researcher used the test (T) for the associated groups, where the average and standard deviation of the scores of the experimental group students were calculated in the pre- and post-applications of the achievement test, and the value of (T) was calculated for the difference between the averages, and the level of significance corresponding to the value of (T), and the following table shows these results:

Table 3 "T" test for experimental group scores in the pre- and post-standards of the achievement test

The Collection	Number	Average	Standard Deviation	Degrees of Freedom	Value "T"	Significance Value
Experimental "pre-test"	18	15.87	1.555	17	48.089 -	< 0.001
Experimental "post-test"	18	38.11	1.287			

It is clear from the results of the previous table that there are statistically significant differences at the level of (0.05) between the averages of the scores of the experimental group students in the pre- and post-measurements of the achievement test in favor of the post-measurement, where the calculated value of (T) was (-48.089), which is statistically significant when compared to the tabular value of (T) at the level of (0.05), and the degree of freedom (17). The following figure illustrates this.

Figure 3 the average scores of the control group in the pre- and post-applications of the achievement test

This finding suggests that a learning environment based on the use of mobile augmented reality has helped improve students' level hearing-impaired students. Thus, the hypothesis is fully realized.

2- Consequences of hypothesis

The hypothesis states that "there are statistically significant differences between the averages of the experimental group students' scores in the pre- and post-measurements of the observation card, in favor of the post-measurement."

To verify the validity of this hypothesis, the researcher used the test (T) for the associated groups, where the average and standard deviation of the scores of

the experimental group students were calculated in the pre- and post-applications of the observation card, and the value of (T) was calculated for the difference between the averages, and the level of significance corresponding to the value of (T), and the following table shows these results:

Table 4 "T" test for experimental group scores in the pre- and post-standard of the observation card

Group	Number	mean	Standard Deviation	Degrees of Freedom	Value "T"	Significance Value
Experimental "pre-test"	18	75.28	3.322	17	80.549 -	< 0.001
Experimental "post-test"	18	163.61	4.565			

It is clear from the results of the previous table that there are statistically significant differences at the level of (0.05) between the averages of the scores of the experimental group students in the pre- and post-measurements of the observation card in favor of the post-measurement, where the calculated value of (T) was (-.80.549), which is statistically significant when compared to the tabular value of (T) at the level of (0.05), and the degree of freedom (17). The following figure illustrates this.

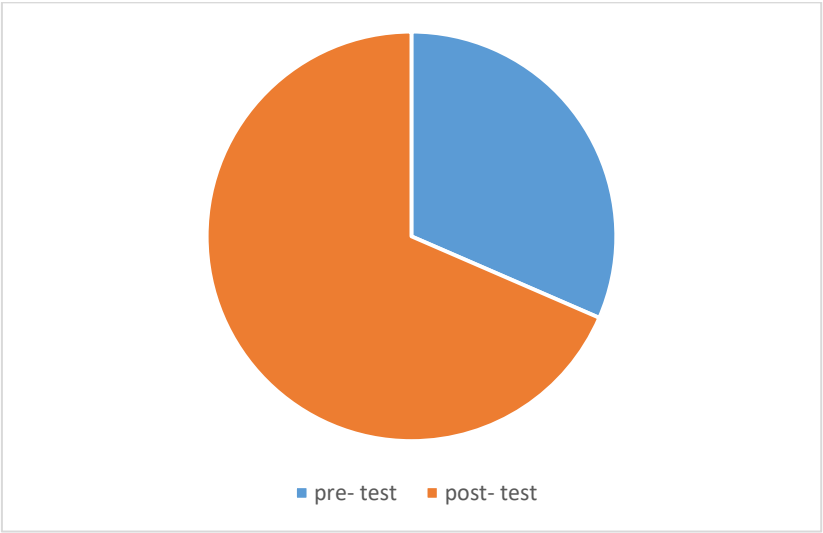

Figure 4 Average scores of the control group in the pre- and post-application of the observation card

This finding suggests that a learning environment based on the use of mobile augmented reality has helped improve students' level of mathematics course skills among hearing-impaired students. Thus, the hypothesis is fully realized.

3- The effectiveness of an educational environment based on the use of mobile augmented reality in increasing academic achievement among hearing-impaired students means the percentage of students in the experimental group who achieved the required level of learning for each of the objectives of the proposed environment, through their scores on the achievement test and the observation card. To measure the effectiveness of the proposed educational environment, the researcher used the modified gain equation for Black, Black determines this ratio between (1-2) in order to be an acceptable effectiveness of the proposed learning environment. The following table shows the calculation of the adjusted gain ratio for Black's achievement test.

Table 5 Percentage of adjusted gain for achievement test

A pre mean	A post mean	Total	Black coefficient
15.78	38.11	40	1.48

It is clear from the previous table that Black's adjusted gain ratio (1.48), which is between the percentages set by Black, which indicates the high percentage of students who benefited, and achieved the required level in the concepts of the mathematics course, which confirms the effectiveness of the proposed learning environment related to the field of research. The following table shows the calculation of BlackBerry adjusted gain ratio for the observation card.

Table 6 Adjusted Gain Percentage of the observation Card

A pre mean	A post mean	Total	Black coefficient
75.28	163.61	176	1.38

It is clear from the previous table that Black's adjusted gain ratio (1.38), which is between the percentage determined by Black, which indicates the high percentage of students who benefited, and achieved the required level in the skills of the mathematics course, which confirms the effectiveness of the proposed learning environment related to the field of research. The following figure shows the adjusted gain ratio of the achievement test and the observation card.

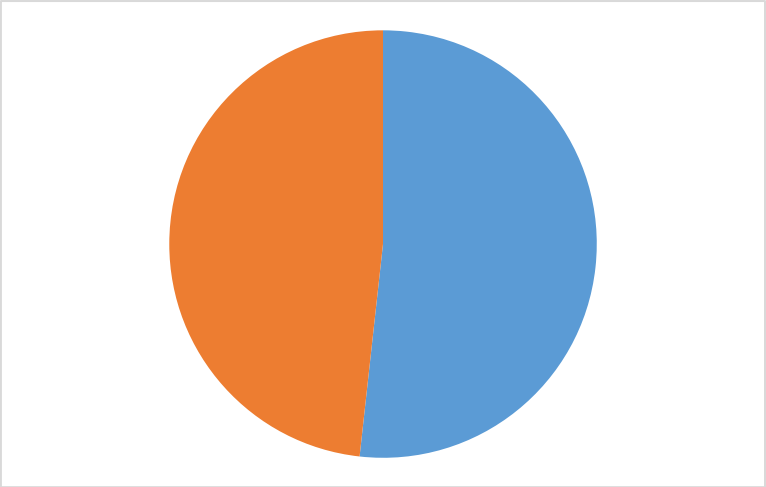

Figure 5 Adjusted Gain Percentage for the Achievement Test and the Observation Card

According to the study, pupils in the AR group pick up information more quickly, which gives them more time to repeat and practice. Unlike students who have learned using traditional methods, they achieve higher academic achievement. As studying has become more enjoyable for students with hearing problems, it has been discovered that using portable augmented reality solves their educational problems.

7. Conclusions

The current research reached several results that can be summarized as follows:

1- There are statistically significant differences between the averages of the scores of the experimental group students in the pre- and post-measurements of the cognitive test, in favor of the post-measurement.

2- There are statistically significant differences between the averages of the scores of the experimental group students in the pre- and post-measurements of the observation card, in favor of the post-measurement.

3- The effectiveness of an educational environment based on the use of mobile augmented reality in increasing academic achievement among hearing-impaired students.

MAR has become widely used in the field of education. It has an effective role in the teaching and learning process, helping to solve many educational problems, and working on better education for the hearing-impaired.

MAR technology adds a new dimension to teaching concepts compared to other teaching methods. AR technology achieves tangible results in collaborative and self-learning processes that make hearing-impaired students perform better and take into account the psychological aspects that tend to isolate and distance them from others. The methods provided by MAR in education also include physical perception, embodied perception, situational learning, and mental work.

The hearing-impaired and the deaf need to use special teaching methods, so that they can focus visually, pay attention, and understand the information that is presented to them. Also, the deaf are in dire need to develop means of clarification that take into account the nature of their hearing impairment. When the hearing-impaired begin to study the educational content presented to them using MAR algorithms, they must acquire knowledge and information, and they will also have to learn some skills.

This paper discussed an algorithm framework based on MAR for hearing-impaired students. The first algorithm deals with analyzing the needs of hearing-impaired students. A second algorithm helps them convert written words into expressive images. Another algorithm helps them learn matrices, in addition to another that helps them learn clock times. Finally, a fifth algorithm helps them distinguish between odd and even numbers. As a result, students' academic achievement increases since they feel more equal to other children without any deprivation.

We can say that MAR is the most important technological innovation to serve humanity in several areas in general and in education in particular, due to its characteristics and advantages that help make the educational environment more effective and flexible. In this context, the proposed work aimed to facilitate the learning process for students who suffer from hearing impairment by creating a vivid picture of the concepts and skills so that they become tangible and acquired with ease in comparison to traditional methods. This system can also be expanded to implement AR in practice in a classroom service in real time for students with hearing impairment.

8. Limitations and Future Work

As for the challenges faced in implementing this system, there were many challenges, including: financial challenges, infrastructure challenges, training challenges, and technical problems. As for financial challenges, in a normal situation these schools suffer from a lack of financial support in addition to providing a device for each child. As for infrastructure challenges, it is required to have a device for every child and to ensure that it is always charged. In terms of technical problems, the device may malfunction and require maintenance.

We suggest studying the effectiveness of using MAR in educational materials, such as science and history. We have to develop different skills and produce educational programs that help students with hearing –impaired learn. This is in addition to reviewing educational curricula in line with MAR. It is necessary to generalize the use of MAR technology in education.

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إطار عمل مقترح للواقع المعزز المتنقل للطلاب المعاقين سمعيًا

الملخص

يعزز الواقع المعزز (AR) الإدراك البشري للعالم من خلال دمج الحياة الواقعية مع البيئة الافتراضية. مع الزيادة غير المتوقعة في الأجهزة المحمولة ذات الأسعار المعقولة وتطوير البنية التحتية للاتصالات، تكتسب تطبيقات الواقع المعزز عبر الأجهزة المحمولة (MAR) شعبية. من المهم جدًا توفير التعليم المناسب للطلاب ضعاف السمع والصم. واليوم، يبدو أن استخدام أساليب التدريس التقليدية وحده لا يكفي لتعليم الطلاب ضعاف السمع. تركز هذه الورقة على الطلاب الذين يعانون من ضعف السمع. يؤثر ضعف السمع بشكل كبير على استقبال المعلومات (الشفهية والمكتوبة) وإتقان المفردات لدى الأطفال. تهدف هذه الورقة إلى إنشاء مجموعة من الخوارزميات المعتمدة على MAR للطلاب المعاقين سمعيًا. تتناول الخوارزمية الأولى تحليل احتياجات الطلاب المعاقين سمعيًا. وهناك خوارزمية ثانية تساعدهم على تحويل الكلمات المكتوبة إلى صور معبرة. وهناك خوارزمية ثالثة تساعدهم على تعلم المصفوفات، بالإضافة إلى خوارزمية أخرى تساعدهم على تعلم أوقات الساعة. وأخيرًا، تساعدهم الخوارزمية الخامسة على التمييز بين الأرقام الفردية والزوجية. ونتيجة لذلك يرتفع التحصيل الأكاديمي للطلبة ضعاف السمع مقارنة بالطلبة العاديين، ولا يشعرون بالحرمان أو بأنهم أقل من غيرهم من الأطفال.

الكلمات المفتاحية: الواقع المعزز المتنقل، الطلاب المعاقين سمعيًا، إطار عمل مقترح .