

Effect of Augmented Reality Technology on Spatial Intelligence among High School Students

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Ban Hassan Majeed¹(✉), Haider TH. Salim ALRikabi²

¹College of Education for Pure Science/Ibn Al-Haitham, University of Baghdad, Baghdad, Iraq

²Electrical Engineering Department, College of Engineering, Wasit University, Wasit, Iraq

ban.h.m@ihcoedu.uobaghdad.edu.iq

Abstract—Spatial Intelligence is a mental ability to understand and solve real-world problems. These visual-spatial representations are fundamental in learning various “STEM” topics, like digital drawing, art presentations, creating graphical representations, 2D designs. Opportunity to interact with real and/or virtual objects. It is a good opportunity in applying new techniques such as the augments, which is able to clarify mathematical tables, concepts and generalizations greatly to the visualization, understanding and mastery of concepts mathematically. The purpose of the research is to investigate impact of using AR technology in developing spatial intelligence for secondary school students, Baghdad. The quasi-experimental design was used, the participants consisted of (60) students of 4th class scientific in mathematics. Tools used where a spatial intelligence scale was prepared and contains three skills that include (20) questions. Research findings show that AR technology has a positive on spatial intelligence in mathematics, and concluded with a set of recommendations and proposals.

Keywords—Augmented Reality (AR), Spatial Intelligence (SI), mathematics, high school

1 Introduction

Great scientific and technological progress in various areas of life, in addition to the communications and information revolution that caused the proliferation of human knowledge, especially scientific and technological knowledge in very short periods of time, there is a tremendous leap in the field of satellite technology, multimedia and the Internet. It wasn't long ago that there were huge leaps in technology that seemed only possible in the realm of science fiction, and this technology is AR technology [1, 2]. In the era of information technology, and the expansion of technological tools and devices, the technological education movement has witnessed a remarkable development in recent years, as devices have spread and technologies have multiplied, access to knowledge and its digital representation, retrieval, and storage has become available everywhere and at all times. As tablets and smartphones have become in the hands of young and old, the love of exploration and experimentation using these devices

has become a demand sought by all. Accordingly, educators and those in charge of technology education have sought to integrate advanced technologies into education and use them in line with the interests and trends of this generation, and among those commonly used in various fields is what is known as augmented reality, symbolized by (AR) [3]. “AR” extends the real reality by adding layers of computer-generated information to the real environment, and this added information can be text, graphics, videos, audio, GPS...etc. That is, “the synthesis, visualization and addition of digital data, and the use of digital methods for the real reality of the environment surrounding the human being. From a technical perspective, augmented reality is mostly associated with wearable computers or portable smart devices”, so it is an engaging interactive technology that brings a virtual object (text, graphics, video, sounds) or a composite of them all in a three-dimensional form into an environment realistic with a digital dimension, designed and developed by computer to serve many purposes in life fields such as computer, instructional technology, engineering ... etc [4–7]. Modern strategies in teaching based on modern technology are among the strategies that contribute to increasing achievement and developing students’ abilities in many areas, including intelligence, thinking, self-learning, and the formation of practical and applied skills for learners. Technology also provides opportunities for teachers. To adapt teaching to the specific needs of students, students who find it difficult to focus can increase their attention through computer programs and effective techniques. The successful teacher is the one who can develop creativity and innovation in the learner, and works to provide him with the skills and abilities necessary for him to be able to contribute to making the future [8, 9]. The target group for the research is high school students, and this is what has gained the importance of being a group that requires preparation and preparation for the university stage later. The importance of mathematics and the lack of previous studies to the knowledge of the researcher that dealt with the impact of augmented reality technology on spatial intelligence.

2 Augmented Reality (AR)

The AR depends on the real environment and is partially derived from the idea of the virtual “environment”, i.e. it is located in the middle of them, and it cannot be considered an augmented reality if it does not combine its characteristics [10, 11]. (“Augmented reality technology”) blends fantasy and reality in a real environment.

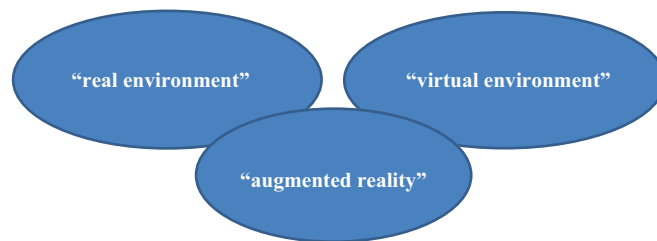


Fig. 1. Augmented reality website from virtual and real environments

There are many types of augmented reality that have been mentioned in the educational literature and related studies according to the purpose of its application. It is represented in projection, which means taking virtual shapes and projecting onto the real environment to show the details to be seen with a high level of accuracy. Recognizing shapes and depends on the principle of detecting the shape, angles or symbols to link and connect them with other additional virtual information. Location; by determining certain locations in conjunction with other software, such as the Global Positioning System (GPS). Outline for merging the real and virtual environment is based on the principle of allowing the person to merge the outlines of his body with any other virtual object, and allows the person to deal with this illusory merging that does not exist in reality, as in the fields of educational science centers and museums [12, 13]. “Augmented-reality” has many characteristics, including processing by integrating reality with the virtual world in a real interactive environment at the time of use; providing strong, robust and accurate information; his ability to enter information in an easy and efficient manner. The possibility of interaction between the two parties such as lecture and learner. Facilitating complex actions for users; its cost-effectiveness and easily scalability; presenting forms in a simplified and clear way for learners. The cost of producing educational materials is relatively low; the educational mode gives a lot of dynamism and activity; and finally combines the real explanation of the teacher with the digital [14, 15]. (AR) is used in marketing by companies to combine the elements of print and online advertising with an interactive experience [16]. In games; where augmented reality games essentially integrate audio and visual game content with the user’s real-time environment [17, 18]. Education; it is a new experience of imparting information, an affordable option for schools to purchase a variety of classrooms [19]. In engineering; architects are experimenting with (AR) applications and software that are used to build 3D virtual building models that can be experienced inside and out [20, 21].

2.1 (AR) Technology in education

Augmented reality technology (ART) is one of the modern teaching methods based on the electronic environment and one of the latest types of e-learning used in education in response to future needs to take advantage of its multiple advantages and diverse applications, thus enriching the learning environment with information and educational experiences in a sophisticated style in an interactive educational environment rich in learning resources, to maintain the impact of learning for longer, and to help open up the many avenues for self-learning, and lifelong learning, needed to face the challenges of this era [22, 23].

The term (ART) is one of the modern terms, as it is a system that combines virtual and real environments through special techniques and methods. It is a technology that allows the integration of real and virtual reality by means of enhanced devices and systems that allow the generation of virtual reinforcements from various media, images and information that the user interacts with. Augmented reality technology lies between the real and the virtual environment [24–26]. AR technology is a type of e-learning that is based on a set of educational theories, such as communicative learning theory, whose principles are that learning exists in non-human tools and devices, and the ability to

retain knowledge in order to facilitate the learning process. It builds on this technology with these principles, from its use of mobile devices and is designed in such a way that students can use it more than once and review what they have learned well [27–29].

Modern learning theories, such as the constructivist theory of learning, assert that learning is an active and interactive process, and that the student builds his knowledge by himself, and has an opportunity to think, and then learning is meaningful, and learning is better and more effective when it occurs in a social context and this is what distinguishes AR technology; enhanced, interactive and easy to use. It supports interactions between students, content and teaching aids, and interaction between each student. This enables them to identify problems in educational situations through cooperation and teamwork [30]. It is a biotechnology used to enhance scenes in the real world with virtual information that is generated, on computers or smart devices, in the form of images, sounds, videos or interactive 3D shapes. While the procedural definition as an interactive participatory method based on linking elements from the mathematics book for the fourth class in multimedia (images, video, three-dimensional objects,) using technical programs and displaying them using tablets or smart phone screens. It is also a technology that actually enriches information with the information available in technological devices, and the basic information lies in the real content, as the digital content only enhances and complements it [31]. This technology has many advantages that can be used to improve the learning process in general, as mentioned that the augmented reality technology enables the teacher to enter, communicate his information and data in an easy way, in addition to its cost-effectiveness and scalability easily, and it encourages self-learning; Because it provides educational content that is easy for the student to refer to at home [32]. It is also giving the student the opportunity to translate what he sees from real images, as well as the opportunity for colored mental reflections, and to see the tripartite images. Dimensions, making abstract concepts tangible and adding to them the fun of imagination, as the student gets out of the control of the traditional routine, and develops his imagination skill, and this is what was confirmed by AR technology which blends fantasy and reality in a real environment [33, 34]. Finally Augmented reality technologies in the educational process have several advantages which justified the need for them in educational institutions, and they can be identified as arousing the motivation and enthusiasm of the learners, as the scientific material is presented in an attractive and interesting manner in a manner that is compatible with the technology generation, where the learner is involved in ways that were not possible through activating the senses. The possibility of providing educational experiences through three-dimensional models, where the learner can view and analyze topics from different sides, and this gives a deeper understanding of the topics, as it provides a correct and comprehensive mental picture of educational experiences. Providing educational experiences in the same hard-to-reach educational site as Space. It does not need a specific learning environment as it can be applied in the classroom. Taking into account individual differences, as it gives an opportunity to see shapes from different sides and the learner interacts with real experiences away from misconceptions. Promote collaborative learning and social interaction among learners in the same teaching environment [35–37].

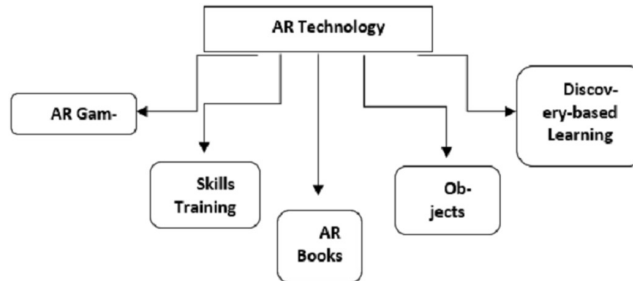


Fig. 2. The five classifications of AR technology

Technological Innovations and Mathematics; which is a broad and deep science that is classified as one of the pure sciences, but implicitly it interacts and accepts technological innovations. Rather the mathematics is an essential element in technology and its techniques, so it must be in a parallel line with all technical innovations, and these innovations must be volunteered in the development of mathematics, or at the very least, technology should invest in simplifying mathematics and facilitating its understanding and practice. From here, technological innovations are no longer a luxury that the teacher can use or neglect, but rather have become one of the basics that must be employed in the process, which requires the teacher to be familiar with the innovations of technology [38, 39].

3 Spatial Intelligence (SI)

Gardner asserts that intelligence has a structure or specific style and has a scope that expresses organized activities within the framework of a culture, and any existing scope can be identified through one of the types of intelligences, and stresses that capacity has a content of processes that can be inferred by differentiating between the term intelligence and the term pattern by noting the situation in which the individual lives with all its elements. Visual intelligence, at its simplest level, is the ability to recognize and enjoy colors and shapes, create simple images, shapes, and models, and physically manipulate them, in addition to manual assembly of parts. Forming mental images and seeing shapes from different angles. The owner of this intelligence is also characterized by the ability to remember details of images and shapes, draw maps, determine paths, and understand engineering drawings [40]. The most important thought processes come directly from our perception of the world, where sight is the first sensory organ that provides the basis for our cognitive processes and forms them. The visual-spatial imagination is a primary source of thought. Learning through sight gives a person a sensory experience that is realistic or close to reality, and the sensory experience is recorded for greater understanding and stability in the mind and more ability to resist forgetting. Reality is full of sensory images that can be perceived through the sense of sight. If the learning method is effective, then the experience gained through it is a sham experience that can be expressed in drawings as well [41]. SI means the ability to perceive visually with precise clarity, to mentally recreate objects or/and models, even in the absence of

physical stimuli, and to make transformations or modifications to them. It is a mental activity that works on compiling the mental images resulting from the educational situation data regarding the sensory perceptions that he is going through with the previous experience associated with this image and conducting mental experiments on it and re-forming it in an innovative way, and it is inferred through the apparent behavior that it takes different forms for student [42]. It has the ability to remember through graphics, diagrams. The meanings can be accessed through the images. Remember routes well, even if the places are unfamiliar. Distinguishing the four directions in any place with the distinction of the direction if it is upside down or on the side. Solve puzzles in the form of mazes, shapes, and imagine spinning. The use of shapes and images in reading. High observation of distances, volumes, and areas. Easily read maps and the ability to draw what others are saying. Representation of information geographically in the form of graphics or maps. Understand the relationships between shape [43, 44]. To develop “Spatial Intelligence” in the classroom, by relying on teaching on images, shapes, conceptual and mental charts, and thinking maps. Using colors to identify important points. Giving students enough time to observe, collect information. Encourage them to write notes they see and then discuss what they noticed. Assign students visual activities [45]. Within “STEM”, it is essential intelligence for students to increase their abilities to transfer digital data and 2D projections into 3D objects simply and flexibly. Therefore, students who enjoy a high degree of it enjoy their love for drawing, fascinated by books with many pictures, love colors, have the ability to distinguish shapes quickly and accurately, are able to mix reality with imagination, describe the images that they form, three-dimensional theory, they use the four directions in determining new places. Able to design in all its forms and excel in architectural decoration, engineering, drawing, art, invention and planning [46]. Educational system, which raises this kind of intelligence in some students, may contribute to the development of their mental abilities to face different life situations. The AR technology allows to enrich any learning environment with digital data and take advantage of mobile devices which, due to their portability, contribute to off-site learning, wherever it is. Which increases the integration between the fields of teaching and learning, which focuses on developing the educational model. Initially, it was used as a tool, but now, its applications are subject to innovations, as students have moved from being recipients to providers of scientific knowledge, and teachers have assumed the role of a mentor with the aim of students generating knowledge by using technology in a flexible, interactive way, as the cognitive, constructivist and construction theories are the basis for this new educational model [47].

4 Previous studies

All previous studies confirm that “Augmented Reality” technology has a clear positive effect in terms of differences in the sample, tools, method, and objectives. Through it, many books, journals and scientific conferences that enrich his achievement were identified. While the current research is distinguished from being the first In Iraq

(within the limits of researcher’ knowledge), which deals with knowing the effect of “AR” technology on SI and the size of the effect for high school students, as previous studies did not address this stage, as well as in mathematics in particular.

Table 1. Studies that have looked at AR in general

Name; Year	Approach	Sample	Study Tools	Results
[48]	descriptive	Students enrolled at field of child	31 – items questionnaire	The use of “augmented reality” in the classroom will be useful & positively affect the teaching and learning of children
[49]	A quasi-experimental	Primary education students	Test & interview	augmented reality as an educational tool reveals that students’ performance and their acquisition of knowledge improve Significantly, the teaching and learning process is seen as positive, stimulating and facilitating in acquiring knowledge
[50]	A mixed illustrative way	44 female students	technology integration self-efficacy scale & interviews	Augmented reality-based learning tools have a positive impact on technology integration. In addition, a significant increase in the self-efficacy of prospective teachers was observed

5 Methodology

Research followed the quasi-experimental approach based on both groups (an experimental group taught by “AR” technology), plus (a control group taught by an ordinary way). Community of research consisted of fourth-class science students, who attend government schools affiliated to the Rusafa Directorate of Education/1, Baghdad Governorate, Iraq. The sample consisted of (60) students from (Al-Istiqlal Secondary School for Girls) which were divided into two groups. Research tools are a scale of spatial intelligence that was prepared and built according to the procedures followed in constructing the scales, which included (20) questions of the type of choice from the multiple quarter of alternatives. The researcher presented it to a group of experts and arbitrators, and its psychometric properties, apparent honesty, content validity, stability coefficient, discriminatory strength of the paragraphs, and the effectiveness of the wrong alternatives were extracted. The chosen mathematics subjects (Equations and Inequalities, Bases and Roots, Trigonometry) [51–55]. With regard to details the stages of production of augmented reality technology, the design consists of:

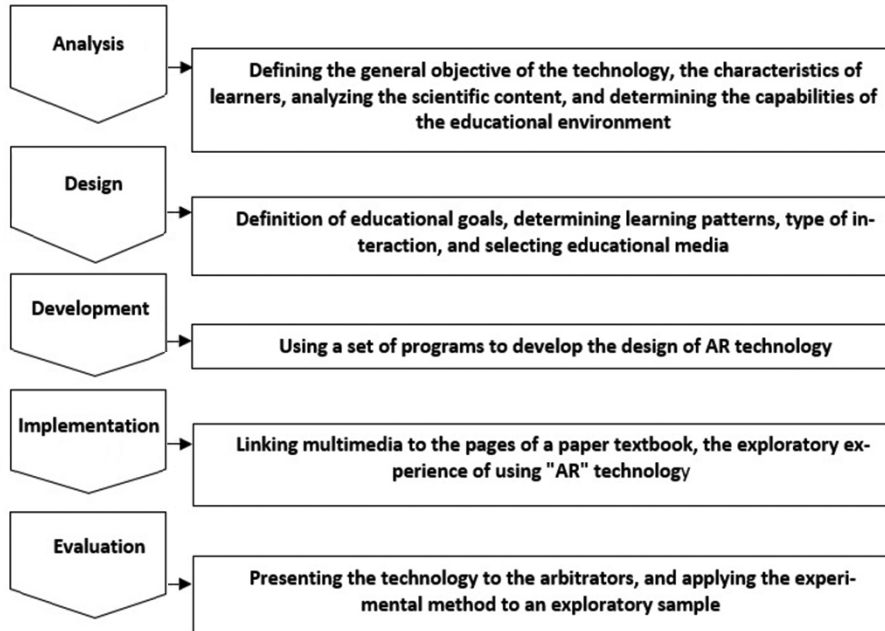


Fig. 3. (Addie) model for the design of ART

6 Results and discussion

To check the hypothesis, and its text: there are no statistically significant differences at the level (0.05) between the average grades for fourth-grade students in mathematics on the post-application of the spatial intelligence scale due to the teaching method (AR technology – the usual teaching method).

Table 2. SI scale

Groups	No.	Mean	Std. Deviation	t-test Calculated	Freedom Degree	Sig.	value η^2
Exp.	30	15.63	1.56	6.128	58	0.05	0.38
Control	30	8.45	6.2				

Noticed that there are statistically significant differences between both groups at level of significance. This confirms the effectiveness of “AR” in developing “VI” with students. Finding out size of the effect of the “independent variable AR” on the “dependent variable SI” the value of the Eta square was calculated, and it was (0.38), and the calculated value indicates that the size is high. Which indicates that the differences between the two groups were not the result of chance, but were the effect of using AR technology.

7 Conclusions

Based on the results, the superior performance is due to AR technology that presented the information in a different way than the usual teaching methods. The use of technology helped motivate students towards these media provided for each lesson, and paved the way for them to employ them in solving problems and other situations in a smooth manner, in addition to the classroom and extracurricular activities provided to them, which are based on their awareness of the problem with its limits and dimensions, and the retrieval of previous sensory images, which contributed to Developing their abilities, and achieving higher cognitive goals that motivate them to develop their spatial abilities for realistically different situations than what is only theoretical. Also, this technique makes them focus on the sensory aspects by engaging all the senses in imagining the different situations and events presented, which makes it easier for the brain to deal with, store and retrieve mental images, which had an impact on that and leads to an increase in the students' ability to associate familiar images and clips with images and imaginary situations. AR technology gave students the opportunity to delve deeper into and understand topics, help students improve their cognitive levels and develop their ability to apply this information in new educational situations.

8 Recommendations

Finally, we recommend holding training sessions for mathematics teachers to train them on how to use AR technology and AR applications while teaching. We also recommend using it to be integrated into learning models that can make general students, college students especially pre-service math teachers more active. We recommend similar studies to look at their impact on new variables such as self-learning, imaginative intelligence, cognitive stimulation, and geometric reasoning.

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10 Authors

Ban Hassan Majeed, She is an Assistant Professor and one of the faculty member in the Department of Computer Science, College of Education for Pure Sciences/ Ibn Al-Haitham, University of Baghdad, Baghdad, Iraq. Her current research interests include Mathematics Education, Educational Technology, Digital Education, Smart Learning, Multiple Intelligence in Teaching and Learning, and Thinking with its skills. She holds an international assessor certified Publons and Academy peer reviewer. She is also an active researcher in the field of ICT in education. She is currently a member of editorial board in the peer review process for several international journals. The number of articles in national databases – 7. The number of articles in international databases – 18. ban.h.m@ihcoedu.uobaghdad.edu.iq

Haider TH. Salim ALRikabi, Electrical Engineering Department, College of Engineering, Wasit University, Wasit, Iraq.

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