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The Relationship Between the Type of Dimensions (3D, 2D) and Mental Interaction (High, Low) in the Augmented Reality Environment and its Effects on Learning

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ABSTRACT

The research aims to reveal the relationship between the type of dimensions (3D, 2D) and the type of mental interaction (high and low) and its impact on students' knowledge of the types of wireless networks and their components in the course "Wireless Communications and Mobile Security" based on their satisfaction with this learning, and their academic achievement. The research sample is 144 students in the second year, fourth level of the cybersecurity diploma, and they were divided into four experimental groups. The first experimental group studies with books augmented with three-dimensional models with high mental interaction, and the second experimental group studies with books augmented with three-dimensional models with low mental interaction. The third experimental group is taught with books augmented with two-dimensional models with high mental interaction, and finally, the fourth experimental group is taught with virtual books with two-dimensional models with low mental interaction. The research results that there is an interaction between the type of dimensions in augmented reality books and the mental interaction (high, low) in identifying the types of wireless networks and their components, where the high mental interaction groups excelled, regardless of the type of dimensions (3D, 2D) in the achievement test, and there was clear satisfaction for the students of the groups that study with 3D models compared to the 2D groups.

INTRODUCTION

Augmented reality lets you unite the real world with the virtual world, in additional words you can do whatever you can do things that you cannot in the real world with the help of virtual objects and digital convenience. AR technology is based on three key factors: alignment of virtual and real objects, actual time relations, and a combination of digital and real environments. The phenomenon of AR involves adding a real-world environment into a device with additional virtual elements, according to Milgrim's mixed reality study, for example, if a map is considered through Augmented reality, it will portray a modified version of the area with an easy glance to all the checkpoints and destinations in that area. In terms of entertainment, Augmented Reality provides a huge variety of video games and virtual entertainment allowing a person to explore the digital world (See Figure 1) (Alqifari *et al.*, 2021; Iordache *et al.*, 2012; Khan *et al.*, 2019; Küçük *et al.*, 2014; Miller *et al.*, 2019).

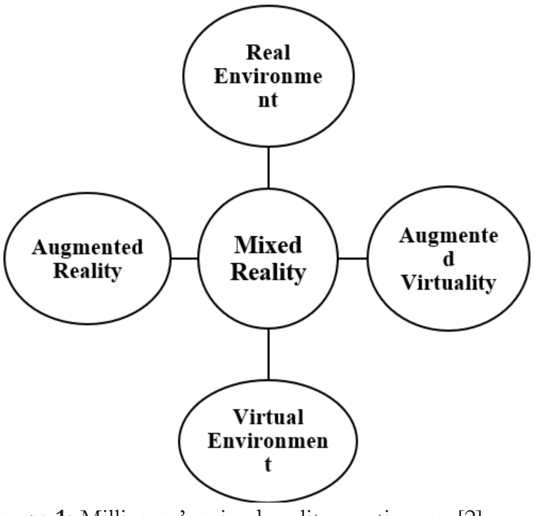

Figure 1: Milligram's mixed reality continuum [2]

Figure 1 shows a taxonomy related to the studies through which the actual human world and virtual fundamentals may be interlinked. The continuum varies from a whole different perspective in a real environment in contrast to a digital/virtual environment. According to this continuum, interlinked reality can be explained as a platform where the virtual world meets the real world. AR enables one to interact in the depths of the digital world and be a part of it. In consideration of augmented reality in smartphones, the features come through the camera that connects both worlds on a technical level and helps explore. A very well-known and easily understandable example is the virtual Map application which allows accessing different locations appearing in the digital view mocking the real view of the person while augmented reality GPS drive/navigation enables an AR-based tracking and navigation system. Such a combination of both worlds can discover a vast aspect of possibilities and opportunities for things that were not possible before.

The attractive fact about AR is also the fact that it is portable and does not require any sort of specific instruments or equipment and can be accessed through a digital device with ease and minimum effort. An augmented reality mimics the real world through small segments of information in order to interpret the data on digital screens, the amount of accessed data and information decides the degrees of immersion of tracking and displaying technical results.

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LITERATURE REVIEW

Digital growth takes its course to a further level each day as easy access enables the average people to possess access to AR through their devices which also plays its part in learning and educational purposes. Many students face difficulties in learning and remembering the information they need as the Cognitive Load has its certain capacity, therefore, it is not wise to overload the mental capacity with information one cannot process. Hence, Augmented Reality devices are introduced into the learning and educational systems that allow the students to develop an interest and pay attention to the knowledge that is being provided to them. The commonly used devices grant experience to graphics hardware, fast processors, and multiple onboard sensors. It also works on platforms like military and marketing. Many researchers acknowledged augmented reality as a potential source of learning (Alqifari *et al.*, 2021; Iordache *et al.*, 2012; Khan *et al.*, 2019; Küçük *et al.*, 2014; Miller *et al.*, 2019)

The research intends to examine the progress of the students of the Qassim University in Qassim, Saudi Arabia, when they were provided an AR-based learning system.

Impact of AR in Diverse Departments

Apart from the educational department, augmented reality is now gaining a reputation in other departments as well, especially in the Medical Department. Techniques like VR exposure therapy help heal patients with anxiety claustrophobia, acrophobia, and social anxiety. It uses the mechanism of safely exposing them to a virtual situation designed according to their condition in order to overcome their mental illness (Thwaites, 2021).

Another technique is the Autism Glass Projects which lets kids with autistic issues understand their emotions without using Google glass and maintain socially healthy relationships with people in their lives (Van Krevelen & Poelman, 2010).

AR phantom limb pain treatment

In this situation the patients with missing limbs or parts of limbs are given the experience of physical feelings in those parts of their body using AR technology, which lets the amputee comprehend the virtual arm that is shown on the screen while the patient functions the amputated arm, the virtual arm on the monitor will also be displayed in the same action through the interfaces to stimulate and permit the patient to regulate the originally amputated limb with their mind, in directive to experience a satisfying effect.

VR Surgery Simulation

In addition to the opportunities AR provides, helps in ordinary surgical training and surgeries by medical experts as it reduces the chances of errors. Numerous medical organizations are now adopting this technique for multiple varieties of surgical performances like knee arthroscopy where physicians practice injection of anesthesia during knee cap replacement surgery, this makes the procedure a lot simpler and more accurate as surgeons are able to understand the sensitivity of the situation accordingly. Other than the risk-free factor it also enables the interns a chance to learn from their errors. Following technologies should be encouraged and implied in clinical procedures rather than the hurdles that are put in their way like construction cost, the addition of system software for the record, and the reliability of quality (Alqifari *et al.*, 2021; Khan *et al.*, 2019)

Augmented Reality has set its course and remains on track as it enters different domains of working organizations such as a virtual toolkit for robotic manufacture or fusion of physical/digital robotic covering workflows to validate the probable of augmented and diversified actuality for computerization and support in human-appliance original interface workflows, while fresh cases of AR use in manufacture locations show the upcoming potentials of the equipment (Alqifari *et al.*, 2021; Hussein, 2017; Krüger *et al.*, 2022)

The unique usage of Virtual Reality and Augmented Reality methods permits a continuous modification of the spray at dissimilar levels throughout the duplication development and benefits in rectifying or stopping the procedure quick if a certain part of the assemblies is exposed to be unattainable, or if they are predictable to unanticipated risky circumstances and struggles like if some curves are distorting a lot, then the spraying has to instantaneously be halted and assortments of suitable distortion are to be arranged after repetitive physical trials and detailed plotting of the adequate variations (Alqifari *et al.*, 2021; Diegmann *et al.*, 2015; Hussein, 2017; Krüger & Bodemer, 2020; Krüger *et al.*, 2022).

This way it can permit the instant re-arrangement of serious limitations, such as the approach of deposition, swiftness, the compression of the spray, pathways, remoteness to the arrangement in progress, and variations in the material physiognomies despite the fact being applied, for instance, the level of moisture, thickness, the number of threads, size of stones, amongst others. Augmented Reality has previously a noteworthy amount of presentation in the construction field, as a regulator device. It is applied in construction positions for the constructors to have an improved acceptance of wherever mistakes can have some precarious damaging inferences in the constructions. Augmented Reality still has not been meaningfully utilized so far as a project and optimizing means for the duration of the manufacturing course (Alqifari *et al.*, 2021; Diegmann *et al.*, 2015; Kesim & Ozarslan, 2012; Krüger & Bodemer, 2020; Krüger *et al.*, 2022).

MATERIAL AND METHODS

Problem-based learning (PBL) is a model methodology in educational sectors where actual-world problems facilitate students' learning instead of the forthright knowledge of facts and conceptions of conventional teaching. The research considers the learning implementation hypothesis that is based on observing the behavior of the students after opting out of a learning approach involving 2D and 3D dimensional types and observing the changes in their Cognitive Load and Attention driven towards the learning procedure.

Participants

A study was conducted based on a sample of 144 students in the second year, the fourth level of the cybersecurity diploma, and they were divided into four experimental groups, for mapping the scientific research skills of students enrolled in Wireless Communications and Mobile Security Curricula by using AR tools and applications, students from AL-Qassim University were selected, and enrolled in the course of computer science research for the year 2018/2019. The teaching of educational courses using 2D and 3D dimensional type was considered the independent variable while mental interaction i.e. The Cognitive load and Learning skills were considered the dependent variable. In order to judge the credibility of the hypothesis and its results two tools were designed, an achievement test to inspect the influence on students' learning skills and a track of the amount of attention and pleasure AR learning provided, using the Likert scale. The students were tested for the Reliability Coefficient based on an academic test taken from 15 students per hour (Table 1) (Alqifari *et al*., 2021; Hussein, 2017; Iordache *et al*., 2012; Khan *et al*., 2019; Küçük *et al*., 2014; Miller *et al*., 2019).

Table 1: Total Test Variance

No of students	Total test variance Reliability Coefficient = 0.75
15	14.75

Design

The attentiveness and learning indexes of the test queries were determined through the calculations of results of the investigational sample which comprised (15) students. A two-by-two between-subject design was used in the investigation. Mental interaction, which might be low (m–) or high (m+) using 2D dimensional type, was one influence. The mental interaction, which might be low (m–) or high (m+) measured using 3D dimensional type, was the other element. The values of attentiveness and learning index ranged between (33% - 67%). The Cognitive Load reached (67%), which is statistically accepted (Table 2). The outcomes of the study showed that the technology has been well acknowledged by students and facility members. They claimed that it helped them in teaching and evaluating their abilities in learning. Furthermore, it was time-saving and required less amount of effort. It was also fast and easy to use and it provided excellence of data, according to the participants.

The research approached the data implementation technique on different themes based on pre and post-test trials where the data of 34 students were investigated who were provided the opportunity of AR learning. The mean score of the pre-test for this theme observed was 23.1, whereas the post-test equaled 50.9. This indicated the escalation of the statistically substantial changes between the mean scores of students in the theme of data collection expertise for the pre and post-test of the digital learning skills (Table 3). The former conclusion shows that there was a positive impression of using AR research for the progressive learning skills among students of the course.

Materials and Apparatus

The study also concluded different independent and dependent variable results based on the practice of Dimensional type (2D and 3D) in educational departments, keeping a view of the mental interactions as variables for the research (Alqifari *et al*., 2021; Hussein, 2017; Iordache *et al*., 2012; Khan *et al*., 2019; Krüger & Bodemer, 2020; Küçük *et al*., 2014; Miller *et al*., 2019)[1-7]. The research embraced a 2x2 design, intersecting levels of difficulty and struggles in the tasks. While applicants finalized an anagram task, the dimensional framework was operated (i.e., the use of 2D and 3D dimensional type), and the task struggle was set to two conditions, either hard or easy. There were four experimental situations, mentally-easy using 2D dimensional type, mentally-hard using 2D dimensional type, mentally-easy using 3D dimensional type, and, mentally-hard using 3D dimensional type. Members were unsystematically allocated into one of each potential order of the four conditions. Each situation was observed individually at the four sequential positions correspondingly crossways participants, permitting for both a subject-based inquiry concluding all four trials and an among subject analysis only by means of the participants' initial anagram trials.

Procedure

The participants were greeted and given an explanation of the study's protocol and content at the start of the study. After all of their questions were answered, they signed an informed consent form. Participants individually assessed their capability principles, expectations for accomplishment, and subjective assignment standards regarding the topic and task on a mutual feedback form that was launched on a computer screen.

Participants were then directed to the research room, where they finalized two short preparation tests. First was an anagram-deciphering task with the sample anagram and a couple of training anagrams. This confirmed that the participants were able to see the anagrams and implicit the anagram task. Then, the research provided the AR headset to the participant in order to carry out the second task which was a navigation trial using AR objects. The experimenter requested participants to make sure if they observed a virtual ball and then to move in its direction until the ball changed color. This procedure was implied again with a digital cube. The number of anagrams answered was recognized by evaluating the footage of every single participant. To accelerate examination, a program was introduced by means of

Python (version 2.7) to figure out the audio and cut large segments of stillness from each of the demos. A human coder then attended to the clipped recordings and made it clear what words were communicated by participants. Each participant was awarded a point for each anagram deciphered appropriately (Alqifari *et al.*, 2021; Hussein, 2017; Iordache *et al.*, 2012; Khan *et al.*, 2019; Krüger & Bodemer, 2020; Küçük *et al.*, 2014; Miller *et al.*, 2019).

Statistical Tables

The groups' individual ratings of their familiarity with the matter, their expectation of how well they would unravel the tasks, and their apparent worth, significance, and awareness of information were equated to ensure that the groups did not fluctuate in their pre-study data about and attentiveness in the matter.

Table 2: Cognitive Load and Attentiveness

Positive Impression	Cognitive Load	Attention Span
	67%	33%

Table 3: Test Score

Test Credit		Dimensional Type	
		Using 2D Dimensional Type	Using 2D Dimensional Type
Mental Interaction	**Low (m)**	**22.1%**	**24.4%**
	High (m)	**49.6%**	**52.4%**

Table 4: Mean Score

Data Collection	Significance 0.01
Pre-Test mean score	23.2
Post-Test mean score	50.9

RESULTS

Participants deciphered multiple queries in the easy situations than in the tough situations representing that the management of exertion in the middle of situations was effective. Social reserve indicates that contributors can solve harder cyber security assessments when they are alone than socially. The chief result of striving (easy vs. hard) on the mark was noteworthy, with easy (2D &3D) as the dependent variable = 7.68, while hard (2D &3D) was the independent variable = 4.16 based on interactions in the Anagram test.

The results showed major differences when the bar chart was designed according to the results of assessment trials, Mental interactions using 2D dimensional type ranged from 3.24%-2.11% while Mental interactions using 3D dimensional type ranged from 5.70%-9.70%. The subjects with a high level of accomplishment gave forth a positive attitude toward Augmented Reality Applications. The developing statistic showed that the participants who were given AR opportunities in terms of knowledge possessed a high level of attainment, which made a constructive approach obvious towards this technology and put forth a low extent of energy during the application procedure. Moreover, the outcome of the examination showed that the subjects who have used the applications of Augmented Reality, had a future intent to use these techniques in the future, as they were pleased with the practice of using virtual models, and had a reduced level of nervousness while functioning through this technology. These circumstances of results can be enlightened by the detail that the AR applications fascinate the responsiveness of the users, also enables

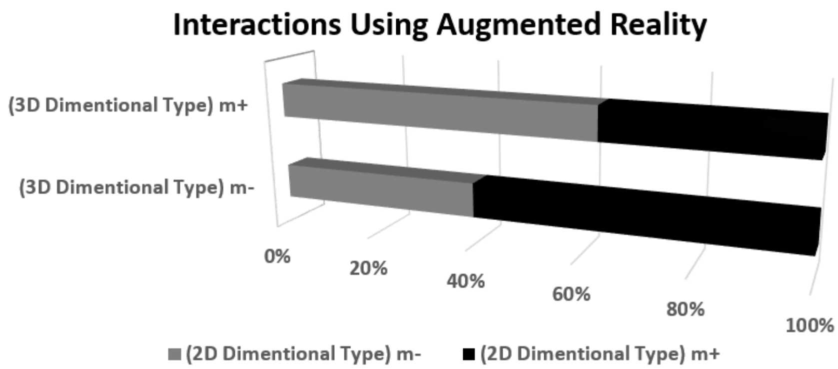

Figure 3: Interactions using AR

an operative learning atmosphere, and encourage them for focusing better on the learning (Alqifari *et al.*, 2021; Diegmann *et al.*, 2015; Hussein, 2017; Kesim & Ozarslan, 2012; Krüger & Bodemer, 2020; Krüger *et al.*, 2022; Mason, 2020; Miller *et al.*, 2019).

DISCUSSION

The fundamental object that turned the attitude of the participants into affirmative could probably be the fact that the learners discovered a diverse learning objective other than depending on the old-style learning techniques. The prominent situation was that using Augmented Reality applications escalates enthusiasm and the users can also have fun working with them, resulting in a positive outlook towards these applications. It was also witnessed that the participants could raise the capability of their understanding, reading, speaking, and learning using AR techniques, more in comparison to the ones who followed the customary ways of learning and research. As it was proven from the collected data that the participants developed better expertise and talents like spatial learning capability, technology efficiency, computer science approximation, finding solutions for their problems, and collaboration in order to avoid any difficulties (Bartosh & Anzalone, 2019; Fernando *et al*., 2017).

Metzler and Shepard (1974), R. N. Shepard and Cooper (1982), and Corballis (1986) all describe a similar process of mental rotation (Corballis & Blackman, 1990; Metzler & Shepard, 1974; Shepard & Cooper, 1986). How much can this approach take use of the fact that 3-D figures have steeper slopes than 2-D ones? If one considers the "dimensionality" of a stimulus to be equivalent to its "complexity," then one may say that the "effect" of dimensionality (as in the case of complexity) results from the higher amount of information that must be maintained in the case of 3-D stimuli or more complex stimuli. This argument is supported by the fact that it is possible to make it. Folk and Luce (1987) demonstrated this for 2-D polygons by finding that mental rotation rates were slower for polygons with more vertices than for polygons with fewer vertices. This was true for simple and complicated polygons alike (Folk & Luce, 1987). Folk and Luce claimed that they were able to produce the complexity effect because they did not depend on reflected or perturbed distractors, but Cooper (1975, 1976) was unable to do so because they used distractors that were more similar to their standard polygons. Folk and Luce were able to achieve the complexity effect for this reason. Participants were required to encode and modify a more comprehensive representation of the stimulus so order to avoid being fooled by a distractor that resembled it too closely. This was done to prevent being fooled by a distractor that resembled it too closely. Slower rotation rates were detected as a result of the increased information load brought about by the more realistic presentation of more complex pictures (Cooper, 1975, 1976).

Since it is thought that students may learn accurate mental models of a topic by envisioning and engaging with the portrayal of the phenomenon, much study has been conducted on the influence of virtual reality technology on the teaching of chemistry (Antonoglou *et al*., 2011; Chiu & Wu, 2009; Halpern & Collaer, 2005; Phillips *et al*., 2010). This was the most comprehensive research conducted to date on how chemistry students engage with desktop 3D virtual reality learning environments. It examined the students' perceptions of the surroundings, sensation of presence in the environment, spatial orienting abilities, and sentiments of self-efficacy. Throughout the length of the experiment, students will be able to zoom in and out of the 3D virtual reality environment to observe molecules and the angles at which they are bonded from a variety of perspectives. In addition, they may spin and control a molecule in order to explore how the atoms contained inside it are bonded to one another by using the many opportunities presented by the surrounding environment. As part of this kind of chemistry education exercise, students are tasked with mentally manipulating or changing an object into a mental configuration. Students with a high level of spatial intelligence may be able to perform the mental adjustments required for molecular organization more quickly. This is a reasonable conclusion. Researchers have shown, however, that students often lack this mental capacity for seeing and manipulating three-dimensional chemical groupings (Halpern & Collaer, 2005; Wu & Shah, 2004).

On the basis of this examination, applying the AR implicational technology in computer laboratories supervised by the expert's leadership results in having no trouble while using the opportunities provided by the application and dealing with reduced levels of unease among the learners (Bartosh & Anzalone, 2019; Fernando *et al*., 2017). The purpose of students to use AR applications in the forthcoming can be clarified by the basis of the matters that go further for revolution to catch the attention of users and give growth to the learning impulse of students.

CONCLUSION

The research concludes that the use of AR can either increase or decrease the cognitive load and attention span of an individual as provides various possibilities and learning techniques for the users. Learning techniques that involve Augmented Reality will allow educational departments to give forth promising results and develop a better reputation through their unique teaching styles and technicalities.

Understanding such occurrences needs the construction of a mental model based on knowledge about the separate stages and connecting these phases according to the basic rules of causation (Lowe & Boucheix, 2008; Narayanan & Hegarty, 2002). Both Lowe and Boucheix (2008) and Narayanan and Hegarty (2002) discovered the same thing. Both 2.5D and 3D provide a third dimension, which might be important for constructing accurate mental representations. This is especially true in instances when spatial expansion is necessary for understanding. Since monoscopic presentations already communicate a variety of spatial signals, the move from monoscopic 2.5D to stereoscopic 3D is a less important one. However, shifting from two dimensions to two and a half dimensions may provide crucial information. Recent research has shown that students can only profit from stereopsis in a restricted number of situation.

It is obvious that for the purpose of reducing the cognitive load of the users and making certain of efficient learning, the fundamentals of multimedia and learning concepts have the tendency to work when designed in an Augmented Reality application. Hence, the study recommended techniques that can help improve the quality in accordance with dependent and independent variables of Augmented Reality, firstly, planning AR applications that can be adopted in order to decrease the cognitive load and increase the achievement levels in students to enhance the learning abilities of the learners. Secondly, for the purpose of attention increasing and inspirational increase, an updated learning environment should be created that provides AR application access. Courses that involve AR applications should be put in the curriculum so that the learners can have access to opportunities at their homes. Reasonable studies should be planned by evaluating the insolence, success, and perceptive loads of learners for Augmented Reality's uses in dissimilar grounds of learning (Alqifari *et al.*, 2021; Corballis & Blackman, 1990; Fernando *et al.*, 2017; Hussein, 2017; Metzler & Shepard, 1974; Miller *et al.*, 2019; Shepard & Cooper, 1986).

There are certain drawbacks and limitations to this technology specifically when it comes to the cost and maintenance of Augmented Reality and applications, it also requires expertise and an appropriate crew to keep the technology functional and advanced, speaking of advanced, it takes specific understanding to update and keep track of the advancements that the technology requires and the technical issues that AR devices face at certain times. There is also a need for a further vigorous discussion about virtual knowledge. There remains the issue of a compressed understanding of the discriminations of countless simulated spaces, stages, and technologies. Another issue is that access to the gadgets with AR tech, the admittance to the internet, a computer or laptop, a Nintendo Switch domain, or even the intellectual space to get involved in the virtual world is not appropriately circulated. The capability to observe the situation and provide current reports, information and projections is reflected as an unachievable luxury in lots of parts of the world. Also, many regions are still unaware of this technology and the possibilities they are missing out on that is why there should be certain sourcing to promote awareness of the opportunities of the virtual world (Alqifari *et al.*, 2021; Corballis & Blackman, 1990; Folk & Luce, 1987; Hussein, 2017; Krüger & Bodemer, 2020; Metzler & Shepard, 1974; Miller *et al.*, 2019; Shepard & Cooper, 1986).

Even though Augmented Reality has no limit to the informational opportunities it provides, there still are certain limitations that get in the way of evolution because much of this data likely possesses doubtful consistency when associated with outmoded bases. The innovative generation is familiarized with constructing virtual existence in the digital world of their own according to their own requirements and desires. As a result, their aims and objects have taken a different course by communal worldwide connections as a substitute to textbooks and certain other customary written sources of knowledge and learning, on the other hand, exist to be the predictable and steadfast basin of understanding. In concern to that, there are certain boundaries and hurdles that are uncrossable, for example, the complication that rises while arranging overlaid means of information (Cooper, 1975, 1976).

Many students face malfunction problems while using Augmented Reality applications and the case situations where it gets rather troublesome for the students to make use of the device or technical markers to get access to the augmented information or the virtual world. It is often believed that the possible explanation for this boundary is that application designers need to advance the set of rules in the pursuit and processing of representative departments. There is another suggested possibility to be considered, that is for the common future scientist to discover further into the realm of Augmented Reality and its virtual world in order to understand the aspects of this domain further and provide answers to the complications so that those solutions can be considered and tally in the future AR application designing in the academic contexts (Antonoglou *et al.*, 2011; Chiu & Wu, 2009). Augmented Reality sometimes also proves itself to be a distraction for the users when they divert their attention towards the charm of the virtual world being a novelty rather than the information that they are supposed to be absorbing it also has imaged itself as a disadvantage in terms of learning and getting tasks done using the virtual assets.

It is also stated that Augmented Reality can be measured as a "Disturbing Technology," as Augmented Reality can be a source of interference for users trying to learn and develop reading abilities while they use tools such as Head-Mounted Displays (HDM) in terms coaching and educational session. Some researchers declared in their analogies that the device that transports virtual figures can disorder the original commitment among the user with other users and related folks in relation to communication. An additional way of intrusiveness is the circumstance that whenever to completely make use of this opportunity in the learning session, a discussion requires to be entirely equipped in the computer hardware division and partake unwavering internet connections so the session stays on its flow while in commencement (Antonoglou *et al.*, 2011; Chiu & Wu, 2009; Halpern & Collaer, 2005; Lowe & Boucheix, 2008; Mason, 2020; Narayanan & Hegarty, 2002; Phillips *et al.*, 2010; Wu & Shah, 2004).

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Conflict of interest

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Consent for publication

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