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The Effectiveness of Augmented Reality in Improving Students Motivation: An Experimental Study

By Malek Jdaitawi[*]*, Fatima Muhaidat*[±]*, Ayat Alsharoa*[°]*, Abeer Alshlowi*[•]*, Marwa Torki*[♦] *& Mona Abdelmoneim*[‡]

Augmented reality (AR) has become a potential technology tool to improve the skills of students with learning disabilities. The effects of AR technology approach on students with learning disabilities motivation levels is considered as the research motivation. This study examined the effect of the AR on Jordanian 6th grade students' motivation levels. A quantitative quasi-experimental study is preceded with the pretest-posttest control group design model, where 24 students who identified to have learning disabilities were participated in this study and were randomly divided into two groups. Two groups, control group 12 students were taught conventionally, and 12 students were designated as the experimental group, they used the AR technology for four weeks. The results show significant results for the AR technology in enhancing student motivation. The results concluded the effectiveness of AR technology in enhancing students' motivation.

Keywords: augmented reality, learning disabilities, motivation, science.

Introduction

Learning disabilities stem from one or more fundamental psychological processes that involve the understanding or usage of spoken/written language, and it surfaces in the form of the lack of ability to listen, think, speak, write, spell or solve mathematical questions (IDEA, 2007). In regard to this, the movement towards the improvement of educational opportunities for special needs individuals mainly concentrates on the delivery of novel learning models, the cognizance of disabilities categories, and provision of suitable services to students (Al Medlij, 2018). Hence, this calls for the organization of education and training processes for special needs students, by taking into consideration the movements and their characteristics. Emphasis is laid on the possibility to allow learning disabled students to obtain the required social and personal skills, enhance their intellectual ability, their motivation and engagement in class via the facilitation of an enriched learning environment equipped with learning models and services (Arslan Kofoglu, & Dargut, 2020; Cimer, 2012; Savelsbergh et al., 2016). Global studies of this caliber supported the same notion and stressed that learning disabled students suffering

[*]Associate Professor, Imam Abdulrahman bin Faisal University, Saudi Arabia.
[±]Associate Professor, Hashemite University, Jordan.
[°]Assistant Professor, Imam Abdulrahman bin Faisal University, Saudi Arabia.
[•]Lecturer, Imam Abdulrahman bin Faisal University, Saudi Arabia.
[♦]Lecturer, Imam Abdulrahman bin Faisal University, Saudi Arabia.
[‡]Assistant Professor, Imam Abdulrahman bin Faisal University, Saudi Arabia.

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from different cognitive and physical disorders require teaching approaches to enhance learning (e.g., their achievement, motivation, confidence, spatial ability, interest, engagement and satisfaction) (e.g., Çakır & Korkmaz, 2019; Kellems, Cacciatore, & Osborne, 2019; Weng, Otanga, Christianto, & Chu, 2020).

Literature highlighted that there is a decrease in science achievement among students (Bicer & Lee, 2019). On the basis of prior literature on the topic, students generally lose interest and motivation in learning science courses (Potvin & Hasni, 2014) as they face difficulties in learning science. Erbas and Demirer (2019) attributed such lack of interest and motivation to abstract and invisible course contexts that lead to misunderstandings and low levels of academic achievement. In this line of argument, educators have been constantly coming up with evidence-based practices to ensure that individuals with specific learning disabilities (SLDs) live productive and fulfilling lives and this is possible through the enhancement of effective methodologies and coming up with better ones (Kellems et al., 2020).

Generally speaking, students suffering from disabilities can leverage creative interactive activities, visual presentations, project-based learning, school experiments and other activities that are engagement-based (Obradovic, Bjekic, & Zlatic, 2015). In other words, disable students need to be stimulated through different levels of visual and perceptive aspects (Rega & Mennitto, 2017). Hence, different authors such as Savelsbergh et al. (2016) and Cimer (2012) proposed changes to be made on the teaching style and methods for science subjects. Despite the available teaching approaches that have been utilized for enhancing learning of students without disabilities, the outcome of research on the enhancement of science courses outcomes remains inconclusive as to the top effective interventions (Kellems et al., 2020; Savelsbergh et al., 2016). Developments in technology have extended the teaching/learning boundaries and the development of delivery models of courses, such as e-learning, virtual lectures, augmented reality, video recording methods, computer-assisted teaching, and multi-sensory based teaching (Doğan, 2015; Kellems et al., 2020). To begin with, Doğan (2015) reached to the conclusion that extracurricular activities driven by technology positively impact the students' cognitive and physical development, and Doenyas et al. (2014) revealed that ASD students can be inculcated with ordering skills through web-based iPad application. Similarly, Escobedo et al. (2012) focused on the development of auxiliary tool to support social skills of ASD children and concluded that the tool did bring about learning and social skills application while reinforcing social interaction both in the qualitative and quantitative sense. Moving on to another study, Çakır and Korkmaz (2019) revealed that AR teaching materials are invaluable to special needs learning in a way that it enhances interest and readiness to learn. In conclusion, authors are of the consensus that technology use in teaching and learning assists success of students with and without disabilities (e.g., Çakır & Korkmaz, 2019; Kellems, Cacciatore, & Osborne, 2019).

Education-centered research has been pro-active in defining particularly actions that teachers can avail from to enhance their students' motivation in the classrooms (Huitt, 2011; Taran, 2005). In this regard, the active participation of students in their learning has been found to be significantly related to motivation, while motivation is significantly related to their achievement in academia (Weiser,

2007). The past few years have seen increasing efforts in the technology usage to support and enhance learning, with learning environments transforming in the form of integration of computers, multimedia material, whiteboards, internet, Web 2.0 authoring tools, simulations, games and mobile phones as well as immersive technologies (e.g., 3D virtual worlds, flipped learning and augmented reality) (Dror, 2008; Khan, Johnston, & Ophoff, 2019; Jdaitawi, 2020a; Jdaitawi, 2019). AR application studies in education are still in their infancy stage and thus, they are limited, particularly those focusing on effects and implications of AR in the education field (Khan, Johnston, & Ophoff, 2019; Jdaitawi & Kan'an, 2022). According to Kamil et al. (2008), school engagement is the level to which a student processes the activity/task using active strategies and using prior knowledge (p. 26). Student engagement and motivation, therefore, have had a key role in successful learning and the selection of engagement and motivation strategies facilitating and enhancing the student's learning process (Mundy, Hernandez, & Green, 2019). Gersten, Fuchs, Williams, and Baker (2001) and Wood and Blanton (2009) advocated that engagement makes a great difference in the comprehension of the students in his/her participation abilities in discussion, activities, particularly those that require higher order thinking skills. In this regard, technology has become an invaluable strategy used in schools (Mundy, Hernandez, & Green, 2019), with computers, Internet and videos being the top technological resources availed within classrooms (Mundy, Hernandez, & Green, 2019). In addition, instructors are constantly searching for innovative methods to use, such as tools that bring about the process of learning with ease through higher student's engagement (Mundy, Hernandez, & Green, 2019). However, the innumerable technologies that have been used in instruction succeed only as far as the ability of technology to enhance the students' engagement and interests. With the development of technology and its integration into school curriculum, AR is predicted to lead to enhanced engagement and motivation (Mundy, Hernandez, & Green, 2019).

There is a consensus among scientists, researchers and teachers as to motivated learning motivation, with motivated students being those that are inclined towards engagement, persistence and expending efforts towards completing their tasks rather than those who are not (Schiefele & Csikszentmihalyi, 1995). AR applications usage may lead to enhanced motivation and enhancement of academic achievements among students (Khan, Johnston, & Ophoff, 2019), with AR utilized to increase their motivation and attention, and their interaction with AR objects for understanding and memory retention (Sahin, Keshav, Salisbury, & Vahabzadeh, 2018). Furthermore, as an emerging interactive technology AR has been used to enhance learning among students with disabilities through the enhancement of their motivation and engagement, which in turn lead to other positive results (Sahin, Keshav, Salisbury, & Vahabzadeh, 2018; Dhamdhere et al. 2019). One of the studies supporting this notion is Çakır and Korkmaz (2018) who related that AR teaching materials is suitable and useful in light of the development of students with special needs, and they are used to provide real-life experiences for training. The students showed interest and enthusiasm towards the course with increased readiness to learn the lesson, and the subjects, and they were more proactive and responsive to the questions being asked. In the context of university

students, Çakır, Solak, and Tan (2015) reached to the conclusion that AR technology materials development impacted the learning autonomy of students, particularly with mobile augmented reality (MAR). This in turn, affected their academic success and cognitive burdens as well as their perceptions of practical professions. On the basis of the findings, students in the experimental group exposed to MAR applications showed higher success and lower cognitive loads in comparison to that of the control group, with the former group's positive learning perceptions when it comes to MAR. In a related study, Dhamdhere et al. (2019) related that AR assists abnormal kids in their cognitive and motor skills development and make them look forward to education through fun, interactive and compelling activities.

In the realm of learning, augmented reality (AR) is deemed to be an invaluable technology to pave the way for teaching and learning while increasing the achievement of success among students with and without disabilities (Çakır & Korkmaz, 2019; Kellems, Cacciatore, & Osborne, 2019). Currently, (AR) is transforming the students' (with and without special needs) interaction and engagement with animated objects through their visualization of the topics and understanding of actual situations and problems (Weng, Otanga, Christianto, & Chu, 2020). A few recent studies dedicated to the impact of AR applications use for teaching students with disabilities revealed positive effects, but they are still not enough to shed light on AR apps use and actual effects (Kellems et al., 2020; Rega & Mennitto, 2017). Research is still lacking on the impact of mobile AR usage in the field of education and the issue still calls for thorough exploration (Sahin, Keshav, Salisbury, & Vahabzadeh, 2018; Khan, Johnston, & Ophoff, 2019; Di-Serio, Ibanez, & Kloos, 2013; Lin, Chai, Wang, & Chen, 2016), specifically with regards to AR effect on students' motivation (Di-Serio, Ibanez, & Kloos, 2013). Hence, the need for further exploring AR and learning disabilities along with the categories (Kellems et al., 2020; Ok, Haggerty, & Whaley, 2020; Mundy, Hernandez, & Green, 2019). The study primarily aims to establish and contribute to the knowledge base of interventions that motivate students', particularly students with disabilities through the use of AR approach in a basic science course. Therefore, the study attempts to answer the following research questions:

1. Is there a significant difference between motivation of students with learning disabilities when learning basic science lessons using AR approach, and motivation of students when learning using the traditional approach?
2. Do the total students mean score have different motivation level in the pre-test compared to the post-test?

Research Methodology

General Background

A quantitative quasi-experimental approach with equivalent control group pretest and posttest design was employed (Creswell, 2012), to explore the AR effectiveness in students' motivation. The students were selected from two primary schools in Jordan. A survey method was used to collect data from the study participants as it has been generally used to determine characteristics abilities, and attitudes, expectations and thoughts (Creswell, 2012; Fraenkel & Waleen, 2006; Jdaitawi, 2020b). The study group consisted of 24 grade 6th students in primary schools that have special needs to examine AR supported instructional experience.

Students with special need were defined as individual with disability such as visually, hearing, intellectual and learning. However, students with special education needs in this study were identified to have a special designed education program to fit their needs especially those whom required development instruction to fully participate in class activities. 24 students were included and were identified using purposive sampling method, where the sample is determined on the basis of the research purpose (Fraenkel & Wallen, 2006). This research used the criterion of experience in AR supported instruction to determine the study group. The instruction was provided in a span of 4 weeks divided into 4 units according to the 6^{th} grade science curriculum of the academic year 2018/2019, using AR application. The students were categorized into two groups (AR groups and Control group).

Research Setting and Sampling

In this research, 6^{th} grade students were selected from schools having students with special needs in Jordan. A total of 24 students were selected and assigned into two groups 24 students were selected as they were accessible and available to the researcher. 12 (50%) students were selected as the experimental group taught using the AR application to learn science, and the other 12 (50%) students taught using the traditional approach.

Research Instruments

This study used tools to collect data included demographic variables, motivation test, which were administered among school students with learning disabilities. With regards to the motivation scale, the study made use of the learning motivation questionnaire that Keller (1987) developed to determine the motivation level of the secondary school students when it comes to learning using AR technology. Fifteen (15) out of the 36 items were selected for the study for the same purpose because of the limitations in time and class sessions. This scale was employed by prior studies of the same caliber such as Chen, Huang, and Chou (2019). The 15 items were forwarded to the experts for perusal and for content validity. Each item was measured using a 5-point Likert scale, which ranged from 1 (strongly disagree) to 5 (strongly agree).

Validity and Reliability

Necessary permission was obtained from the schools where the research was conducted followed the guidelines and ethical principles stipulated by Jordanian Ministry of Higher Education & Scientific Research. Furthermore, the researcher informed the participants that the data will be used for the research purpose only. The original version of research instruments was developed in Arabic, since students participated in this research are native language being Arabic, the instrument was translated and validated translators for Arabic speaking students. However, the instruments were translated by two bilingual speakers who are specialists and a PhD holder. The translated version was given to 5 educational experts for instruments validations, most of them working at the university and some with special needs students. The experts highlighted some issues, and their feedbacks were accepted and incorporated and were corrected accordingly. For the internal consistency of the scale, reliability coefficient was obtained for the study and was found to be 0.73. The values supported the validity and reliability of the scale to assess the secondary school students' (with disabilities) motivation towards using AR applications. The coefficient of reliability of the scale was obtained and found to be 0.62, supporting the scale's validity and reliability in assessing the engagement of secondary schools' students' (with learning disability) towards learning through AR applications. AR application was developed by taking the acquisitions an activity of the "Space" unit included in the 6th grade science class, based on the activities in the textbook. Initially, in this study, the research obtained the opinions and feedback of 2 field experts, 2 teachers and 3 technical experts during the process of the AR application development. The study conducted pre-test and post-test evaluation. There were 24 students with special needs at the schools. In a ten minutes pre-test organized in the first day, students were given a question to answer without access to any information material or reference classes. Next, they were given the questionnaire related to the study variables. Then, the students were split into two groups. The first group was a control group and the teacher taught them using traditional method, which began by explaining the main ideas and supportive activities and ending by assigning assignment and discussion. The second group was exposed to AR classes in their learning activity. The AR classes were introduced into several lessons in science curriculum. The introduction lesson involved assistant from the teacher as a moderator to demonstrate the activity to students and detailing their difficulties in the subject's context in the form of a visual. Then the students would have to repeat the activity without assistance. Then teacher introduced AR activity to easier the topic. For each task, participants were accompanied after the learning activities, the post-test questionnaire were distributed to students for completion experimental group were taught using AR application.

Data Analysis

The data was examined for checking the normality (skewness and kurtosis = ± 3.00-7.00) and outlier (Mahalanobis) cases using several indicators such as (Judd, Westfall, & Kenny, 2017; Tabachnick & Fidell, 2007). However, the results proved to be normal and outlier cases were identified. Descriptive statistics such as mean *M* and standard deviation *SD* and other statistical tests such as independent sample t-test, and Paired sample test were involved in this study to identify the possible mean differences between the AR group and control group.

Research Results

Prior to testing the hypotheses, the study conducted independent sample T-test on the independent samples to identify the statistical equivalence of the groups. Motivation is the dependent variable examined in the present study. In the initial set of statistical tests, the differences between the experimental and control groups in pre-test motivation was obtained based on the level of significance (0.05). Insignificant differences in t-test were found between the groups based on pre-test of motivation scores (t=-1.250, 0.224, p>0.05). The test was specifically used to determine if the learners placed in both groups had significant differences in terms of motivation in the pre-test. Results indicate insignificant differences, and the groups were equal prior to examination of motivation. Table 1 results indicates that students exposed to AR application in basic science learning had enhanced motivation, with the mean score off 3.20, SD=0.304. The results of t-tests are presented in Table 1, and based on them, a significant difference was found in the motivation level between the two groups (one learned through AR technology and other through traditional methods) at (t=2.397 (0.025, p<0.05). The mean score obtained by the experimental group in terms of motivation is 3.20, with standard deviation of 0.304, while the control group's motivational level is 2.78, with standard deviation of 0.528 as shown in Table 2. The mean results support the positive contribution of AR technology in enhancing the motivation of the students.

Table 1. T-test Results Between Groups for Posttest Motivation

Variable	**Mean**	**Standard Deviation**	**t-value**	**Sig. 2-tailed**
Motivation				
AR Group	3.20	0.304	2.397	0.025
Control Group	2.78	0.528		

Table 2. Summary Statistics for Motivation Variable Posttest (N=24)

Variable	**Mean**	**Standard Deviation**
Motivation		
AR Group	3.20	0.304
Control Group	2.78	0.528

For the total sample mean score, motivation pre and post-test was determined and presented in Table 3. From the table, it is evident that the students that used AR application in learning basic science had enhanced motivation levels with a mean score of 2.99, SD=0.473, after AR technology was implemented. The study used paired sample test to identify if there are significant differences between the pre-post motivation in using AR technology. Table 3 shows significant differences between the pre-post-test motivation level, having a value of (t=4.411 (0.000, $p<0.05$). In Table 3, the mean score value obtained by the posttest motivation is 2.99 with standard deviation of 0.473, while the pretest motivation level mean is 2.48, with standard deviation of 0.352. Based on the results, AR technology positively contributes to students' motivation enhancement.

Table 3. T-test Results of the Groups for the Pre-Posttest Motivation

Variable	**Mean**	**Standard Deviation**	**t-value**	**Sig. 2-tailed**
Motivation				
AR Group	2.99	0.473	4.411	0.000
Control Group	2.48	0.352		

For students' recipients of AR application approach (experimental group), their motivation pre and post-test was determined and presented in Table 4. From the table, it is evident that the experimental group students that used AR application in learning basic science had enhanced motivation levels with a mean score of 3.30. The study used paired sample test to identify if there are significant differences between the pre-post motivation in using AR technology for the experiment group. Table 4 shows significant differences between the pre-post-test motivation level in the experimental group, having a value of (t=5.546 (0.000, $p<0.05$). In Table 4, the mean score value obtained by the posttest motivation is 3.30 with standard deviation of 0.362, while the pretest motivation level mean is 2.53, with standard deviation of 0.292. Based on the results, AR technology positively contributes to students' motivation enhancement.

Table 4. Paired Sample T-test Results Experimental Group for Pre-Posttest Motivation

Variable	**Mean**	**Standard Deviation**	**t-value**	**Sig. 2-tailed**
Motivation				
Pre	3.30	0.365	5.546	0.000
Posttest	2.53	0.292		

Discussion

The primary aim of this study is to examine the AR application effectiveness in enhancing the motivation of students with learning disability. The AR application was developed on the basis of basic science lessons teaching materials and incorporated into the study framework, with the assistance and feedback of field experts, technical experts and teachers. Prior to gathering data, students were

exposed to basic science lessons provided through the AR technology approach for two weeks. The students were thus provided a learning experience using the technology. Notably, AR supported positive environment in classrooms which is in contrast to that of traditional classroom, and the former is expected to lead to higher motivation of students towards learning basic science. Using AR technology provides advantages in the field and environment of education, providing active and interactive learning through enhanced reality (Sirakaya & Cakmak, 2018). The finding supported a significant result, and this may be attributed to the involvement of AR technology in the learning activities, within which it simulated complex knowledge for easy learning.

In literature, Chen, Huang, and Chou (2019) related that AR technology presents lessons through the combination of actual real-world environment and virtual objects, the result of which immerses students in the learning content and its exploration. The significant result may also be due to the students' inspiration via the AR learning approach which facilitated their enjoyment in class and enabled their interaction with the activities. AR activities thus contribute to the learning of students with learning disabilities, through exercises which pave the way to recognizing lessons and practical activities contributing to the students' motivation level. According to Çakır and Korkmaz (2019), AR technology materials is suitable to use in enhancing dyslexic students' motivation and in understanding information while Yip, Wong, Yick, and Chan (2019) revealed that AR technology brings about the processing skills, learning motivation and tasks understanding among students. The study findings supported those reported by prior studies, which supported the integration of new technology (i.e., AR) into learning activities for motivation enhancement (Çakır & Korkmaz, 2019; Hwang, Wu, & Kuo, 2013). Specifically, Chiang, Yang, and Hwang (2014) investigated the AR-based mobile learning inquiry activity and revealed that students exposed to AR-based system in learning learned from real-world environment and virtual objects, with enhanced level of motivation in learning. The students supported the assistive effectiveness of AR technology as a promising learning tool.

Studies dedicated to AR and its contribution to special education needs and motivation are still few and far between (Baragash, Al-Samarraie, Alzahrani, and Alfarraj 2019; Khan, Johnston, & Ophoff, 2019; Sirakaya & Sirakaya, 2018; Yuliono & Rintayati, 2018) but what few studies there are supported evidence for technology-supported environments and their contributions (e.g., Alghabban, Salama, & Altalhi, 2017; Bakker, Van-den, & Robitzsch, 2016). In particular, Di-Serio et al. (2013) recommended that education-based AR may be used to assist in attracting and maintaining learners' attention and interest, while supporting their learning environment. In the context of special education, AR technology was evidenced by Lin, Chai, Wang, and Chen (2016) to improve the motivation level of children with disabilities, and to enhance their participation in educational activities. The authors found learning activities developed on AR technology for special education students to be easier to provide explanations and demonstrations. In a related study, Baragash, Al-Samarraie, Alzahrani, and Alfarraj (2019) conducted a meta-analysis that eventually supported the effectiveness of AR technology in learning promotion and in obtaining social, living and physical skills

among students with special needs. Also, Gomez-Puetra, Chiner, Melero-Perez, & Lorenzo (2019) and Alshafeey et al. (2019) illustrated potential advantages of AR for individuals suffering from disabilities and these were self-determination, self-management, guidance, and the promotion of mental and physical disabilities normal living and hobbies. Based on literature dedicated to AR teaching material, positive contributions are provided to the motivation level of students. The study results support those of prior studies in literature, where students that are dyslexic were motivated towards learning in a technology-based environment.

In another related study, Khan, Johnston, and Ophoff (2019) reported that the immersion and interaction features of AR may be the catalyst in the students' learning motivation. Also, basic science lessons are lessons that could assist learners in absorbing diverse range of skills, abilities and engagement. Students with learning disabilities often prefer individual learning styles and as such, AR technology allows them to learn at their pace, while promoting individualized learning approach (Bujak et al., 2013) and improving class outcomes. The obtained significant result in this study is aligned with that reported by Kamarainen et al. (2013) and Lindgren, Tscholl, Wang, and Johnson (2016) who revealed that AR instruction recipient students showed positive outcomes compared to their peers.

Conclusion and Suggestions

In the present study, the obtained findings have implications to the use of learning instruction delivery using technology method and its role in improving motivation, and eventually personal and academic skills success among students with learning disabilities. The study's research questions are significant for researcher and practitioner circles – for the former, it has implications in terms of limited database of interventions for students with special learning disabilities, with the use of AR technology, and for the latter, it has implications as to the most effective instruction method for learning. Both can steer clear of making extrapolation attempts that are known to one population and not to the other without evidence of guidance as to the decisions to be taken. The study specifically examined 6^{th} graders with specific learning disabilities to determine whether the instruction method could enhance their learning motivation. Evidence found showed that students with learning disabilities may benefit from AR instructional methods when learning basic science. In literature, studies of this caliber (e.g., Maccini, Mulcahy, & Wilson, 2007; Stultz, 2017) support the use of AR for special education classes albeit some of them are quite outdated.

The research appeared to be confined to disable students and their exposure to AR technology. Stated clearly, the study refers to students with learning disabilities, and thus generalizability towards all students with disabilities should be carried out with caution. Literature revealed so long as the elements of effective instruction namely, modeling, guided/prompted practice, and instruction, required interactive diagrams, graphics and visual strategies are supported with technology, the instructional modality (AR) did not make a difference. The study results are

expected to contribute to empirical studies on combined instructional AR design in the school context. The results also support individualized and effective academic learning for school students who are deserving of the top effective teaching approaches supported by technology.

This study has two major contributions namely, the examination of effective instruction using AR as a direct method for disabled students and the examination of the AR technology effects on disabled students' motivation, that were largely untouched in literature. The study results recommend that the integration of disabled students into general education classes should involve exposure to several instructional approaches that can generate positive outcomes. It is noteworthy that students with learning disabilities should be provided with the top effective instructional approaches for learning optimization and research and practice should focus on this element. The study findings showed that students' learning is at its best when various instructional strategies are used, specifically those that are technology-assisted. It is thus recommended that both teachers and students select the instruction method suitable and most effective for learning skills, motivation enhancement in the process of learning.

This study has several limitations that have to be considered prior to its extension by future authors, one being the sample size that prevents results generalization to the students' population. Extending the present study sample and experimentation to other students is suggested. Despite the fact that the results indicated the effectiveness of the approach in enhancing the mean scores of motivation levels of students, the experimentation only spanned four weeks and thus, the period should be extended by future studies. This study is also confined in terms of the method used for data collection (self-report measures) as this could contain inflated biases, because of the influence of social desirability. Hence, future studies should examine the objectives using a combined method (quantitative and qualitative). The study can be extended by increasing the sample and period of study to ensure accurate results. The current study conducted an examination of AR technology use in improving the levels of motivation and engagement among 6th grade dyslexic students. The study found AR technology to be effective in realizing positive and promising outcomes. However, further studies are required for the confirmation of results and to provide empirical evidence towards supporting the study variables in the context of disabled students.

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