Promoting Self-efficacy for Students with Special Needs through Augmented Reality

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***Abstract*—Augmented reality technology has a significant influence on the teaching approach provided to students with special needs. This type of technology particularly affects students' level of self-efficacy, and was the premise for conducting the research. In this four-week quasi-experimental study, a pre- and post-test control group design was adopted. 24 students with special needs were randomly assigned to the augmented reality (AR) application group and the control group. Self-efficacy was measured depending on previous studies in a new technological environment. The results showed significant main effects for the AR on students' self-efficacy, as AR group indicated to have higher total score than control group. The paired sample t-test overall mean scores indicated a significant increase in the self-efficacy of the students. For the experimental group, results showed an increase in the mean score of self-efficacy from pre to post-tests. The paired sample t-test overall mean scores indicated a significant, with the differences in the mean scores being −1.694, indicating a considerable increase. This study concluded that AR has significant effects on students with special needs, and that it can undoubtedly contribute to the teaching-learning process.**

***Index Terms*—Augmented reality (AR), special needs, science, self-efficacy**

I. Introduction

Different disabilities have been documented in research [1] but not enough information exists on instructional practices that are used to improve the achievement, learning outcomes, engagement, self-regulation and self-efficacy of the learning of disabled students [1–3]. Therefore, Savelsbergh *et al*. [4, 5] are adjusting the teaching styles and methods to enhance learning outcomes among learners [6]. While there have been several teaching approaches that were utilized to enhance the achievement of students, studies concerning the enhancement of those with special needs and the required interventions are still lacking [4, 7].

Generally, students with special needs, benefit from creative interactive activities, visual presentations, project-based learning and school experiments that focus on the engagement [8]. Furthermore, recent education literature proposed innovative advanced technology as an innovation that could enhance the learning outcomes and achievements of students in both experimental and control groups [4, 9–14]. Developments in technology have extended the teaching and learning boundaries and leading to new delivery modes of courses (e.g., e-learning, virtual lectures and augmented reality (AR) [4, 9, 15, 16]. The current study focuses on augmented reality (AR), a technology with the promising potential of paving the way for new teaching and learning approaches, which aim to increase the achievement and success among students [9, 17].

Numerous studies have highlighted the positive benefit of AR in the 21st century for learners with disabilities [7, 18]. Nevertheless, research focusing on the use of AR interventions for students with disabilities has yet to be extensively conducted as evidenced by the recommendations of [7]. Among the few studies that examined use of AR, it was used successfully in teaching fundamental matching skills and navigation skills [19, 20] for students with intellectual disabilities.

In one study [21], the researchers worked with postsecondary students suffering from intellectual disabilities, where they used AR to teach the vocabulary used in science, while another [22] used AR with students to introduce work-related skills. AR was also used to illustrate ways of identifying emotions [23], and integrated into teaching mathematics to middle school students [7].

The integration of AR into the process of teaching students with special needs is an emerging research field. There is only a small number of published studies on this issue, and research has only recently begun to consider the potential of AR as an instructional technique. More studies are required to examine the effectiveness of AR in helping special needs students [7]. There is a need to explore the extent to which AR may affect and benefit students with special needs when learning new essential skills that would boost their self-efficacy. We hope that the findings of this study will provide information on the effect of AR on the self-efficacy of students with disabilities.

The application of AR technology has been generally found to enhance the experiences of students in distinct learning environments that offer learning activities [24]. Despite the adopted teaching approaches that aim to enhance the learning achievements among students, research dedicated to examining students' attitudes through the use of AR technology is still limited, reporting inconclusive findings regarding the effectiveness of the intervention [4, 7]. Hence, this study primarily aims to enrich the literature concerning the interventions that aim to provide positive learning self-efficacy, specifically in science, for students with special needs through the use of AR, which is a pioneering endeavor and in response to the suggestion of [2, 3].

Literature on AR requires the establishment of an evidence-based approach for teaching students with special needs, and this has been called for by various authors [2, 7, 25]. Therefore, the main aim of this study is to

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test the effectiveness of the application of AR on special needs students for four-weeks, with the aim enhancing the level of their self-efficacy. This objective is achieved by attempting to answer the following formulated research questions:

1) Is there a significant difference between the self-efficacy of students with special needs who learn using an AR approach and the self-efficacy of those learning through traditional approaches?
2) Does the total students mean score have a different self-efficacy level in the pre-test compared to that of the post-test?
3) How do the self-efficacy scores of students in the experimental group compare when considering the results of the pre-test and the post-test?

II. Literature Review

This study is based the theoretical basis of the use of AR on the multimedia learning theory, which explains the advantages of AR in the learning arena [26, 27]. The theory posits that people learn more effectively when the material to be inculcated is presented both in words as well as pictures [28]. In this regard, for the design of multimedia materials to be effective in learning, principles must be applied in a way that enables learners to process both words and pictures. AR is capable of fulfilling such principle by directing and guiding individuals in their learning environment [18], and this makes learning with the assistance of AR more effective compared to other materials (online source/manual source) [26].

A. Augmented Reality for Special Needs Students

The demand for the success of students was at least partially achieved through the introduction of technology into education, but the integration of AR as an assistive technology in the learning process that aims to enhance the learning of students with special needs is still a new territory in literature [7, 10, 25, 29]. Evidently, few studies have focused on the use of AR interventions for students with special needs [7]. In recent times, AR applications have been extensively examined and used to facilitate and integrate individuals with disabilities into the communities they live in [30]. AR applications make this possible through the introduction of mixed environments that allow the combination of actual objects with virtual ones [23]. Essentially, individuals with disabilities as are those who have long-term physical, mental, intellectual or sensory impairments [31]. Such impairments cause barriers in interaction that may prevent individuals from fully participating in society at par with the rest of the individuals without disabilities (p. 1220). A thorough review of literature on the application of AR in special education revealed AR's role in supporting learning among individuals with disabilities when it comes to their self-determination, self-management, self-instruction guidance in the resolution of complex tasks and guidance in different environments [32]. AR technology may also be useful in improving the learning process of students who have special needs [33]. However, using AR to improve the navigation skills of students with intellectual disabilities is still largely untouched [20]. Other studies [21, 23] examined the effectiveness of AR when teaching vocabulary in science courses and emotional recognition. These studies have only begun to examine the potential of AR as a teaching approach, especially among students with special needs, and to date, the number of studies which have investigated AR effectiveness in the same context is still meager [2, 3, 9].

B. Self-efficacy and AR for Students with Special Needs

According to several researchers, virtual reality/augmented reality is capable of facilitating constructive learning through the provision of learner-centered environment, providing a more distinct and flexible experience of learning [34]. More recently, there has been an increasing focus on AR technology with mixed findings. One study [29] looked into the effects of AR activities on the academic achievement, motivation and self-efficacy of 9th graders in a biology course. While studying the different organisms, the experimental group conducted AR activities using tablets, while their control counterparts used standard curriculum-based activities. No significant difference was found between the achievements of the two groups, However, the experimental group scored higher in motivation and self-efficacy compared to the control group. The study concluded that use of AR activities enabled students to visualize and understand abstract concepts, which enhanced their motivation and self-efficacy levels. In a similar study, AR technology was integrated into the observation of plants among third graders and learning outcomes were measured with the help of Bloom's cognitive levels [35]. Results demonstrated higher scores in analysis were obtained by the experimental group who observed plants via AR in comparison to their control counterparts. The authors concluded that the learning material that was supported by AR had a significant role in enhancing the cognitive capabilities of the students, and in allowing them to scaffold knowledge effectively. In the same way, the effect of AR application was investigated on students with learning disabilities when learning scientific topics in Malaysia [36]. The study revealed the AR application helped increase students' motivation and encouraged them become more active and interested in the learning process. Another study explored the impact of AR technology in enhancing students' academic achievement and their knowledge retention [37]. Three instruments were used (academic achievement test, motivation scale of augmented reality and AR acceptance test) to collect data from the participants. The results revealed that AR positively enhanced both the academic achievement of the students and their knowledge retention.

The above-mentioned studies examined AR effects on science-related courses, but largely focused on the achievement and motivation level of students without special needs. Therefore, the present study attempts to examine the effect of AR on the self-efficacy of students with disabilities.

III. Method

This study was a quantitative quasi-experimental study that used a pre- and post-test with experimental and control

groups, the experimental group received an AR technology assisted learning method. This study is a survey study, and as such, it determines the characteristics, views, attitudes, abilities, beliefs, thoughts and expectations of the respondents [33, 38–40]. The primary objective of survey studies is to present the case that is linked to the topic as described by Büyüköztürk *et al*. [41].

In this study, the study group consisted of 24 grade six male students in a public primary school. All participants had special needs (learning, reading and writing), faced different challenges, and were supported with instructional technology experience. The students were identified using an approach known as purposive sampling, which bases the selection of the sample on the purpose of the study [38]. The students were categorized into two groups (experimental group and control group). The students of both groups underwent the same procedures, except for the use of AR activities in the experimental group as shown in Fig. 1. The control group, on the other hand, was taught in a traditional method, using a textbook for explaining ideas and answering questions. The study was completed over the course of four weeks, divided into four lessons. A pre-test and post-test were given before and after the intervention. The students who participated in this study were between the ages of eleven and thirteen.

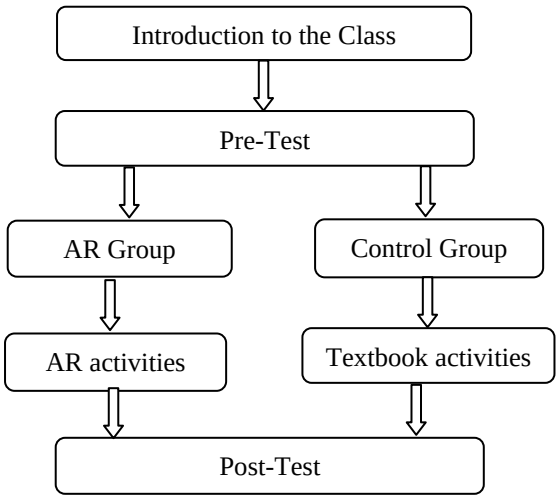

Fig. 1. Experimental procedures.

Before and while collecting the data for the study, ethical considerations were applied. The researchers got all the necessary permits from the schools, they also explained the purpose of the study and kept the information confidential. The collection tools utilized in this study include demographic variables and a self-efficacy test. First, the self-efficacy scale was adopted from study [42, 43], which was guided by conceptualization of self-efficacy. This scale determines the level of AR knowledge that the students with special needs have. Several items were used in the scale, gauged on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Examples of the items include: "I usually teach myself the AR tool features", "I feel confident explaining to others how to use the AR technology", and "I am fairly confident in using AR features". The scale's internal consistency reliability was found to be 0.91, which supports its validity and reliability as a tool for self-efficacy assessment for students with special needs. Finally, in this study, descriptive statistics were carried out to identify students' characteristics. The t-test and ANCOVA test were conducted to examine the significant differences between the two groups (the AR group and the control group) regarding the students' self-efficacy.

IV. Results

In this study, t-tests were carried out, particularly ANOVA and ANCOVA, to examine the differences in the groups' pre- and post-test results in terms of overall self-efficacy. Specifically, ANOVA was used to obtain self-efficacy mean scores, and the study used a sample t-test to examine the differences in the overall self-efficacy of the two groups prior to the start of the learning activity. However, the pre-test results showed significant differences between the two groups. Whereas ANCOVA was used to obtain pre-test scores as covariates to account for the differences in the post-test mean scores between the two groups. Table I shows significant differences between the results of the experimental group and the control group on the self-efficacy pre-test. Upon close inspection of Table I of the t-test's (t = 3.046, p = 0.006 < 0.05) mean and standard deviation scores of the two groups, it was noted that the result is significant, and that the experimental group indicated higher total self-efficacy (M = 2.47, SD = 0.642), compared to its control counterpart (M = 1.86, SD = 0.264).

TABLE I: T-Test Results between Groups on Self-efficacy

Variable	Mean	SD	t-value	Sig.
Self-Efficacy				
AR Group	2.47	0.642	3.046	0.006
Control Group	1.86	0.264		

In order to answer question one "Is there a significant difference between the self-efficacy of students with special needs who learn using an AR approach and the self-efficacy of those learning through traditional approaches? ANCOVA was conducted on the post-test results to check if there are any differences between the two groups. ANCOVA analysis was also used to control the noted differences between the two groups in the pre-test post-tests, and the results showed significant main effects for the group with the dependent variable, in that there were significant differences in the experimental group with the following results (MS = 4.744, F = 26.237, p = 0.000 < 0.05) as shown in Table II. Upon close inspection of the mean and standard deviation scores of the two groups, it was noted that the experimental group indicated a higher total self-efficacy (M = 4.16, SD = 0.460), compared to its control counterpart (M = 3.30, SD = 0.437).

To answer question 2, a paired sample t-test was conducted on the students' self-efficacy mean scores in the pre and post-tests. For the total sample, the overall self-efficacy in the pre-test mean was (M = 2.16, SD = 0.573), while the post-test mean was (M = 3.73, SD = 0.621). Thus,

there is an increase in the mean score of self-efficacy from the pre to post-test. The paired sample t-test overall mean scores indicated a significant *t* (8.316, *df* = 23, *sig* 0.000), with the differences in the mean scores being 1.569, indicating a significant increase of ($p < 0.05$) in the self-efficacy of the students as shown in Table III.

To answer question 3, a paired sample t-test was conducted on the students' self-efficacy mean scores in pre and post-tests. For the experimental group, results showed that the overall self-efficacy in the pre-test mean was (Mean= 2.47, *SD* = 0.642), while the post-test mean was (*M* = 4.16, *SD* = 0.460). Thus, there is an increase in the mean score of self-efficacy from pre to post-tests. The paired sample t-test overall mean scores indicated a significant *t* (−7.249, *df* = 11, sig 0.000), with the differences in the mean scores being −1.694, indicating a significant increase of ($p < 0.05$) in the self-efficacy of the students as shown in Table IV.

TABLE II: ANCOVA RESULTS BETWEEN GROUPS ON SELF-EFFICACY POSTTEST

Variable	df	Mean Square	F	p-value
Self-Efficacy				
Corrected Model	2	2.544	14.068	0.000
Intercept	1	28.526	157.769	0.000
Group	1	4.744	26.237	0.000
Pre-test	1	0.638	3.530	0.074
Error	21	0.181		
Total	24			
Corrected Model	23			

TABLE III: PAIRED SAMPLE T-TEST RESULTS FOR SELF-EFFICACY

Variable	t	df	Sig.2-tailed
Self-Efficacy Pre-Post	8.316	23	0.000

TABLE IV: PAIRED SAMPLE T-TEST RESULTS FOR SELF-EFFICACY

Variable	t	df	Sig.2-tailed
Self-Efficacy Pre-Post	−7.249	11	0.000

V. DISCUSSION

This study examined the effectiveness of AR application on the self-efficacy of 24 sixth graders with special needs. The findings of the study indicated that students with special needs showed significantly improved self-efficacy following the application of AR in learning science. This indicates that AR technology can be used as an effective tool to teach students with special needs. The levels of self-efficacy achieved by students using AR are notably higher than those achieved when traditional approaches are applied in classrooms. Students with special needs develop positive self-efficacy in a learning environment supported by technology. This significant result may be attributed to the fact that students with special needs are generally affected by the use of technology in learning, particularly when considering their cognitive and effective skills. This result aligns with Doğan [44] which concluded that extracurricular activities enriched by technology positively influence the cognitive and physical development of students. In the same line of findings, Yalçınkaya [45] concluded that students with mild mental disabilities show improved social skills in a computer-supported environment with a web-based distance education system. In the latter study, students participated in technology-related activities such as drawing on a drawing tablet and shooting short videos within the planned framework. In the present study, the significant effect of AR technology on self-efficacy indicates the effectiveness and potential of AR in supporting students' self-learning, particularly students with special needs. Also, Erbas and Demirer [29] came to the conclusion that AR activities play a key role in students' learning by giving them the opportunity to observe and examine organisms and their structures, a task that is normally extremely difficult under traditional teaching conditions. Technology tools such as AR technology provide advantages as a support tool in the process of learning and teaching [46–50]. The positive significant result found in this study may also be attributed to the fact that AR technology is capable of facilitating students' learning and understanding of the material through the activities it provides. Moreover, AR can upgrade a given learning activity from being simple and straightforward to one that is interactive for students with special needs. The study's results showed that the experimental group had significant differences in self-efficacy after being exposed to AR technology, confirming the impact of AR on the self-efficacy of students (e.g., [10, 32]. The study concluded that AR activities enhance students' motivation, self-efficacy and their ability to visualize and understand abstract concepts.

The introduction of AR technology into the educational scene has many advantages for students. One such advantage is providing students with the possibility of improved educational achievement through providing instant feedback with real-time interaction and control over the process of learning [24, 51]. More recently, it has been evidenced that technological development, including AR, has been used to enhance the skills of students who require special education. The results showed that AR is effective in providing such students with real-life experiences, enhancing their eagerness and enthusiasm to learn, and boosting their level of readiness and interest in the subject. According to [7, 50–55], the use of technology tools and video-based instruction through AR is effective in improving problem-solving skills when dealing with mathematics, specifically for students who require special education. Real-life experiences are essential for students with special needs in order for them to learn and acquire basic skills and knowledge in the classroom, and this can be achieved through the use of AR. Thus, it is clear that the study results contribute to literature on the use of AR for the purpose of enhancing the self-efficacy of students with special needs.

VI. Conclusion

The study results support the premise that delivering education with the help of instructional technology leads to enhanced learning and success in acquiring academic skills among students with special needs. Therefore, the research questions formulated in this study have implications on the benefit from the effective intervention of AR technology as one of the most effective instructional methods in the education of students with special needs. Although the benefit of technology in enhancing students skills, literature highlighted that students with special needs have been largely excluded from these studies, literature highlighted that students with special needs have been largely excluded from these studies. Therefore, this study findings are expected to contribute to literature on the use of AR technology in the education of school students. The results of this study could be held as evidence of the importance of providing effective academic instruction for students with disabilities who are a minority that require and deserve the best teaching methods supported by technology. This study came out with two distinct findings: effective instruction of students with disabilities is achieved through the use of AR as a direct method of teaching, and that AR technology has positive effects on the self-efficacy of students with special needs. Therefore, the study findings support the notion that the best learning for students with disabilities is achieved through different instructional strategies, supported by technology. In summary, the study succeeded in achieving positive outcomes. This study recommends future studies to confirm the findings, and to provide further support to improve the learning process of students with special needs.

VII. Limitations and Suggestions

This study has its limitations that should be taken into consideration by future authors in the same line of research. First, the study's sample size prevents the generalization of the results to the general population of students with special needs. The results of this study reflect the perception of the study participants and thus, the study sample for future studies must be extended and other students should be included in the experiment. The results showed an improvement in the students' self-efficacy mean scores, but the study period was only limited to four weeks. Therefore, future studies need to extend the period of experimentation. Another limitation lies in using self-reported measures as the data collection method, since it could be riddled with exaggerated biases due to the influence of social desirability. As such, future researchers are advised to achieve the study objectives through the use of mixed methods (quantitative and qualitative).

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Literature: Muteeb Alahmari, Malek Jdaitawi, Mohammad Alzahrani conducted review literature; Marwa Kholif, Nahed Nasr, and Reham Ghanem conducted the research methodology; All researchers contributed to the results and discussion sections; all authors had approved the final version.

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