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THE EFFECTIVENESS OF A PROGRAM BASED ON AUGMENTED REALITY ON ENHANCING THE SKILLS OF SOLVING COMPLEX PROBLEMS AMONG STUDENTS OF THE OPTIMAL INVESTMENT DIPLOMA

Marwa Yasien Helmy Elbyaly[1] and Abdellah Ibrahim Mohammed Elfeky[2*]
[1]Centre for Sharia, Educational and Humanities Research, Najran University, Najran, Saudi Arabia,
[2]Department of Curriculum and Instruction, College of Education, Najran University, Najran, Saudi Arabia
E-mails: [1]Marwa.mohamed1@spe.kfs.edu.eg / [2]abdalah.elfeqi@spe.kfs.edu.eg

ABSTRACT
There are few studies related to programs based on augmented reality in the educational field, so measuring the effectiveness of augmented reality technology programs on the educational environment in higher education needs to be explored. Therefore, this study aimed to know the effectiveness of a program based on augmented reality on enhancing the skills of solving complex problems for the students of the optimal investment diploma. The participants were 60 participants from the Optimal Investment Diploma students at the College of Education at Najran University. They were randomly divided into two groups (control and experimental), each group included 30 participants. So that the control group studies the course "Issues and Problems in Teaching Digital Skills" in the traditional way, and the experimental group studies the same course through a program based on augmented reality. And 7 tasks of the Micro-DYN test battery were used as a tool to achieve the objective of the study. The study found the effectiveness of the program based on augmented reality in enhancing the skills of solving complex problems, mainly the acquisition and application of knowledge.

Keywords: augmented reality technology; solve complex problems; the acquisition of knowledge; knowledge application; optimal investment

INTRODUCTION
Augmented reality is an emerging technology that uses mobile devices, smartphones, and tablets that enable participants to interact with digital information embedded in the physical environment (Ahmed, Alharbi, & Elfeky, 2022; Dunleavy, 2014). It is a new technology that can be applied in the educational field (A. I. M. Elfeky & Elbyaly, 2021a). It enables users to enrich the real world with virtual content (Tesolin & Tsinakos, 2018). Augmented reality technology enhances students' experiences in real-world environments by dynamically interlacing digital materials with the real-world environment (A. I. M. Elfeky & Elbyaly, 2019; Masada, 2017; P.-H. Wu, G.-J. Hwang, M.-L. Yang, & C.-H. Chen, 2018); Information in virtual reality corresponds to real-world objects in or near the current location (Sandberg, 2018). On the other hand, highly augmented reality contains virtual information that enriches the real world and is frequently accessed (A. I. M. Elfeky & Elbyaly, 2021b; Wu, Lee, Chang, & Liang, 2013). In contrast to virtual reality, which completely immerses the user's senses in a virtual environment (M. Y. H. Elbyaly & Elfeky, 2022; A. I. M.

Elfeky, Alharbi, & Ahmed, 2022). The focus of the learning task interaction is performed in the real world rather than in the virtual environment (McGrath et al., 2018). Real-world experiences provide valuable learning opportunities without isolating the learner from their natural environment (Alharbi, Elfeky, & Ahmed, 2022; Almalki & Elfeky, 2022; Rabia M Yilmaz, 2016). In other words, augmented reality is closer to the real world and virtual reality is closer to a purely virtual environment. Augmented reality technology should essentially combine real and virtual objects; To be interactive in real time, and to record virtual objects within a real 3D environment (Pidel & Ackermann, 2020). Allowing AR technology to enhance a user's perception of reality by inserting virtual content into the real world and playing it in the same presentation and in real time (Elbyaly & Elfeky, 2021; Tagaytayan, Kelemen, & Sik-Lanyi, 2018). Augmented reality technology can transform 2D images into 3D virtual objects and animations, providing an engaging and fun way to learn (Rabia Meryem Yilmaz & Goktas, 2017). In addition, augmented reality technology is used for various purposes; Such as large-scale commercial gaming, supporting maintenance workers with schematics of machines or buildings, communication with virtual avatars, and medical diagnostics (Lukosch, Billinghurst, Alem, & Kiyokawa, 2015). Augmented reality technology consists of three main components: immersion, participation and interaction, while immersion is associated with a sense of being in the environment. Participation correlates with the degree of motivation to engage the person in a particular activity. Interactivity (ranked third) refers to the ability of a computer to detect user inputs and instantly modify the virtual world and actions according to these inputs (da Silva, Klein, & Brandao, 2017; Masadeh & Elfeky, 2016). Since AR technology is a particularly attractive technology, which is one of its important characteristics, it is believed that AR encourages learners to make use of it (Elfeky, 2017; Rabia Meryem Yilmaz & Goktas, 2017). Several studies have explored the effectiveness of using AR technology for complex tasks (Lukosch et al., 2015). Poelman, Akman, Lukosch, and Jonker (2012) show that the use of AR technology supports mutual understanding, leads to consensus, and supports hypothesis testing. A study by Wu, Hwang, Yang, and Chen (2018) showed that AR technology can improve performance time and mental effort on collaborative design tasks. Furthermore, augmented reality technology helps learners engage in real-world exploration, and virtual objects such as texts, videos, and images are complementary elements for learners to conduct investigations in real-world surroundings (Elfeky & Elbyaly, 2017; Wu et al., 2013). This technology also enhances interpretation skills, problem-solving, creative thinking, and motivation (Küçük, Yýlmaz, & Göktaþ, 2014). Based on the foregoing, the current study attempts to take advantage of the increased computing power in smart phones and use the technology of augmented reality based on images to develop a system that presents educational videos using a printed image for some problems and issues in teaching digital skills. A new part of the psychology of thinking and problem solving has appeared under the title of solving complex problems (Elfeky & Elbyaly, 2016; Funke, 2010). Solving complex problems has attracted an increasing amount of attention in recent years (Kretzschmar, Neubert, Wüstenberg, & Greiff, 2016). Complex cognition deals with all the mental processes that an individual uses to extract new information from certain information in order to make decisions, solve problems, and plan actions (Funke, 2010). In

addition, Problem-solving is the foundation of many undergraduate education processes and is therefore seen as a primary educational goal. It can be said that problem solving is a self-directed mental process that requires users to constantly acquire knowledge (Limbu, Maquil, Ras, & Weinberger, 2015). On the other hand, a complex problem can include a number of objectives such as controlling the fullness of the fabric by creating ensembles, and enhancing the elasticity of the garment through the combination of stitches, pattern, fabric, and threads, which must be taken into account in coordination and sometimes given priority to find a suitable solution. Complex problem solving involves successfully interacting with problems that change dynamically over time. Accordingly, solving complex problems includes a set of abilities such as: the ability to gain knowledge about a complex system by exploring it (knowledge acquisition), and the ability to correctly apply the acquired knowledge to reach the goal state (knowledge application) (Funke, 2001; Greiff, Niepel, Scherer, & Martin, 2016). In other words, it can be said that solving complex problems is an individual skill that has gained importance in educational and psychological research. Because it requires skills that go beyond routine thinking (Greiff et al., 2016). Moreover, complex problem-solving tasks require the performance of more complex mental processes than intelligence tests do, such as actively interacting with a problem to gain knowledge about the problem environment (M. Stadler, Becker, Gödker, Leutner, & Greiff, 2015). In general, complex problems of reducing the barrier between a given starting state and the intended goal state are solved with the help of cognitive activities and behavior (Seel, 2011). The results of some studies showed that solving complex problems is affected by many other variables, for example students' use of an exploration strategy that requires a series of multiple interventions showed better performance in solving complex problems (Elfeky, 2019; Kretzschmar et al., 2016) (Kretzschmar et al., 2016). The use of the Innovative Game Design course has also shown significant improvements in learners' complex problem-solving skills, particularly in terms of system exploration, system knowledge, and system application. There was also a statistically significant change in learners' interest in solving complex problems after attending a game design course program (Akcaoglu, Gutierrez, Hodges, & Sonnleitner, 2017).

RESEARCH PROBLEM

The problem of this study arose due to the noticeable decrease in the skills of solving complex problems among students of the optimal investment diploma, which hinders the achievement of the objectives of the course "Issues and Problems in Teaching Digital Skills". Augmented reality-based programs have great potential in achieving educational goals (Bower, Howe, McCredie, Robinson, & Grover, 2014; Cai, Chiang, Sun, Lin, & Lee, 2017; Plunkett, 2019). Researchers and experts who encourage the use of augmented reality-based programs believe that it provides students with more opportunities to be more knowledgeable and skilled (Elfeky, Masadeh, & Elbyaly, 2020). In addition, programs based on augmented reality are attractive to students, and attractiveness is considered the most important characteristic of augmented reality. Programs based on augmented reality encourage students to benefit from it (Rabia Meryem Yilmaz & Goktas, 2017). Problem solving is the foundation of many higher education processes and is therefore seen as a primary educational goal. It can be said that solving complex problems is a

self-directed mental process and requires users to constantly acquire knowledge (Limbu et al., 2015). Solving complex problems is of great value in the skills of the "Issues and Problems in Teaching Digital Skills" course, which provides many opportunities to make significant progress in solving many issues and problems that we encounter in teaching digital skills. Hence, complex problem solving is seen as a critical factor in making a difference in achieving the objectives of this course (A. I. M. Elfeky & Masadeh, 2016; Hwang, Sanders, & Damhorst, 2014). However, little is known about whether AR-based programs are effective in enhancing complex problem-solving skills in Optimal Investment Diploma students. Based on the foregoing, the problem of this study can be formulated in an attempt to identify the effectiveness of a program based on augmented reality on enhancing complex problem-solving skills for students of the Optimal Investment Diploma.

RESEARCH OBJECTIVE

The main objective of this study is to explore the effectiveness of a program based on augmented reality on enhancing complex problem-solving skills among students of the Optimal Investment Diploma.

RESEARCH IMPORTANCE

The following are projected benefits from the study's findings:

- Achieving educational goals by taking advantage of digital transformation in the educational process.
- Achieving the objectives of the course "Issues and Problems in Teaching Digital Skills" by employing a program based on augmented reality technology.
- Developing complex problem-solving skills in the "Issues and Problems in Teaching Digital Skills" course.

RESEARCH LIMITS

Objective Determinants

The current study is limited to exploring the effectiveness of a program based on augmented reality in enhancing the skills of solving complex problems in the course "Issues and Problems in Teaching Digital Skills" for students of the Optimal Investment Diploma.

Human Determinants

The sample of the current study is limited to students of the optimal investment diploma in the Department of Curricula and Teaching Methods.

Temporal Determinants

The investigation was carried out in the first semester of 2022.

Spatial Determinants

The spatial determinant of this study is the College of Education, Najran University, Saudi Arabia.

Research Terms

Augmented Reality Technology

Technology utilizing augmented reality is brand-new, user-friendly, and intriguing. It is described as a virtual item created by a computer using the actual world that a mobile device, such as a phone or tablet, observes (Fazel & Izadi, 2018; Hsieh & Lee, 2018). The goal of the current project is to increase students' hand embroidery skills and help them tackle challenging tasks in the "Hand Embroidery" course by using procedurally augmented reality, which is defined as a means to enrich the real environment by superimposing additional virtual information.

Solve Complex Problems

Solving complex problems is a process that involves successfully interacting with problems that change dynamically over time. Accordingly, solving complex problems includes a set of abilities such as: the ability to gain knowledge about a complex system by exploring it (knowledge acquisition), and the ability to properly apply the knowledge gained to arrive at The goal state (knowledge application) (Funke, 2001; Rudolph, Greiff, Strobel, & Preckel, 2018). Solving complex problems procedurally in the current study is defined as a process that includes a number of objectives such as controlling the fullness of the tissue by creating groups. The flexibility of the garment is enhanced by the combination of stitches, pattern, fabric and threads, which must be considered in coordination and sometimes given priority to find a suitable solution.

METHODOLOGY

The methodology of the current study was to use the semi-experimental approach, in order to find out the effect of the independent variable (a program based on augmented reality) on the dependent variable (complex problem-solving skills), and as a result, the design shown in Table (1) was used using two groups (control and experimental).

Table (1): Design of the study

	Treatment	**Post-test**
Control Group	Traditional way	Micro-DYN test battery
Experimental Group	Augmented reality technology	

RESEARCH TOOL (MICRO-DYN TEST BATTERY)

This study included a tool, the Micro-DYN test battery, and its description is as follows:

Using (7) tasks of the Micro-DYN test battery developed by Fischer, Greiff, and Funke (2011), the students' skills in solving complex problems were assessed. Tasks based on the Micro-DYN test battery have consistently demonstrated their high reliability and validity (Greiff et al., 2016; Mainert, Niepel, Murphy, & Greiff, 2019; Meißner, Greiff, Frischkorn, & Steinmayr, 2016; M. J. Stadler, Becker, Greiff, & Spinath, 2016). It should be noted that the test relied entirely on the computer, where each task consisted of two phases (the exploration phase and the control phase). During each phase, the participants had to deal with three variables that were evaluated to measure

each of the two dimensions to solve complex problems. That is, the acquisition of knowledge and the application of knowledge. Then the scores of each student in both dimensions are added to form the total score of the students. Complex problem solving was fully assessed using the computer-based Micro-DYN test (Fischer, Greiff, & Funke, 2011). In order to familiarize the participants (study sample) with the program for the Micro-DYN test and its tasks. Detailed instructions, including a trial task, were provided to participants before the start of the assessment. Afterwards, the participants' dealt with (7) Micro-DYN tasks to assess their complex problem-solving abilities. In general, learners had to find relationships between a variety of variables, where at least three input variables were associated with two/three output variables. Initially, the participants were not aware of the relationships between the variables. The output variables also changed gradually and dynamically in some tasks without addressing the input variables, as this is a feature of complex problems. For example, in the "Micro-DYN Wind Power Station" mission, various technical components (X, Y, and Z) can incrementally affect plant noise and maintenance costs (see Figure 1). Because the relationship between the input and output variables in the station is not clear at task initiation, learners need to actively participate in the task control inputs (eg, if the learner increases control over variable X, station noise may be reduced, but only when they interact Learned with testing, this relationship becomes apparent). The learners' task was twofold: first, the learners were asked to acquire knowledge of the structure of the problem (i.e. acquisition of knowledge) to freely explore the task, recognize relationships and draw connections for three minutes between the input and output variables (eg variable X and noise). Secondly, the control phase whereby learners have to achieve certain goals by applying that knowledge (ie knowledge application), after which they are required to reach specific performance thresholds within a one and a half minute time frame (e.g. noise and cost reduction). In addition to the "wind power plant," participants were given six more Micro-DYN tasks with different contextual settings after receiving detailed instructions (feeding a cat, using fertilizer to grow vegetables, logistics for transporting goods by road, gardening, setting rules for a new board game, and farming Forests).

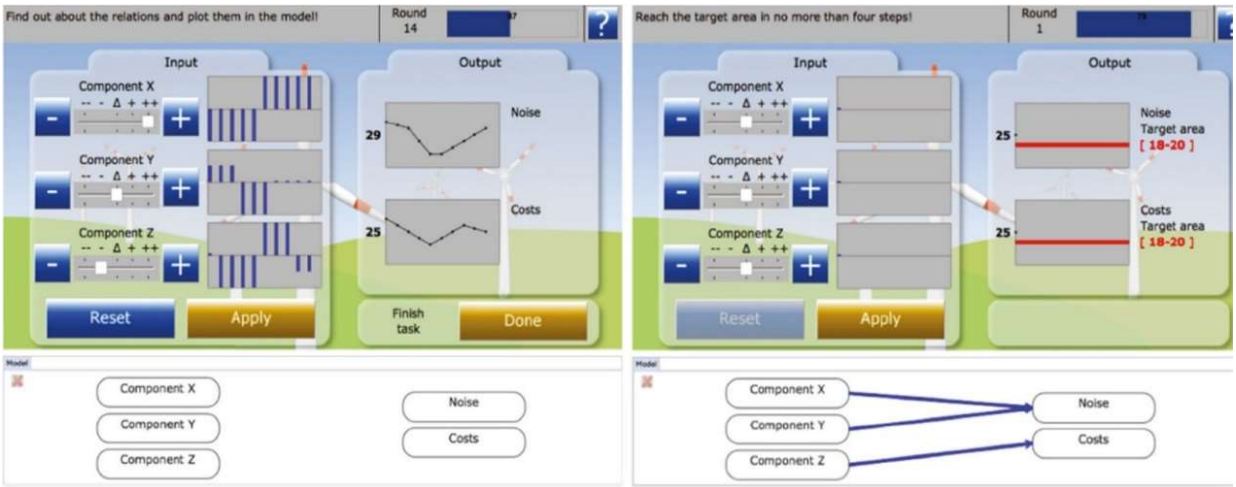

Figure (1). The Micro-DYN Wind Power Station mission (Mainert et al., 2019; Wüstenberg, Greiff, & Funke, 2012)

Micro DYN Score: After excluding the Micro-DYN Wind Power Station mission that served as a practical introduction. The remaining six tasks are scored in relation to the two basic phases of knowledge acquisition and knowledge application (Mainert et al., 2019). In the first stage: a full point (1 = true) is given for knowledge acquisition if all relationships are drawn completely and correctly between variables (such as variable X and noise) and otherwise (0 = false) for incorrect relationships. In the second stage: a full point (1 = true) is given for the application of knowledge if all target values for the output variables (such as noise reduction and cost reduction to the target) are obtained and otherwise (0 = false) for not obtaining the desired target.

RESEARCH SAMPLE

The sample of this study consisted of (60) participants from the Optimum Investment Diploma students at the College of Education at Najran University during the first semester of the year 2022. The average age is 19 years, and the standard deviation is 3.28. They were randomly divided into two groups (control and experimental), so that each group consisted of 30 participants. Where the experimental group studied the course "Issues and Problems in Teaching Digital Skills" through a program based on augmented reality, and the control group studied the same course in the traditional way.

RESEARCH VARIABLES

- The independent variable: Augmented reality technology.
- Dependent variable: Solve complex problems.

EXPERIMENTAL PROCESSING MATERIAL

Because they put the student in a genuine social and physical context, AR-based programs largely align with my theory (constructivism and topical learning) (Dunleavy & Dede, 2014). Programs that use augmented reality are also consistent with constructivist learning theories, which hold that students may direct and oversee their own learning through active engagement in both virtual and physical contexts. The experimental group was given an explanation of the difficult problem-solving techniques contained in the paper book of the course "Issues and Problems in Teaching Digital Skills" using an augmented reality software. After considering a number of instructional design methods, a collection of suggested actions that can help this course's goals are developed. The augmented reality-based program that teaches these skills to the participants in the experimental group was created using the Aurasma application with educational videos, which is also the most extensively used and well-liked of the augmented reality applications (Carmigniani et al., 2011; Elbyaly, 2016; Elbyaly & El-Fawakhry, 2016). It utilizes a smartphone camera, has an improved user interface, and is a free software for iOS and Android users. A program gives students flexibility. Where a video with the same size as the image replaces the image of the difficulties found in the paper copy of the course book for "Issues and Problems in Teaching Digital Skills." The app had to be launched by participants in the experimental group once they had downloaded it from the Google Play or Apple Store. Next, you click. Continue Learning This Research-Developed Course and Share In the experimental group, each participant is required to point their smartphone camera towards the illustration of the issue in the paper book. To understand

how to solve complex problems like this one, a video with the solution is displayed. The experimental group's participants can easily and affordably review the specifics of each sophisticated problem-solving skill related to the challenges of teaching digital skills through the software based on augmented reality. On the other hand, the control group participants' complicated problem-solving abilities are strengthened in the classroom (by projecting them there) with the use of instructional DVDs comparable to those given to the experimental group.

STATISTICAL PROCESSING

To analyze the data collected to answer the study question, Confirmatory Factor Analysis (CFA) was used using AMOS software to describe indicators of two latent variables of complex problem-solving skills, i.e. knowledge acquisition and knowledge application.

RESULTS

To answer the main study question; To prove whether the use of data analysis technology has an impact on the development of complex problem-solving skills among female students, Confirmatory Factor Analysis (CFA) within the Structural Equation Model (SEM) was used as a measurement model for latent variables. Two dimensions of complex problem solving (i.e. knowledge acquisition and application) were considered as latent factors/variables, with six scores attached to each dimension. All the statistics for the measurement model were fit as RMSEA = .043, PRATIO = .993, CFI = .979. Thus, the model adequately fits the extracted data (Alanzi & Alhalafawy, 2022b; Alshammary & Alhalafawy, 2023; Alzahrani, Alshammary, & Alhalafawy, 2022; Greiff et al., 2016). Figure (2) presents these statistics:

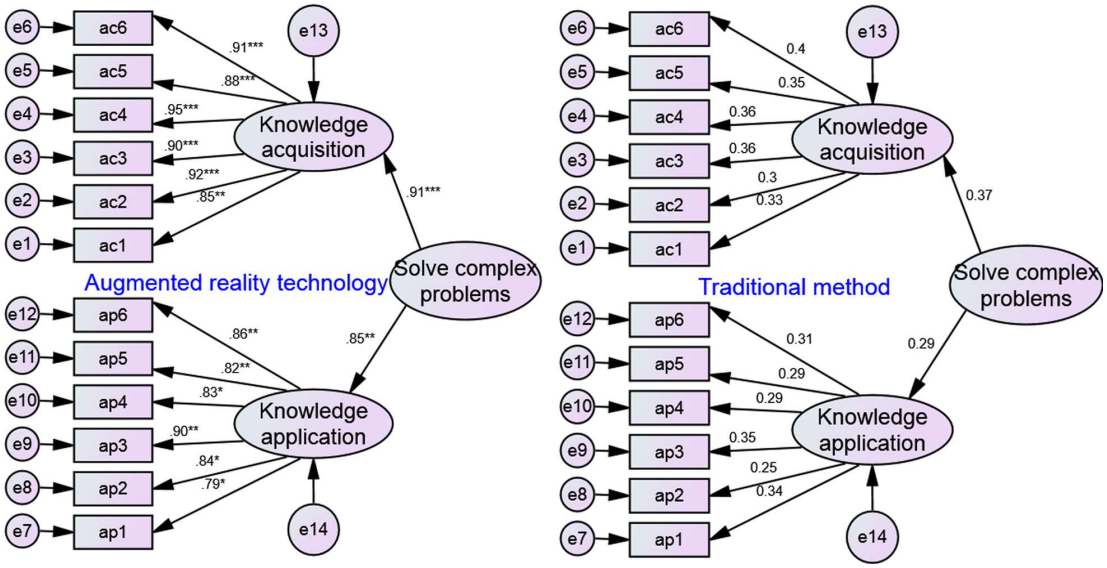

Figure (2). Confirmatory Factor Analysis (CFA) for the acquisition and application of knowledge to solve complex problems; ac(1:6) = acquiring knowledge for the task, ap(1:6) = applying knowledge.

Note: *p ≤ 0.05, **p < 0.01, ***p < 0.001

Figure two shows that the first task of the Micro-DYN test battery for the experimental group, knowledge acquisition was positively related to AR technology (ß = .85, p < 0.01). In addition, knowledge application was positively related to AR technology (ß = .79, p < 0.05). While knowledge acquisition and application were less correlated in the control group (ß = 0.33, p = 0.17; ß = 0.34, p = 0.26), respectively. In the second task, both knowledge acquisition and knowledge application were also positively associated with AR technology in the experimental group (ß = 0.92, p < 0.001; ß = 0.84, p < 0.05), respectively; While knowledge acquisition and application was less correlated in the control group (ß = 0.30, p = 0.09; ß = 0.25, p = 0.11), respectively. Moreover, in the third task, both knowledge acquisition and knowledge application were positively associated with AR technology in the experimental group (ß = 0.90, p < 0.001; ß = 0.90, p < 0.001), respectively; While knowledge acquisition and application was less correlated in the control group (ß = 0.36, p = 0.15; ß = 0.35, p = 0.19), respectively. Figure two also shows that for the fourth task, the acquisition and application of knowledge were positively related to AR technology in the experimental group (ß = 0.95, p < 0.001; ß = 0.83, p < 0.05), respectively; While knowledge acquisition and application was less correlated in the control group (ß = 0.36, p = 0.21; ß = 0.29, p = 0.16), respectively. Besides, in the fifth task, both the acquisition and application of knowledge were positively associated with AR technology in the experimental group (ß = 0.88, p < 0.001; ß = 0.82, p < 0.05) respectively; While knowledge acquisition and application was less correlated in the control group (ß = 0.35, p = 0.25; ß = 0.29, p = 0.22), respectively. Finally, in the sixth task, both the acquisition and application of knowledge were positively related to AR technology in the experimental group (ß = 0.91, p < 0.001; ß = 0.88, p < 0.001), respectively; While knowledge acquisition and application was less correlated in the control group (ß = 0.40, p = 0.32; ß = 0.31, p = 0.26), respectively. By comparing the results of the students in the experimental and control groups, it can be seen that the complex problem-solving skills (acquiring and applying knowledge) of the students who learned with augmented reality technology were better than the skills of their colleagues in the control group, and thus the study answered the main question.

DISCUSSION

This study mainly aimed to investigate the effectiveness of a program based on augmented reality on enhancing complex problem-solving skills among students of the Optimum Investment Diploma. The results related to the study question confirm that the program based on augmented reality was effective in enhancing the skills and solving complex problems of optimal investment diploma students participating in the experimental group. In addition, the average scores of the participants in the experimental group who learned through the program based on augmented reality technology was higher than the average scores Control group participants who were taught in a classroom with instructional video support. That is, this study highlights the added value of programs based on augmented reality in enhancing complex problem-solving skills of learners in the experimental group. This is largely because well-designed AR-based programs can help students relate the task to the real world and create new meanings for them (Alanzi & Alhalafawy, 2022a; Alzahrani & Alhalafawy, 2022; Wu et al., 2013). This result also confirms that programs based on augmented reality are a very flexible tool that can be used to achieve different goals in

different educational environments if applied well and integrated (Diegmann, Schmidt-Kraepelin, Eynden, & Basten, 2015). In other words, the use of this technology had a significant impact because it provided students with high levels of independent thinking, creativity, and critical analysis (Bower et al., 2014). Augmented reality stimulated and excited the participants in the experimental group by creating a distinct learning environment in which they did not feel bored. When programs based on augmented reality are properly designed for educational purposes, this can stimulate the authentic practice of skills (Schrier, 2006). In addition, the ability of programs based on augmented reality to change images into moving objects once participants look at them using their smartphone cameras. Or tablets were also interesting and attractive to learn better. In other words, augmented reality technology has positive potential and advantages that can be adapted in education (Saidin, Halim, & Yahaya, 2015).

RECOMMENDATIONS

Following our analysis of the study's findings, we recommend the following:

- Preparing instructors to use augmented reality-based instructional software.
- Use a variety of other technology products to improve the solving of complex issues.
- Interest in learning how to solve complex problems in various courses and at different educational levels.

SUGGESTED RESEARCH

Given the research issue, the following recommendations might be made:

- To confirm the success of using programs based on augmented reality in other environments, we recommend conducting similar research and studies in other educational stages.
- Conducting more research and studies to develop complex problem-solving skills using virtual reality.
- Using the project method to conduct studies to develop complex problem-solving skills for detection.

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REFERENCES

Ahmed, E. S. A. H., Alharbi, S. M., & Elfeky, A. I. (2022). Effectiveness Of A Proposed Training Program In Developing Twenty-First Century Skills And Creative Teaching Skills Among Female Student Teachers, Specializing In Early Childhood. Journal of Positive School Psychology, 4316-4330.

Akcaoglu, M., Gutierrez, A. P., Hodges, C. B., & Sonnleitner, P. (2017). Game design as a complex problem solving process Handbook of research on serious games for educational applications (pp. 217-233): IGI Global.

Alanzi, N. S. A., & Alhalafawy, W. S. (2022a). Investigation the Requirements for Implementing Digital Platforms during Emergencies from the Point of View of Faculty Members: Qualitative Research. Journal of Positive School Psychology, 6(9), 4910-4920.

Alanzi, N. S. A., & Alhalafawy, W. S. (2022b). A Proposed Model for Employing Digital Platforms in Developing the Motivation for Achievement Among Students of Higher Education During Emergencies. Journal of Positive School Psychology, 6(9), 4921-4933.

Alharbi, S. M., Elfeky, A. I., & Ahmed, E. S. (2022). The effect of e-collaborative learning environment on development of critical thinking and higher order thinking skills. Journal of Positive School Psychology, 6848-6854.

Almalki, A. D. A., & Elfeky, A. I. M. (2022). The Effect of Immediate and Delayed Feedback in Virtual Classes on Mathematics Students' Higher Order Thinking Skills. Journal of Positive School Psychology, 432–440-432–440.

Alshammary, F. M., & Alhalafawy, W. S. (2023). Digital Platforms and the Improvement of Learning Outcomes: Evidence Extracted from Meta-Analysis. Sustainability, 15(2), 1305.

Alzahrani, F. K. J., & Alhalafawy, W. S. (2022). Benefits And Challenges Of Using Gamification Across Distance Learning Platforms At Higher Education: A Systematic Review Of Research Studies Published During The COVID-19 Pandemic. Journal of Positive School Psychology, 6(10), 1948-1977.

Alzahrani, F. K. J., Alshammary, F., & Alhalafawy, W. (2022). Gamified Platforms: The Impact of Digital Incentives on Engagement in Learning During Covide-19 Pandemic. Cult. Manag. Sci. Educ, 7, 75-87.

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented Reality in education–cases, places and potentials. Educational Media International, 51(1), 1-15.

Cai, S., Chiang, F.-K., Sun, Y., Lin, C., & Lee, J. J. (2017). Applications of augmented reality-based natural interactive learning in magnetic field instruction. Interactive Learning Environments, 25(6), 778-791.

Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., & Ivkovic, M. (2011). Augmented reality technologies, systems and applications. Multimedia tools and applications, 51(1), 341-377.

da Silva, I. C., Klein, G., & Brandao, D. M. (2017). Segmented and detailed visualization of anatomical structures based on augmented reality for health education and knowledge discovery. Advances in Science, Technology and Engineering Systems Journal, 2(3), 469-478.

Diegmann, P., Schmidt-Kraepelin, M., Eynden, S., & Basten, D. (2015). Benefits of augmented reality in educational environments-a systematic literature review.

Dunleavy, M. (2014). Design principles for augmented reality learning. TechTrends, 58(1), 28-34.

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. Handbook of research on educational communications and technology, 735-745.

Elbyaly. (2016). Heritage Revival by the Use of Saudi Bedouin Textiles in the Gulf Mantle. Journal of Home Economics, 26(4).

Elbyaly, & El-Fawakhry. (2016). Online teaching course to develop STUDENTS'CREATIVITY in handmade embroidery. British Journal of Education, 4(13), 30-51.

Elbyaly, & Elfeky. (2021). Investigating the effect of vodcast to enhance the skills of the Canadian smocking and complex problem solving. Current Psychology, 1-11.

Elbyaly, M. Y. H., & Elfeky, A. I. M. (2022). The role of metacognition in promoting deep learning in MOOCs during COVID-19 pandemic. PeerJ Computer Science, 8, e945.

Elfeky. (2017). Social Networks Impact factor on Students' Achievements and Attitudes towards the" Computer in Teaching" Course at the College of Education. International journal on E-learning, 16(3), 231-244.

Elfeky. (2019). The effect of personal learning environments on participants' higher order thinking skills and satisfaction. Innovations in Education and Teaching International, 56(4), 505-516.

Elfeky, & Elbyaly. (2017). The use of CSCL environment to promote students' achievement and skills in handmade embroidery. European Journal of Training and Development Studies, 4(2), 19-32.

Elfeky, & Elbyaly, M. Y. H. (2016). The impact of learning object repository (lor) in the development of pattern making skills of home economics students. British Journal of Education, 4(2), 87-99.

Elfeky, Masadeh, T. S. Y., & Elbyaly, M. Y. H. (2020). Advance organizers in flipped classroom via e-learning management system and the promotion of integrated science process skills. Thinking Skills and Creativity, 35, 100622.

Elfeky, A. I. M., Alharbi, S. M., & Ahmed, E. S. A. H. (2022). The Effect Of Project-Based Learning In Enhancing Creativity and Skills of Arts Among Kindergarten Student Teachers. Journal of Positive School Psychology, 6(8), 2182-2191.

Elfeky, A. I. M., & Elbyaly, M. Y. H. (2019). Multimedia: Different Processes. Interactive Multimedia-Multimedia Production and Digital Storytelling.

Elfeky, A. I. M., & Elbyaly, M. Y. H. (2021a). Developing skills of fashion design by augmented reality technology in higher education. Interactive Learning Environments, 29(1), 17-32.

Elfeky, A. I. M., & Elbyaly, M. Y. H. (2021b). The use of data analytics technique in learning management system to develop fashion design skills and technology acceptance. Interactive Learning Environments, 1-18.

Elfeky, A. I. M., & Masadeh, T. S. Y. (2016). The Effect of Mobile Learning on Students' Achievement and Conversational Skills. International Journal of higher education, 5(3), 20-31.

Fazel, A., & Izadi, A. (2018). An interactive augmented reality tool for constructing free-form modular surfaces. Automation in Construction, 85, 135-145.

Fischer, A., Greiff, S., & Funke, J. (2011). The process of solving complex problems. Journal of Problem Solving, 4(1), 19-42.

Funke, J. (2001). Dynamic systems as tools for analysing human judgement. Thinking & reasoning, 7(1), 69-89.

Funke, J. (2010). Complex problem solving: A case for complex cognition? Cognitive processing, 11(2), 133-142.

Greiff, S., Niepel, C., Scherer, R., & Martin, R. (2016). Understanding students' performance in a computer-based assessment of complex problem solving: An analysis of behavioral data from computer-generated log files. Computers in human behavior, 61, 36-46.

Hsieh, M.-C., & Lee, J.-J. (2018). Preliminary study of VR and AR applications in medical and healthcare education. J Nurs Health Stud, 3(1), 1.

Hwang, J.-y., Sanders, E. A., & Damhorst, M. L. (2014). South Korean Fashion designers' decision-making process: The influence of cultural values and personal experience in the creative process. Paper presented at the International Textile and Apparel Association Annual Conference Proceedings.

Kretzschmar, A., Neubert, J. C., Wüstenberg, S., & Greiff, S. (2016). Construct validity of complex problem solving: A comprehensive view on different facets of intelligence and school grades. Intelligence, 54, 55-69.

Küçük, S., Yýlmaz, R. M., & Göktaþ, Y. (2014). Augmented reality for learning English: Achievement, attitude and cognitive load levels of students. Education & Science/Egitim ve Bilim, 39(176).

Limbu, B., Maquil, V., Ras, E., & Weinberger, A. (2015). Tomb of osiris: Gamifying the assessment of collaborative complex problem solving skills on tangible tabletops. Paper presented at the International Computer Assisted Assessment Conference.

Lukosch, S., Billinghurst, M., Alem, L., & Kiyokawa, K. (2015). Collaboration in augmented reality. Computer Supported Cooperative Work (CSCW), 24(6), 515-525.

Mainert, J., Niepel, C., Murphy, K. R., & Greiff, S. (2019). The incremental contribution of complex problem-solving skills to the prediction of job level, job complexity, and salary. Journal of Business and Psychology, 34(6), 825-845.

Masada, T. S. Y. (2017). Immediate versus delayed feedback in promoting student teachers skills for lesson plan implementation. Thouqan Saleem Yakoub Masadeh and Abdellah Ibrahim

Mohammed Elfeky (2017) Immediate Versus Delayed Feedback in Promoting Student Teachers Skills for Lesson Plan Implementation, British Journal of Education, 5(8), 43-58.

Masadeh, T. S. Y., & Elfeky, A. I. M. (2016). Efficacy of open-source learning management systems in developing the teaching skills of English language student teachers. American Journal of Educational Research, 4(4), 329-337.

McGrath, J. L., Taekman, J. M., Dev, P., Danforth, D. R., Mohan, D., Kman, N., . . . Lemheney, A. (2018). Using virtual reality simulation environments to assess competence for emergency medicine learners. Academic Emergency Medicine, 25(2), 186-195.

Meißner, A., Greiff, S., Frischkorn, G. T., & Steinmayr, R. (2016). Predicting Complex Problem Solving and school grades with working memory and ability self-concept. Learning and Individual Differences, 49, 323-331.

Pidel, C., & Ackermann, P. (2020). Collaboration in virtual and augmented reality: a systematic overview. Paper presented at the International Conference on Augmented Reality, Virtual Reality and Computer Graphics.

Plunkett, K. N. (2019). A simple and practical method for incorporating augmented reality into the classroom and laboratory: ACS Publications.

Poelman, R., Akman, O., Lukosch, S., & Jonker, P. (2012). As if being there: mediated reality for crime scene investigation. Paper presented at the Proceedings of the ACM 2012 conference on computer supported cooperative work.

Rudolph, J., Greiff, S., Strobel, A., & Preckel, F. (2018). Understanding the link between need for cognition and complex problem solving. Contemporary Educational Psychology, 55, 53-62.

Saidin, N. F., Halim, N., & Yahaya, N. (2015). A review of research on augmented reality in education: Advantages and applications. International education studies, 8(13), 1-8.

Sandberg, J. (2018). Methods, apparatuses and computer program products for automatically generating suggested information layers in augmented reality: Google Patents.

Schrier, K. (2006). Using augmented reality games to teach 21st century skills ACM Siggraph 2006 Educators Program (pp. 15-es).

Seel, N. M. (2011). Encyclopedia of the Sciences of Learning: Springer Science & Business Media.

Stadler, M., Becker, N., Gödker, M., Leutner, D., & Greiff, S. (2015). Complex problem solving and intelligence: A meta-analysis. Intelligence, 53, 92-101.

Stadler, M. J., Becker, N., Greiff, S., & Spinath, F. M. (2016). The complex route to success: complex problem-solving skills in the prediction of university success. Higher Education Research & Development, 35(2), 365-379.

Tagaytayan, R., Kelemen, A., & Sik-Lanyi, C. (2018). Augmented reality in neurosurgery. Archives of Medical Science, 14(3), 572-578.

Tesolin, A., & Tsinakos, A. (2018). Opening real doors: Strategies for using mobile augmented reality to create inclusive distance education for learners with different-abilities Mobile and Ubiquitous Learning (pp. 59-80): Springer.

Wu, Hwang, Yang, & Chen. (2018). Impacts of integrating the repertory grid into an augmented reality-based learning design on students' learning achievements, cognitive load and degree of satisfaction. Interactive Learning Environments, 26(2), 221-234.

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., & Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. Computers & education, 62, 41-49.

Wu, P.-H., Hwang, G.-J., Yang, M.-L., & Chen, C.-H. (2018). Impacts of integrating the repertory grid into an augmented reality-based learning design on students' learning achievements, cognitive load and degree of satisfaction. Interactive Learning Environments, 26(2), 221-234.

Wüstenberg, S., Greiff, S., & Funke, J. (2012). Complex problem solving—More than reasoning? Intelligence, 40(1), 1-14.

Yilmaz, R. M. (2016). Educational magic toys developed with augmented reality technology for early childhood education. Computers in human behavior, 54, 240-248.

Yilmaz, R. M., & Goktas, Y. (2017). Using augmented reality technology in storytelling activities: examining elementary students' narrative skill and creativity. Virtual Reality, 21(2), 75-89.