Journal of Palestine Ahliya University for research and studies
مجلـة جامعة فلسطين الأهلية للبحوث والدراسات
ISSN: 2959-4839
Vol. 03 Issue 02 (2024)

Using an Interactive Learning Model of Teaching Physics Labs Due to Corona Virus

Asma H Sobeih[1], Ritta Shaheen[2], Gülsüm Aşiksoy[3]

[1] Palestine Ahliya University (Palestine)
Asma_sbeih@paluniv.edu.ps
[2] Near East Univetsity (North cyprus)
ritta.shaheen@gmail.com
[3] Ankara University (Turkey)
gulsum.asiksoy@neu.edu.tr

Received:04/07/2024 Accepted:28/07/2025 Published:01/08/2024

Abstract:

Due to the corona virus pandemic, with a problem has emerged with courses that need practical laboratories, such as physics, chemistry and biology, as they cannot be applied remotely. Therefore, in this research, we aimed to develop an educational and smart system for physics labs, which is considered one of the most difficult subjects. This paper identifies how augmented reality can be used to teach the physics labs remotely and proposes a mobile application using the augmented reality technique to teach students the physics labs by using mobile technologies. The application provides all the options to conduct the experiments of the physics lab 1 and 2 courses. Through a usable graphical interface and augmented reality technique, the student enters the mobile app then chooses any experiments that he/she wants to practice and finally, the results are recorded. Furthermore, the students can repeat the experiments several times to improve their knowledge and skills. This application forms a basic step in the educational lab teaching in the higher education, and which can be improved to be compatible with more smart devices and applicable to more labs than physics.

Keywords: *E-Lab; Smart Phone; Augmented Reality; Corona.*

استخدام نموذج التعلم التفاعلي لتدريس مختبرات الفيزياء بسبب فيروس كورونا

أسماء صبيح[1]، ريتا شاهين[2]، جولسوم اسيكسوي[3]

[1] جامعة فلسطين الأهلية (فلسطين)
Asma_sbeih@paluniv.edu.ps
[2] جامعة الشرق الأقصى (قبرص الشمالية)
ritta.shaheen@gmail.com
[3] جامعة أنقرة (تركيا)
gulsum.asiksoy@neu.edu.tr

تاريخ الاستلام:2024/07/04 تاريخ القبول:2024/07/28 تاريخ النشر:2024/08/01

ملخص:

بسبب جائحة فيروس كورونا ظهرت مشكلة مع المقررات الدراسية التي تحتاج إلى مختبرات عملية مثل الفيزياء والكيمياء والأحياء حيث لا يمكن تطبيقها عن بعد، لذلك هدفنا في هذا البحث إلى تطوير نظام تعليمي ذكي لمختبرات الفيزياء والتي تعتبر من أصعب المواد الدراسية، حيث يحدد هذا البحث كيف يمكن استخدام الواقع المعزز لتدريس مختبرات الفيزياء عن بعد ويقترح تطبيق جوال يستخدم تقنية الواقع المعزز لتدريس مختبرات الفيزياء للطلاب باستخدام تقنيات الجوال، يوفر التطبيق كافة الخيارات لإجراء تجارب مقررات مختبر الفيزياء 1 و 2، من خلال واجهة رسومية قابلة للاستخدام وتقنية الواقع المعزز يدخل الطالب إلى التطبيق الجوال ثم يختار أي تجارب يريد ممارستها وأخيراً يتم تسجيل النتائج، علاوة على ذلك يمكن للطلاب تكرار التجارب عدة مرات لتحسين معرفتهم ومهاراتهم. يشكل هذا التطبيق خطوة أساسية في تدريس المختبر التعليمي في التعليم العالي، ويمكن تحسينه ليكون متوافقًا مع المزيد من الأجهزة الذكية وقابل للتطبيق على المزيد من المختبرات من الفيزياء.

الكلمات المفتاحية: *المختبر الإلكتروني؛ الهاتف الذكي؛ الواقع المعزز؛ كورونا.*

1. Introduction

By definition, Augmented Reality (AR) is the implantation of a virtual object within a real environment in real time. This virtual 3D object appears to be integrated in the real world (Azuma, 1997) which helps not to isolate the handlers from the surrounding environment as well as the manipulation of the object which overlays the reality, (Andujar et al., 2011), Augmented Reality can be categorized into one of the following: 1) marker-based, which need particular clues seen via the camera. 2) marker-less, in which the location information from the mobile is used, then the digital information is superimposed (Pence, 2010). The recent advancements in technology have made Augmented Reality more feasible with more noticeable applications in the field of education among other fields (Bower et al., 2014; Lee, 2012). Furthermore, it is anticipated AR will be increasingly embraced by teachers in coming years since this technology has the possibility to encourage learners and provide them with new perspectives, enrich the teaching efficiency, and allow the students to learn by practice and experience (Kerawalla et al., 2006; Kesim & Ozarslan, 2012; Scrivner et al., 2016). Yuen et al. (2011) emphasized these advantages of AR in their study published in 2011, stating that planting AR in education, help to merge and prompt the learner to discover the educational material from different approaches, which will assist them in studying courses and subjects (at their own pace), particularly in situations where it is not easy to gain to real world experiences; this will also help the teachers and make the teaching more smooth.

In this research, we propose a smart application designed within the mobile phones in order to teach the physics labs remotely. Due to Corona virus "COVID-19" that causes Corona virus disease, this disease that affects the respiratory system is spreading rapidly. The World Health Organization (WHO; 2020 a; 2020b; 2020 c) declared the outbreak of COVID 19 to be a pandemic at the beginning of March 2020, and it has a direct effect on worldwide teaching systems and has brought major educational problems in most countries in the world 2. Hence, the education in most universities and schools has become electronic. As a result, researchers have accelerated the discovery and development of new teaching methods that can help students to continue with the education process. However, a problem exists with regard to courses that need practical laboratories, such as physics, chemistry and biology, which cannot be applied remotely. Therefore, in this research, we aimed to develop an educational system for physics, which is considered one of the “most difficult subjects” (Nilsook, 2015). We aim to implement our system in physics lab using interactive teaching techniques (augmented reality, virtual reality, and multimedia) through which the student can implement physics experiments, improve their knowledge, increase their creative thinking and engage in more hands-on learning at universities and schools, which will also make the education process simpler and more exciting. Moreover, we aim to analyze and include some of the skills. We intend to present these skills by utilizing different technology models and practice in delivering lectures. Consequently, the use of the interactive teaching techniques model, which consists of a set of sources for different media such as text, graphics, animation, sound / audio, interactive video and video / or animation to explain an idea or make a remote experiment, so that these resources are not available in science laboratories. Therefore, it can be applied remotely by using these techniques. Figure 1 explains how interactive teaching can build a virtual lab in a certain sense and improve knowledge.

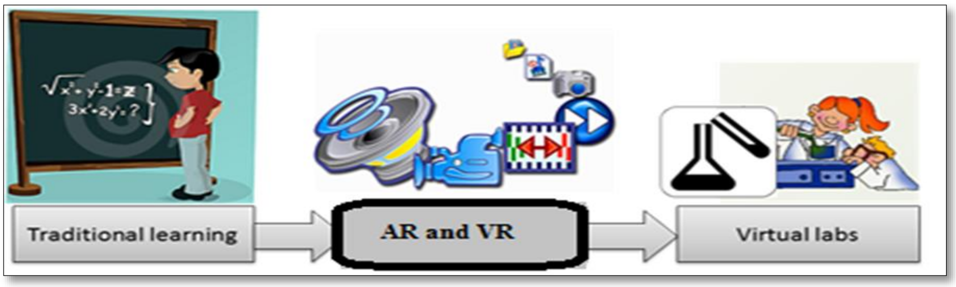

Figure 1: Using AR and VR in Science education

1.1 Problem Statement

Many students suffer from a limited understanding of physics labs as a result of remote education. Due to the coronavirus pandemic, problems have emerged with respect to courses that need practical laboratories, such as physics, chemistry and biology, which cannot be applied remotely. Therefore, in this research, we aimed to develop an educational and smart system for the physics labs, which is considered one of the "most difficult subjects". In addition, there are few such applications for teaching physics labs remotely based on augmented reality, which provide students opportunities to conduct experiments remotely.

The target groups for this application are:

- Teachers: any user who have the interest to teach the physics lab remotely.
- Students: any students who take the physics lab 1 and 2 courses.
- Laboratory assistants: the teaching assistant of the physics course.

1.2 System Objectives

The ultimate goal of this research paper is to develop an interactive learning tool to enhance the teaching of Physics' labs in universities and schools. However, the various objectives include:

1. Develop an automated smart system that can teach students Physics labs remotely.
2. Provide a smart system at low cost, not only for local use but also for global use.
3. Provide opportunities and means for the interested students and teachers to perform the required practical activities as outlined in their textbooks.
4. Make physics teaching affordable.
5. Promote practical-oriented teaching and learning methodologies.
6. Develop an interactive learning tool for some selected courses that can be accessed by students as well as their teachers.

An important question is whether there are similar systems being developed by researchers locally and globally, and it is evident that there are. However, team will work to develop a more effective and an interactive system for teaching science, specifically physics laboratories, which will distinguish the educational system among the universities, particularly at the Near East University.

1.3 Background

Augmented Reality (AR) has been implemented in the field of education in recent years. However, most studies address the opportunities, possibilities and challenges that arise from merging the virtual element with the real environment in an educational situation (Garzón & Acevedo, 2019) as well as the efficacy of AR' implantation in education from the teachers' perspective (Tzima, 2019). In a review published by Saltan and Arslan (2016), it was stated that AR is capable of improving academic performance and enhancing the learning enthusiasm of the learner. Besides the learning gain, the teachers motivate the using of the new technology and new teaching methods, for instance, using the AR with 3Dmax and buildAR to teach electro magnetism was very helpful and applicable at the highest level (Nilsook, 2015). By using meta-analysis, Ozdemir et al. (2018) showed that learners' educational achievements were improved when AR was used comparing to conventional teaching methods.

Thees et al. (2020) conducted a research in which they used smart glasses combined with an AR system in a physics laboratory to examine heat conduction by using an incorporated real - time-data visualization presentation format. This research showed an important lesser exceptional intellectual load than the conventional case. On the other hand, in a conceptual information check, AR transplantation did not constitute a learning advantage. However, Altmeyer et al. (2020) study showed that the AR settings increased the learning compared with the traditional method.

Another study showed the advantages of imbedding AR in a learning platform, where the results indicated that the students' curiosity and commitment increased when using AR. The AR was implanted as a type of mobile application that benefited from location information in order to teach the celestial bodies as a type of game. Information about the physical movement and interaction in reality was used to help the students by integrating formal and informal learning (Costa et al., 2020).

1.4 Analysis

The system is intended for students in diverse contexts and a variety of perspectives. It will be specifically designed for learners studying in physics laboratories.

The software of the mobile application will be created utilizing the new mobile technologies, particularly augmented reality, to provide users with openness, reliability, readability and sustainable growth, making the teaching process easier and increasing awareness about physics laboratories. It will provide students the ability to perform all experiments of physics 1 and 2 remotely by using this application on their mobile devices.

The software is customizable for both Android and IOS platforms.

2. Materials And Methods

2.1 Data collection technique

It is necessary for all application development to insure the correctness, accurateness and high quality of the application data. We had chosen among various data collecting techniques more than one techniques as follow:

- Questionnaire: We administered a questionnaire to five physics teaching assistants, where 20% were male and 80% female, their ages ranged between 20 and 40, and 80% held a master's degree and the rest had a PhD.

To understand the necessity of using augmented reality in the teaching process, we asked the teachers several questions:

1. What method is being used this semester to teach physics labs?
   40% using Moodle, 20% power point, 60% videos
2. How man experiments are performed in the PHY1 and PHY2 courses!
   PHY1 = 5 and PYY2 = 5.
3. How satisfied were the students with the teaching laboratories last semester?
   60% excellent, 40% VG.
4. Have the learning outcomes been achieved in the last semester?
   Due to the coronavirus, no physics labs were held last semester.
5. Which experiment was the most difficult to implement due to the lack of equipment?
   100% Coulomb's Law
6. Have physics labs been canceled this semester due to the coronavirus pandemic?
   100% yes.

7. In the worst-case scenario, if the universities remain closed, in your opinion, what is the solution to continue teaching Physics' laboratories?
   100% the use of virtual labs.
8. Generally, have you ever heard about the Augmented Reality applications?
   100% yes.
9. Have you included Augmented Reality applications in your teaching?
   60% yes and 40% no.
10. Have you ever conducted an augmented reality program in your class?
   40% yes and 60% no.
11. If a system is developed to teach physics labs remotely, will it solve the problem of teaching labs? 60% yes and 40% no.
12. Will you train your students to use the developed system? 100% yes
13. Do you have any suggestions to help us in developing the system?

The teachers suggested that there should not be a specific period for the experiment, which enables students to repeat the experiment as many times as they want and it would be beneficial to use this application in the future, in case the school remains closed to avoid cancellation of the lab.

- Sources of books and electronic websites: We have read several books, scientific articles, and similar electronic applications to develop a distinctive smart application for teaching physics labs remotely, using augmented reality technology.

To conclude, after we analyzed the questionnaire, we found that both physics labs 1 & 2 were stopped due to the coronavirus pandemic. There is currently no alternative at Near East University for teaching the lab remotely. Therefore, we decided to develop this system using Augmented Reality technology as the best way of teaching practical laboratories remotely, particularly the Physics Labs.

1. Recommendations

After analyzing the data, we found the following results:

The master's physics experiments are classified as follow:

1. Physics lab1

A. One Dimensional Motion with Constant Velocity.
B. Straight Line Motion with Constant Acceleration.
C. Projectile Movement.
D. The Rules of Newton.
E. Conservation of Energy.
F. Conservation of Linear Momentum.

2. Physics lab2

A. Coulomb's Law
B. Calculation of the Coulomb's Constant.
C. Ohm's Law.
D. Resistive Circuits and Measurement of Voltages and Currents.
E. The Kirchhoff's rules.
F. Charging and Discharging of RC circuit.
G. LORENTZ FORCE LAW.

The following tables show samples of the experiments' equations for physics labs 1 & 2

Table 1: physics lab 101

#	Name of the experiment	Equations	Meaning of the variables
		Physics Lab 101	
1.	One Dimensional Motion with Constant Velocity	$\bar{v} = \frac{\Delta x}{\Delta t}$ $\Delta x = x - x_0$	$\bar{v}$ average Δt time interval Δx displacement *x* and *xo* are the last and first positions of an object
2.	Straight Line Motion with Constant Acceleration	$v_f = v_0 - at$ $x = x_0 + v_0 + \frac{1}{2}at^2$ $v_f^2 = v_0^2 + 2a(x - x_0)$	-*vf* and *v*0 are the final and initial velocities. -*x* and x0 are the last and first locations. - *a* is the acceleration of an object and *t* is the time taken.
3.	Projectile Motion	$v_x = v_{x0}$ $x = x_0 + v_{x0}t$ $v_y = v_{y0} - gt$ $y = y_0 + v_{y0}t - \frac{1}{2}gt^2$ $v_y^2 = v_{y0}^2 - 2g(y - y_0)$ $v_{x0} = v_0 cos\theta_0$ $v_{y0} = v_0 sin\theta_0$ $R = v_{x0}t_f$	- acceleration due to gravity (g) - R of the projectile motion. -tf is the time of flight. - *vx* and *vy* are the velocities on the -x and y axes, respectively. -*x* and x0 are the last and first positions on the x axis. - *y* and y0 are the last and first positions on the y axis. - *t* is the time taken - θ_0 is the launching angle.
4.	Newton's Laws	$\bar{a} = \frac{\sum \vec{F}}{m}$ $\sum F_x = ma_x$ $\sum F_y = ma_y$ $\sum F_z = ma_z$	Where a_r, stands for acceleration, *m* for the mass and Σ*F* for the net force. $\vec{F}$ is a vector with magnitude and direction.

			F_x,F_y and F_z are the components of $\vec{F}$ form in rectangular coordinates
5.	Conservation of Energy	E = K +U $K = \frac{1}{2}mv^2$ $U = mgh$ $K_i + U_i = K_f + U_f$	E: Mechanical energy. K: Kinetic energy. U: Potential energy. i indicates the initial phase and f is the final one.
6.	Conservation of Linear Momentum	$\vec{p} = m\vec{v}$ $\vec{p} = \sum_{i=1}^{i=n} \vec{p} = \sum_{i=1}^{i=n} m_i\vec{v_i}$ $\vec{p_i} = \vec{p_f}$ $K_i = K_f$	P is linear momentum. m is mass. V is velocity. i indicates the initial phase and f is he final one.

Table 2: Physics lab 102

Physics lab 102			
#	**Name of the experiment**	**Equations**	**Meaning of the variables**
1.	Coulomb’s Law	$F = k\frac{q_1q_2}{R^2}$	q1: Magnitude of the charge on the first object.
2.	Calculation of the Coulomb’s Constant	$F = k\frac{q_1q_2}{R^2}$	q2: Magnitude of the charge on the second object.
3.	Ohm’s Law	$R = \frac{V}{I}$	R: distance.
4.	Resistive Circuits and Measurement of Voltages and Currents	Resistances connected in series: $R_{eq}=R_1+R_2+R_3$ Resistances connected in parallel: $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	K constant and equal to 8.988×109 N ·m2 /C2.
5.	The Kirchhoff’s laws	1) Junction law: At any intersection, the number of all currents that join the junction shall exceed the amount of all currents that exit the junction. 2) Loop law: The sum of the potential changes around any closed-circuit path shall be zero.	E: Mechanical energy. K: Kinetic energy. U: Potential energy. i indicates the initial phase and f is the final one.
6.	Charging and Discharging of RC circuit	$q(t) = VC(1 - e^{-1/RC})$ $V_c(t) = V_0(1 - e^{-1/RC})$	P is linear momentum. m is mass. V is velocity.

			i indicates the initial phase and f is the final one.
7.	LORENTZ FORCE LAW	F=IL*B F=ILBsinθ	F: Lorentz force. I: the current on the wire. L: length of the wire inside the magnetic field. B: the magnetic area. θ: the angle between the magnetic field and wire.
8.	Transformers	$\frac{V_s}{V_P} = \frac{N_s}{N_p}$	P indicates the primary coil. S indicates the secondary coil. V: voltage. N: number of loops.

2.2 System Functional Requirements

After in-depth research to analyze data gathered from different resources, we extracted the functions and features provided by the smart system, and through this application, all experiments in physics laboratories 1 and 2 needed in the physics course at the Near East University can be done. These Functional Requirements are:

➢ **End-user functional requirements**

a. Performing the experiments: the user enters the application and can perform all the experiments in Physics labs 101 & 102; the application will calculate all the physics functions on each experiment and the students can repeat the experiment several times to improve their knowledge and skills.

The application offers the user to labs - PHY1 & PHY2; PHY1 includes 6 experiments and PHY2 has 8 experiments.

b. Writing the report: the students record the results collected by doing the experiments and finally send them to the lecturer.
c. Teachers put the marks: After receiving the report from the students, the teachers assign the marks for the experiments.
d. Obtain mini-report: Students can generate a mini-report on their grade status based on the results teachers have evaluated.

➢ **System Non-Functional Requirements**

- Secure: nobody can access the users' files or their personal data.
- Usability: it offers user guide facilities and is easy to use.
- Availability: The system is available at any time without stopping.
- Scalability: The system can expand and accommodate new records, without crashes and with the same efficiency.

2.3 App’s Design and Interface

A. Database details

In our system, the database is a core component. It will hold all the normal laboratory test records, and display the relationships between the components of a system. The database includes 4 tables representing the following entities: **Test results, Test, Test students, Experiments and students**,

B. Use Case Diagram

We have adopted an object-oriented architecture to construct our system relationships and operations in our system for all groups of entities. To illustrate how the system interacts between the main components in it, the figure below shows the interaction between the elements of the system and its users. The actor may be a learner or a teacher.

Figure 2: Use case Diagram

2.4 User Interface Diagram

We built the software to be effective and user friendly, and to provide all the resources for our program to the users. Our program offers guidance and instructions so that users can make the most efficient usage of the system. Figure below shows the sequence menus of our software interface.

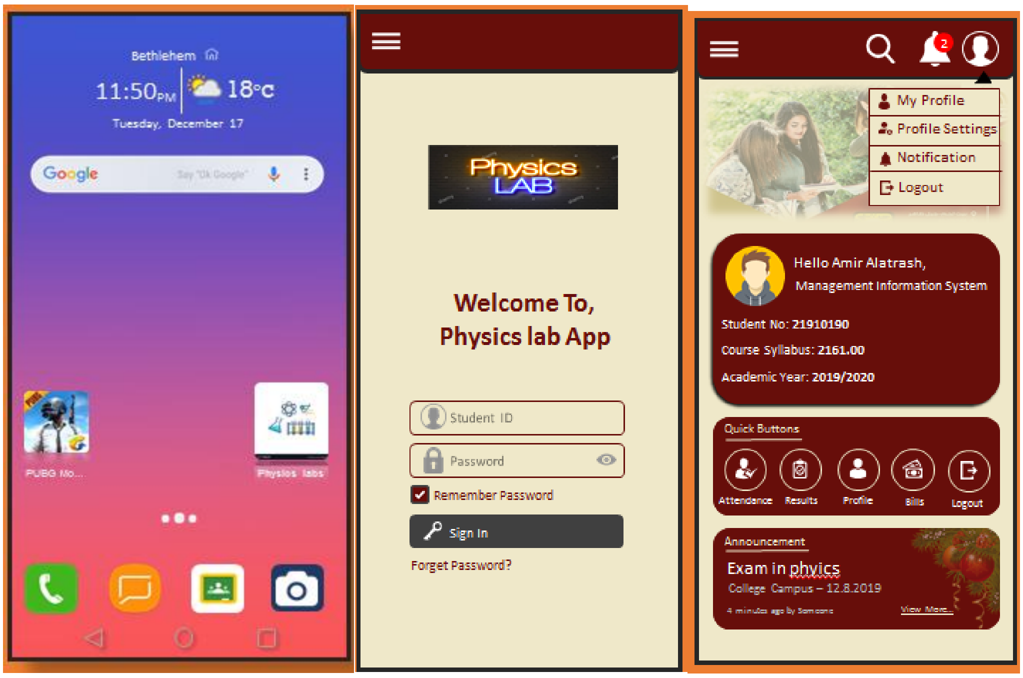

Figure 3: Physics lab APP’s **Figure 4: Sign in** **Figure 5: student profile**

Figure 5: Physics labs

2.5 Augmented Reality Experiment Example

Experiment 1 in physics lab 1 teaches the students One Dimensional Motion with Constant Velocity, the first experiment explains to the student the law of speed, through the experiment he will perform, to calculate the time and distance that the object moves from point to point by augmented reality technology at real time. Finally, the student can calculate the velocity several times, which will improve their knowledge.

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

$$\Delta x = x - x_0$$

$\bar{v}$ average

Δt time interval

Δx displacement

x and xo are the final and initial positions of an object

Figure 6: Sign for AR

Figure 7: AR target

Figure 8: EXP1 with AR

3. System Implementation

We have used (Unity 2019 and Vuforia Augmented Reality SDK) to develop software, which provides many advantages. Vuforia SDK is an open source software used to develop 3D virtual reality apps and Vuforia Project still utilizes computer vision technologies to identify and monitor flat images and 3D artifacts in real time. Unity continues to support 3D and 2D video computer games, consoles and mobile devices; C-Sharp is used by the engine as the primary programming language.

In our system, we do not need in this smart system to specify a mark to show the object in experiments, like most applications of augmented reality, so that the student can use the application without the need for a mark, therefore we used Vuforia Augmented Reality SDK.

4. Acknowledgment and Future Work

Mobile apps have changed the world within a short time, particularly educational mobile and augmented reality applications. In this research paper, we present a prototype for a mobile app created to enable students at Near East University to perform he physics labs remotely. Therefore, we want to implement our system formally within the university curriculum so that we can get feedback from students and lecturers in the following semester, and so that we can give all the experiments of the physics lab remotely. Furthermore, we also intend to create history files for students to store all test values in order to monitor their knowledge and skills.

References

Altmeyer, K., Kapp, S., Thees, M., Malone, S., Kuhn, J., & Brünken, R. (2020). The use of augmented reality to foster conceptual knowledge acquisition in STEM laboratory courses—Theoretical background and empirical results. *British Journal of Educational Technology*, *51*(3), 611-628.

Andujar, J. M., Mejías, A., & Márquez, M. A. (2010). Augmented reality for the improvement of remote laboratories: an augmented remote laboratory. *IEEE transactions on education*, *54*(3), 492-500.

Azuma, R. T. (1997). A Survey of Augmented Reality. *PRESENCE: Virtual and Augmented Reality*, 6(4), 355-358.

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.

Costa, M. C., Manso, A., & Patrício, J. (2020). Design of a mobile augmented reality platform with game-based learning purposes. *Information*, *11*(3), 127.

Garzón, J., & Acevedo, J. (2019). Meta-analysis of the impact of Augmented Reality on students' learning gains. *Educational Research Review*, *27*, 244-260.

Kerawalla, L., Luckin, R., Seljeflot, S., & Woolard, A. (2006). "Making it real": exploring the potential of augmented reality for teaching primary school science. *Virtual reality*, *10*, 163-174.

Kesim, M., & Ozarslan, Y. (2012). Augmented reality in education: current technologies and the potential for education. *Procedia-social and behavioral sciences*, *47*, 297-302.

Lee, K. (2012). Augmented reality in education and training. *TechTrends*, *56*, 13-21.

Nilsook, S. T. a. P. (2015). *Using Augmented Reality for Teaching Physics*. s.l., The sixth International e-Learning Conference.

Ozdemır, M., Sahın, C., Arcagok, S., & Demır, M. K. (2018). The effect of augmented reality applications in the learning process: A meta-analysis study. *Eurasian Journal of Educational Research*, *18*(74), 165-186.

Pence, H. E. (2010). Smartphones, smart objects, and augmented reality. *The Reference Librarian*, 52(1-2), 136-145.

Saltan, F., & Arslan, Ö. (2016). The use of augmented reality in formal education: A scoping review. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(2), 503-520.

Scrivner, O., Madewell, J., Buckley, C., & Perez, N. (2016, December). Augmented reality digital technologies (ARDT) for foreign language teaching and learning. In *2016 future technologies conference (FTC)* (pp. 395-398). IEEE.

Thees, M., Kapp, S., Strzys, M. P., Beil, F., Lukowicz, P., & Kuhn, J. (2020). Effects of augmented reality on learning and cognitive load in university physics laboratory courses. *Computers in Human Behavior*, *108*, 106316.

Tzima, S., Styliaras, G., & Bassounas, A. (2019). Augmented reality applications in education: Teachers point of view. *Education Sciences*, *9*(2), 99.

WHO. (2020 a). Laboratory testing for coronavirus disease. WHO.

WHO. (2020 b). COVID-19. Retrieved from www.who.int: https://2u.pw/tceerCAz

WHO. (2020 c). Mendely. COVID-19 Retrieved from: www.mendely.com.

Yuen, S. C. Y., Yaoyuneyong, G., & Johnson, E. (2011). Augmented reality: An overview and five directions for AR in education. *Journal of Educational Technology Development and Exchange (JETDE)*, *4*(1), 11.