Asia Pacific Journal of Advanced Education and Technology
Volume 1, Issue 2, June 2022 / P- ISSN 2815 – 245X / E – ISSN 2815 – 2468 / www.apjaet.com

Haynayan AR: An Augmented Reality-Based Lesson for the Improvement of Learning Achievement in Cell Biology for the STEM Curriculum

Joel T. Bautista
https://orcid.org/0000-0001-7314-6877
jtbautista@pshs.edu.ph
Knowledge and Innovation Division, DOST Philippine Science High School System, Quezon City, National Capital Region 1104 Philippines

Abstract

ICT-infused lessons have been proven to significantly enhance the learning achievements in various disciplines specially during the pandemic. Most schools have adopted blended and remote learning. In Education 4.0, schools are relying on technology and among these educational technologies are Augmented Reality and Mobile-based Learning. These educational technologies are gaining popularity given their accessibility and advantages. So, the researchers designed and developed Augmented Reality-based learning Tool for Cell Biology and Basic Microscopy. The study aimed to assess the developed learning tool in terms of learning achievement and employed methods such as technology acceptance model for users and pre-post testing approach to assess learning outcomes. Findings revealed that Augmented-Reality based learning tools significantly enhance the learning achievement of students. Thus, the study suggests capability training for teachers on the use of such emerging technologies.

Keywords: cell biology, education, augmented reality, educational technology

Introduction

The Philippine Republic Act No. 9155 declares that it is a basic right of every Filipino to enjoy free access to quality education. Basic education including Tertiary education is offered free in the Philippines. Despite this privilege, Filipinos are still having challenges as far as access to quality is concerned. This was manifested by the results of the Programme for the International Student Assessment (PISA) where the Philippines ranked low in science and mathematics, garnering 353 points and 357 points versus a 489 Organisation for Economic Co-operation and Development (OECD) mean for both categories.

The nature of the topics in Cell Biology is difficult to comprehend and teach as they require time for planning, preparation of instructional materials, and careful delivery of the lessons. Lack of visual materials is prone to producing misunderstanding and misconception among the learners. Learning the interconnected and complicated biological processes without proper materials leads to students' disappointments and disengagement (Tan and Waugh, 2014). Other reasons that decrease learning efficiency include the study habits and attitudes of students in relation to abstract concepts, the teaching style of teachers, and lack of resources. Hence, it is suggested that ICT-based materials that engage the students more could enhance students' learning (Cimer, Atilla 2012).

In learning abstract concepts and complex processes, the perception could be improved by helping the learners create mental models using visualization. Students of cell biology could understand structures, functions, and processes through visualization by using Augmented Reality (AR).

As Augmented Reality (AR) becomes more pervasive in society, there is a natural inclination to see how it can be used for research and education. The effect of utilizing simulation on the learning and retention of concepts among learners is positive. Thus, the possibilities afforded by placing a user in an immersive environment are remarkable and the cost savings afforded by the technology are significant.

Significance/Rationale Augmented Reality (AR) becomes more pervasive in society, there is a natural inclination to see how it can be used for research and education. The effect of utilizing simulation on the learning and retention of concepts among learners is positive. Thus, the possibilities afforded by placing a user in an immersive environment are remarkable and the cost savings afforded by the technology are significant.

There is a need to develop Augmented Reality Modules that would teach complex cell biology topics in the Philippines. These complicated topics make teachers oversimplify lessons during class discussions. Thus, it is essential to design an AR tool and assess its acceptability among teachers and students to ensure better comprehension and understanding of topics in cell biology.

The researchers designed an AR-based lesson on selected topics in Biology for Grade 7-10 students and assessed the viability and outcomes of AR application in teaching selected complex topics in Biology.
Specifically, it aimed to design and develop an augmented reality application that contains relevant content to the selected sought difficult topic in biology. It aimed to validate the usability and acceptability of the application thru testing among the respondents and assessed the effectiveness of the design application in terms of academic achievement.

Objectives of the Study

In this study, the researchers will design an AR-based lesson on selected topics in Biology for Grade 7-10 students and will assess the viability and outcomes of AR application in teaching selected complex topics in biology. The specific objectives are as follows:

1. To design and develop an augmented reality application that contains relevant content to the selected sought difficult topic in biology.
2. To validate the usability and acceptability of the application thru testing among the respondents
3. To assess the effectiveness of the design application in terms of academic achievement

Materials and Methods

The study is Applied Research through the implementation of designed algorithms and processing of the gathered information.

Agile Software Development. The method utilized in the development process is the agile software development model. This section of the study illustrates the different phases and data involved in the development phase. (ICTS Simply Effective, 2020)

Requirement analysis. Research works involving augmented reality-based lessons/training modules were studied by the proponents in order to be more knowledgeable on the background of the study. This phase of the development is vital in the design of the study. The right people from the industry were identified. The researchers utilized the Experimental Research method in order to determine if the implementation of the Augmented Reality based lesson (the independent variable) has positive effects on student achievement on the perceived difficult topic in Biology (dependent variable)

Design Thinking Approach. Design thinking is defined as a human-centered problem-solving process, which is most useful in dealing with problems that are ill-defined or unknown. Through this process, researchers relate with users, challenge expectations, reevaluate trials and make creative solutions for rapid prototyping and testing. It is a non-linear process that involves five phases, which include empathizing with users, defining problems, ideating solutions, prototyping, and testing. Design thinking approach was used by the researchers in digging deeper into the needs of the teachers and the learners in the context of learning Biology. A design thinking workshop session with selected biology teachers and students was done to empathize, define problems and ideate proposed solutions from the participants of the workshop.

Prototype Development

Design. The application was designed based on the design-thinking approach to learners' needs. This step also includes determining the overall software architecture of the application.

Materials. For the materials to use, comprises the software requirements, the hardware requirements, and the data requirements to create the system.

Table 1
Software Requirements

Item	Specification	License
Framework/Platform	Unity 3D	Opensource
Scripting Language	Java	Opensource
Database	Firebase/MySQL	Opensource
Cloud hosting	Amazon AWS	Proprietary

Table 2 exhibits the software requirements needed to develop the information system languages and tools considered for the system. The PHP was used to capture information from the Haynayan User. Then it was saved on the database for future retrieval and access.

Table 2
Hardware Requirements

Part	Specification
Network/Internet Connectivity	Wired/Wireless
Mobile Phone	With AR support

The hardware requirements listed in Table 2 show the hardware considered for the development and implementation of the study. The system was developed online with mobile responsive features for ease of access to the users. The mobile phone used in testing and deployment of the system is the Nougat version to further explore the compatibility issues with other versions.

Data/Sampling. Convenience-purposive sampling was done from Grade 7-10 students and High school Science teachers in Region 3 specifically the Philippine Science High School - Central Luzon Campus in Clark, Pampanga, the Magpapalayok National High School located in San Leonardo, Nueva Ecija and the Maliwalo National High School in Tarlac City.

Instruments. Questionnaire, AR Based Biology Lesson

Intervention. The researchers selected the complex biology topic based on the perception of teachers and students, literature, and other studies (Cimer, 2012; Dewakar et al.,2016; Elongavan and Ismail, 2014; and Sethhilkumar, et al., 2014). Augmented Reality (AR) lessons will be designed to address the difficulty or complexity of the lesson. Cohorts of students who participated in the study undergone the pre-testing. After the pre-testing, Haynayan AR application was installed and utilized. After the use of the application, a post-testing was conducted.

Data Collection. The researchers with the help of biology teachers from the target high schools implemented pre-post testing to assess the effectiveness of the use of an AR-based intervention.

Data Analysis. From the data gathered from the transpired learning and assessment session. The researchers used SPSS software and t-test for paired samples for comparing one experimental group.

User Acceptance Using Technology Acceptance Model (TAM). The researcher used the user acceptance model to assess the performance, functionality and the design of the system. Participants evaluated the system using a questionnaire based on the developed TAM model. The factors considered were the usability, functionality, and complexity of the system.

The external variables considered in the study were computer self-efficacy and system complexity.

Results and Discussion

The teachers from the three schools were oriented, installed, and evaluated the Haynayan AR application. An initial assessment of the teacher's readiness survey was floated during the orientation session. The demographics and profiles of the teachers were obtained. In order to obtain data for testing, Google forms were used as a tool. It was also used for the student participant's pretest and posttest. With this tool, insights were gathered on the effectiveness of the application. Further feedback also helped in developing the application moving forward.

1. Teacher Participants' Profile

Table 3
Gender Profile of the Teacher Participants

	N	%
Male	3	23.08%
Female	10	76.92%

Table 4
Device Readiness of teacher participants

	N	%
Yes	13	100.0%

Table 5
Experience in installing a Mobile Application

	N	%
Yes	11	84.61%
No	2	7.61%

Table 6
ICT Proficiency of Teacher Participants

	N	%
Beginner	1	7.69%
Mid	4	30.76
Advanced	5	38.46
Expert	3	23.07%

The participants of this study are the Science teachers at the Magpapalayok NHS, from Maliwalo National High School and the Philippine Science High School - Central Luzon Campus. Three (3) are male teachers while ten (10) are Female teachers. All of them are Android users. Eleven (11) of them have experience installing a mobile application and two (2) haven't tried installing which was subject to technical assistance from their ICT Coordinator. In terms of their ICT Proficiency, one (1) teacher self-rated as "Beginner", four (4) assessed themselves as mid-proficient while five (5) assessed themselves as advanced while three (3) rated themselves as experts.

During the planning of the evaluation strategy, it was suggested by the Magpapalayok NHS that the Grade 7 students will be the participants of the study since they have a General Biology that will tap on the topics contained in the Haynayan AR. Meanwhile, Maliwalo NHS endorsed the Grade 8 students and for PSHS Central Luzon Campus, the participation of Grade 10 students was suggested.

2. Technology Acceptance Model (TAM)

After installing and utilizing the Haynyanan AR application, teacher participants were given the "Usability and Acceptability Survey". The following are the results of the said evaluation.

2.1. Ease of Use and Satisfaction

Results show that most teacher participants find Haynayan AR easy to use. Moreover, the majority of the respondents like the interface of the app, can use the app at ease in social/instructional settings, would like to use it, and are overall satisfied with the app.

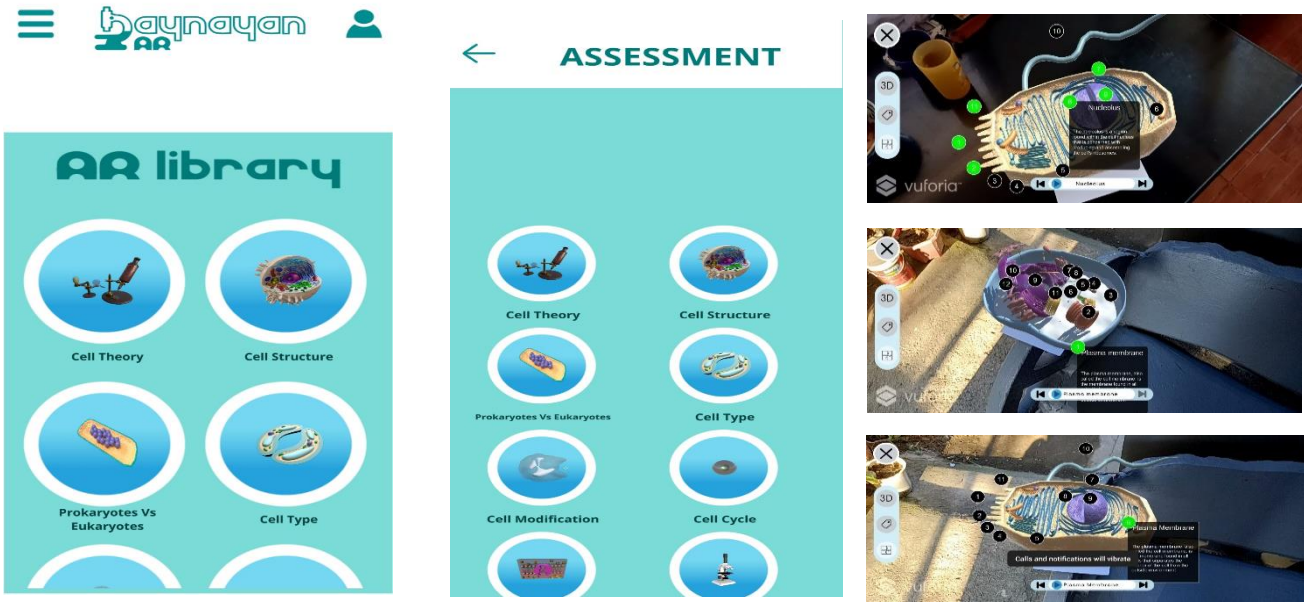

Figure 1. Haynayan AR Screenshots

2. System Information Management

System information management assessed how the Haynayan AR presents the information or lesson including the navigation. The survey result shows that the majority of the teachers can recover easily and quickly whenever they encounter a mistake in the app. All teachers agreed that the app provides a new way of presenting lessons. Most of the teachers agreed that the app acknowledged and informed them of the status of their actions. The majority of the teachers also agreed on the reliability of navigation when switching screens, and that the user interface of the app allowed them to use all the features on the app. Most of them also found that all the functions and capabilities they expected were available on the app.

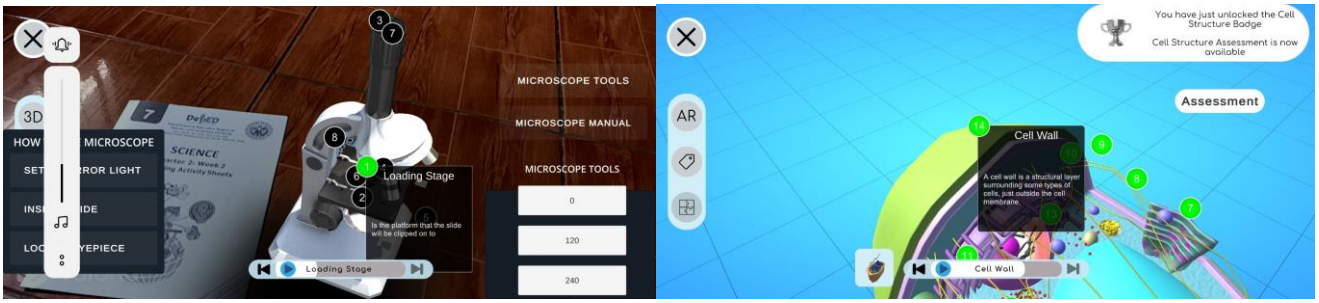

Figure 2. Basic Microscopy and Badge System of Haynayan AR

3. Perceived Usefulness

Perceived usefulness pertains to the conception of teachers on the usability of the application. Five (5) out of seven participants agreed that the app would be useful, provides materials that make learning more fun, and help them assess their understanding of the lessons.

4. Pre-Post Testing Method Approach for Assessing the Learning Outcomes

The t-test was used to measure the dependent variable at the interval level. One group pretest-posttest design with matching scores is employed in the study. (York, 2017) A student orientation session was held to introduce the project and its objectives. Participants were also informed about the option not to participate in the study. Otherwise, they need to submit a duly filled out and signed informed consent form from their parents.

Table 7
Student Participants Gender Profile

	N	%
Male	12	29.27%
Female	29	70.73%

Table 7 illustrates the profile distribution of the student respondents by gender. A total of forty-one (41) students have participated and twenty-nine (29) or more than half of the respondents are female while twelve (12) respondents are male.

5. Pre – Post Test Results

Table 8
Pre-Post Test Results

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Pre	41	27.00	6.00	33.00	21.5455	7.91001
Post	41	24.00	10.00	34.00	24.0606	6.17424

The mean pretest score is 21.5455, while the mean posttest score is 24.0606. This means that the post-test scores are higher than the pre-test scores. It could be surmised that the instructional intervention which is through the use of the Haynayan AR helps in improving the scores of the respondents.

6. Paired Samples Test

Table 9
Paired Sample Test Results

				95% Confidence Interval of the Difference				
	Mean	**Std. Deviation**	**Std. Error Mean**	**Lower**	**Upper**			
Pair 1 Pre-Post	-2.51515	6.36964	1.10878	-4.77367	-.25664	-2.268	32	0.030

A paired-samples t-test was conducted to compare pre-testing results before using Haynayan AR and post-testing after use. These data were subjected to the t-test for paired samples. A statistically significant gain ($t = 2.268$; $n= 32$; $p = .030$) was found on the results shown. The effect size is 0.314, proving that the posttest scores are better than the pretest scores. This could be considered a small effect size.

7. Application of Information and Communication Technologies to Education

Information and Communication Technologies are an integral part of education. ICT provides opportunities and challenges to educators who could utilize them with other teaching strategies and techniques. ICT-based and online instructions are new approaches to providing information to students. This new approach increases the flexibility of the curriculum and allows students to engage and interact as they create new knowledge and novel ideas (Diwakar, et al., 2015).

New discoveries in cell and molecular biology make biology teaching more complicated. However, ICT provides a solution to the problem of visualizing the cellular and molecular processes. ICT provides visual presentations for teachers and students to have an improved comprehension of the process. ICT provides opportunities for teachers to make learning enjoyable for the students. ICT enables educators to access educational materials available in other parts of the world (Sethhilkumar, et al., 2014).

The advances in computer technologies allow teachers to utilize multimedia-based laboratory activities. Teachers can use simulated experiments as tools to improve the academic performance of the learners. Teachers could repeat the experiments if the students were not able to understand them. However, prospective teachers should be ready to utilize ICT-based science instructional materials (Ravichandran and Saravanakumar, 2015).

Through ICT, complex biological processes are becoming easier to teach. It positively affects the understanding of the students of the different concepts and processes. With the increasing development of ICT-based instructional materials, students are motivated to learn the complexities (Elongavan and Ismail, 2014).

The usage of social networks in biology education as an aid to conventional instruction has an effect on students' academic scores. The positive effect of educational social networks could be explained by the views of the students in terms of pacing, complex conceptual understanding, interest and motivation, and interactivity (Nee, 2014).

Virtual environments are used in teaching individuals with special needs. Research shows the positive impacts of virtual environments on the learning of persons with disabilities (Jeffs, 2009). Learners with difficulties in communicating and understanding others could be trained using a virtual environment. However, there is a need to continue to develop new virtual environments to fit the needs of the learners with difficulties (Ramachandiran, et al., 2015).

In the study of Mikropoulus et al. (2003), a three-dimensional synthetic environment was used to support topics in cell biology and photosynthesis. The impact of the virtual environment's teaching was positive. In addition, students show a confident mindset when using computers as learning tools. Students confirmed that e-learning is flexible however it could diminish social contact and interaction. In the absence of direct contact, misunderstanding is often a problem and technical problems could disturb studying. However, it could increase the interaction with other people from different cultures and places (Jeronen and Anttila-Muilu, 2008).

Dewakar et al. (2016) found out that students preferred simulation labs than animation and remote-triggered labs. The users and computers have higher interactivity in simulation labs. The teachers view the use of simulation and animation as tools for students to practice laboratory experiments, especially those with step-by-step procedures.

The use of 3D multimedia simulation and virtual reality (VR) simulation in teaching cell biology provided positive effects on the performance of the students. The simulations helped the students in visualizing the process of cell division and it helped them understand abstract concepts. Furthermore, 3D multimedia simulation has a better impact than desktop virtual reality simulation (Elongovan and Ismail, 2014).

Preference for the use of instructional methods and strategies is based on teachers' judgments if it fits their instructional needs. Students' preferences for instructional materials are based on their perceived learning needs. Thus, the success of the utilization of ICT-based instructional materials is based on the perception and preference of teachers and learners (Katz, 2016).

The constraints that science educators encounter in using ICT as instructional tools include lack of time to earn technology experience and confidence, and lack of access to credible sources. Also, science curriculums with overwhelming content and assessments which do not involve the application of technology were also met. The lack of specific assistance in using ICT in education is another limitation that teachers face. The use of ICT in science is limited to a sector of enthusiastic educators (Osborne and Henessy, 2003).

Visualization process refers to any form of sensory output displayed in a virtual environment. Virtual reality can be presented through desktop or fish tank virtual reality. Another better method is through immersive virtual reality. One application of virtual reality is in education (Abdul-Kader, 2008).

Virtual reality shows a promising potential both as a teaching tool and a learning tool for visualization of complex biological processes. VR is the combination of high-end computing, human-computer interfaces, graphics, sensor technology, and networking. Through this, immersion, and interaction in real-time with artificial 3D models is made possible to the user. These models can represent either realistic environments or imaginary situations (Mikropoulus, et al., 2003).

VR, AR, and other similar variants embody computer interface methods that comprise the three-dimensional space. In this dimension, users can navigate using a multi-sensory approach, exploring with their own sense of sight, hearing, and touch. (Kimer, 2011). Virtual reality can be categorized into three basic ideas (Pinho, 2004). The first one is immersion, wherein users feel actual sensations as if being present inside the virtual world found on the smartphone. This is followed by interaction, where users control the virtual objects present. Finally, the third idea is involvement, wherein users explore and participate in a virtual world. In this, users can navigate actively or passively throughout the virtual world and interfere with the application directly.

According to Clark (2006), Virtual Reality may be utilized to facilitate more engaging and interesting learnings with the intent of increasing attention and motivation, while reducing expenses no matter how costly the simulation is. Furthermore, it makes it feasible to simulate impractical investigations in the real world like traveling around extraterrestrial locations, seeing the insides of a human body, undergoing submarine investigations, checking microscopic places to be seen, or a historical place available only in the past.

Educational visual materials are essential in education. With the advancement of ICT, virtual labs offer help to users especially learners in dealing with complex concepts. Virtual labs improve the academic performance of students who perceive them as useful in understanding complex biological concepts (Dewakar, et al., 2015). Furthermore, the learning styles of the 21st-century learners are anchored on the advancement of technology. The learning styles of students which involve distinctive and observable behavior have a relationship with how they perceive learning and its relationship with the changes in the real world (Gregorc and Ward, 1991).

8. Gamification/Gamified Learning

The etymology of the word gamification came from the English word ‘game’. In terms of AR, the practices of game mechanics, like objective rewards, and inclusion of multiple levels that promotes participation from users, either learning cooperatively as a team or learning competitively, are utilized. (Gonzalez, 2020)

Traditional learning can be increased with a 23% gain by using games. In 2013 research, it is presented that learning outcomes are increased because of games. Content and game mechanics should always come together. Also, games are proven to be powerful motivators, as presented in a 2011 study. They are more effective especially when learning is obtained during the playful part, in contrast to being just a minor part. Games are more effective in teaching and learning when combined with paratexts. A 2011 analysis of simulation games showed that the text combined with the games helped in improving student learnings more than the game alone.

Action games can also develop attentional control. A study from 2012 demonstrates how games can also be effective in training us in learning and shaping our attention.Despite popular opinions, games can encourage learning and suppress negative actions. In fact, the study shows that mental health, as well as cognitive and social skills were improved because of regular gameplay.

9. Augmented reality

The technology that expands our physical world by adding layers of digital information to it is called Augmented Reality (AR). In contrast to Virtual Reality (VR), AR does not generate an entirely artificial world that replaces the real environment with a virtual one. AR appears directly in a current environment and adds assets like 3D models, graphics, videos, and sounds into it.

Conclusion

The teachers are technologically ready given the resources available and their exposure to mobile technology, specifically the use of smartphones and installation of mobile applications. At the same time, the students start to adapt in using technologies such as mobile augmented reality applications. Finally, the use of mobile augmented reality-based tool for Cell Biology and Basic Microscopy has been proven to significantly enhance learning achievement.

Recommendation

Augmented reality-based learning tools can be applied to other difficult topics in science. This will help students engage more in class discussions and understand the lessons more. With the inclusion of these topics, the AR library will not only include topics in biology but also in other fields of science such as chemistry and physics.

Acknowledgments

The author wishes to acknowledge the **Department of Science and Technology (DOST) - Philippine Council for Industry, Energy and Emerging Technology (PCIEERD**) for funding this study. Heartfelt gratitude is extended to the Magpapalayok National High School, Maliwalo National High School and the Philippine Science High School - Central Luzon Campus for the invaluable support. Bunch of thanks to PSHS System Executive Director Lilia T. Habacon for the unwavering support. Kudos to Team Haynayan for their dedication and efforts to this project. Thanks to Mr. Rephael Raagas for contributing his design for the improvement of the Haynayan AR App.

References

Abdul-Kader, H. M. (2008). E-Learning systems in virtual environment. *2008 ITI 6th International Conference on Information & Communications Technology*. https://doi.org/10.1109/itict.2008.4806644

Clark, D. (2006). *Games and e-Learning.* Caspian Learning. http://ww.w.cedma-europe.org/newsletter%20articles/misc/Games%20and%20e-Learning%20(Nov%2006).pdf

Cimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Educational Research and Reviews, 7*(3), 61-71. https://doi.org/10.5897/ERR11.205

Diwakar, S., Radhamani, R., Sasidharakurup, H., Nizar, N., Achuthan, K., & Nair, B. (2015). Roles of ICT-enabled virtual laboratories in biotechnology education: Case studies on blended and remote learning. *2015 International Conference on Interactive Collaborative Learning (ICL)*, 915-921. https://doi.org/10.1109/ICL.2015.7318149.

Elongovan, T., & Ismail, Z. (2014). The effects of 3D computer simulation on biology students' achievement and memory retention. *Asia-Pacific Forum on Science Learning and Teaching*, *15*(2). Article 10. https://www.eduhk.hk/apfslt/download/v15_issue2_files/elangovan.pdf

Gonzalez, C. (2020, March 4). *Geo AR, on a treasure hunt*. Onirix. https://www.onirix.com/geo-ar-on-a-treasure-hunt/

ICTS Simply Effective (2020). What is agile methodology?. https://icts.io/2020/08/04/what-is-agile-methodology/

Jeffs, T. (2009). Virtual reality and special needs. *Themes in Science and Technology Education, 2*(1), 253-268. http://files.eric.ed.gov/fulltext/EJ1131319.pdf

Jeronen, E., Anttilla-Muilu, S., & Jeronen, J. (2008). Problems and challenges in the usage of ICT in biology and geography in schools and teacher education in Finland. *Problems of Education in the 21st Century, 5*, 55-68. http://journals.indexcopernicus.com/abstract.php?icid=857893

Katz, Y. (2016). The historical relationship between affective variables and ICT-based learning and instruction and achievement in the israeli school system. In A. Tatnall, & B. Davey (Eds.), *Reflection on the history of computers in education: early use of computers and teaching about computing in school*. (pp. 324-338). Springer.

Kirner, C. (2012, March) *Realidade Virtual e Aumentada*. http://www.de.ufpb.br/~labteve/publi/2011_svrps.pdf

Mikropoulos, T.A., Katsikis, A., Nikolou, E., & Tsakalis, P. (2003) Virtual environments in biology teaching. *Journal of Biological Education*, 37(4), 176-181. https://doi.org/10.1080/00219266.2003.9655879

Nee, C.K. (2014). The effects of educational networks on students' performance in Biology. *International Journal of Integrating Technology in Education, 3*(1), 21-41. http://airccse.org/journal/ijite/papers/3114ijite02.pdf

Osborne, J., & Hennessy, S. (2003, n.d.). *Literature review in science education and the role of ICT: Promise,* problems and future directions. Futurelab. https://www.nfer.ac.uk/publications/FUTL74/FUTL74.pdf

Ramachandiran, C.R., Jomhari, N., Thiyagaraja, S., & Maria, M. (2015). Virtual reality-based behavioral learning for autistic children. *The Electronic Journal of e-Learning, 13*(5), 357-365.https://files.eric.ed.gov/fulltext/EJ1084231.pdf

Ravichandran, T., & Saravanakumar, A.R.. (2015). Attitude of prospective biology teachers towards multimedia based experiment. *International Journal of Informative and Futuristic Research, 3*(1), 76-82. http://www.ijifr.com/pdfsave/15-09-2015490V3-E1-015.pdf

Republic Act No. 9155 (2001). An act instituting a framework of governance for basic education, establishing authority and accountability, renaming the department of education, culture and sports as the department of education, and for other purposes. https://www.officialgazette.gov.ph/2001/08/11/republic-act-no-9155/

Sethhilkumar, R., Sivapragasam, C., & Senthamaraikannan, B. (2014). Role of ICT in teaching biology. *International Journal of Research*, 1(9), 780-788 https://edupediapublications.org/journals/index.php/IJR/article/download /701/661

Tan, S., Waugh, R., (2014) Use of virtual-reality in teaching and learning molecular biology. https://www.researchgate.net/publication/287779149_Use_of_Virtual-Reality_in_Teaching_and_Learning_Molecular_Biology

York, R. (2017). *Statistics for human service evaluation*. SAGE Publications, Inc.

COPYRIGHTS