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AUGMENTED REALITY IN LABORATORY: PERCEPTION STUDENT ON THE BENEFICIAL SURFACE TENSION PRACTICAL DURING PHARMACEUTICS LABORATORY SESSION

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Abstract

Augmented reality (AR) has recently gained much attention in research. AR has the potential to provide flexible timing for learning at any location with new methods and technology. AR technology can enhance class engagement and make it more informative. This study investigated the feedback of Bachelor of Pharmacy (Hons.) and Bachelor of Science (Hons) Pharmaceutical Chemistry (n = 92) in semester two on the use of AR tools in the joint session of pharmaceutics laboratory during surface tension practical. The study questionnaire was developed from literature

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on AR, and obtained data were analyzed using SPSS 18. According to the collected feedback, 95.6% of the students agreed/strongly agreed that using the AR tool during the practical session was beneficial. Moreover, 94.5% agreed that AR was also helpful after the practical session to recall their learning. 84.8% of the students were found to have a firm agreement with the fact that AR helped to enhance students' knowledge and practical skills. A large percentage of students (80.4%) strongly agreed that using the AR tool is better than videos for the skill-based session. Most students (88.1%) agreed that the quizzes and information given in the AR tool were beneficial to understanding the practical quickly. The highest percentage of students (90.6%) accepted that the quality of teaching and learning material used in the AR tool was good. The potential of AR use in practical could produce promising outcomes. Effective implementation of AR could improve student engagement, understanding, and learning process on practical skills and could effectively impact the quality of teaching and learning.
Keywords: Augmented reality, surface tension, practical skill, feedback

Abstrak

Realiti Terimbuh (RT) telah banyak menerima perhatian dalam dunia penyelidikan sejak kebelakangan ini. Menerusi kaedah baru ini, RT berpotensi mengubah lokasi dan waktu pembelajaran. Keupayaan teknologi RT juga mampu menjadikan pembelajaran lebih menarik dan bermaklumat. Kajian ini menyiasat maklum balas daripada penuntut semester 2 Ijazah Sarjana Muda Farmasi (Kepujian) dan Ijazah Sarjana Muda (Kepujian) Kimia Farmaseutikal (n = 92) atas penggunaan alat RT sewaktu menjalani praktikal ketegangan permukaan ketika sesi makmal farmaseutikal. Borang soal selidik telah dihasilkan daripada kertas kajian berasaskan RB dan data yang diperolehi telah dianalisa menguunakan SPSS 18. Kajian menujukkan 95.6% telah setuju/sangat setuju bahawa pengunnaan alat RB sewaktu menjalankan praktikal amat bermanfaat, 94.5% telah setuju bahawa RB juga bermanfaat selepas sesi praktikal untuk mengingat kembali pembelajaran. 84.8% penuntut didapati bersetuju bahawa RT membantu meningkatkan tahap pengetahuan dan kemahiran praktikal penuntut. Peratusan besar penuntut (80.4%) sangat setuju dengan fakta bahawa pengunaan RT adalah lebih baik berbanding video bagi sesi berasaskan kemahiran. Majoriti penuntut (88.1%) bersetuju bahawa quiz serta maklumat yang diperolehi daripada alat RB amat bermanfaat untuk memahami sesi praktikal dengan mudah. Peratusan tertinggi penuntut (90.6%) berpendapat bahawa kualiti pengajaran dan pembelajaran yang digunakan menerusi alat RB adalah amat baik. Penggunaan RT dalam

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praktikal berpotensi membuahkan hasil yang memberangsangkan. Pelaksanaan RB yang berkesan mampu merangsang minat, meningkatkan penglibatan, pemahaman dan proses pembelajaran penuntut terhadap kemahiran praktikal dan memberikan impak yang berkesan terhadap kualiti proses pengajaran dan pembelajaran.
Kata kunci: Realiti Terimbuh (RT), ketegangan permukaan, kemahiran praktikal, maklum balas

1.0 INTRODUCTION

The increasing excessive use of electronic devices by the current generation has played an essential role in developing technology-enhanced tools for effective learning. In this regard, augmented reality (AR) has been gaining much attention in the research world in the past few years. It has been given different definitions by several researchers (Wu et al., 2013). AR can be generally regarded as a technology that superimposes a computer-generated image (augmented components) into one's real-world image (Akçayır & Akçayır, 2017). This allows one to have real-time interaction while having an exact three-dimensional registration of virtual and real objects. These objects can appear in the same space as objects in the real world (Akçayır et al., 2016). During the early '90s, AR was developed as an educational tool for airline and Air Force pilots (Akçayır & Akçayır, 2017). In recent years, AR has been gaining popularity and is widely recognized as a learning aid in various areas, including research (Akçayır et al., 2016).

As a tool for bridging virtual and real worlds, AR has enabled easier understanding and improved imagination among students. AR provides a platform for students to visualize abstract concepts, experience impossible phenomena, and interact with two- and three-dimensional objects during authentic explorations hence aiding in improved investigational skills. In this regard, Martin et al. developed a manual for the electric machine laboratory to evaluate its effectiveness; students were provided with classical notes and an AR manual. The set AR manual consists of animations and 3D models. In the feedback, students showed positive responses to the AR manual. They also appreciate the augmented content and app structure. Students find it very interesting and accept that the AR manual enhanced their learning (Martin et al., 2012). In other research, a mobile-based AR app was developed to train the students in practical skills. The first model was developed for the titration experiment. The finding showed that the app was well received by the users with good usability. However, some technical issues were resolved with participant feedback. This app enhanced the student's ability to tackle the technical problem

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(Alfaro et al., 2022). Similarly, In another study, AR app was developed to reduce the risk of handling the chemical by new students. This app allows students to practice experiment virtually many time with instruction on common errors associated. The students felt that using this app minimize the handling risk of chemicals during the real practical sessions (Tee et al., 2018).

Despite having a unique ability to provide an immersive hybrid learning environment that incorporates digital and physical objects. AR can be complicated to use and difficult to handle due to its complexity, especially if there is a lack of guidance (Wu et al., 2013; De et al., 2013). It can be produced by coupling several innovative technologies such as handphones, computers, and immersion technologies (Akçayır et al., 2016). It can be widely used for educational purposes, specifically in understanding spatial relationships. For instance, up to now, AR has been utilized to allow students to view the virtual solar system and understand the process of photosynthesis (De et al., 2013). It has also been used to facilitate the understanding of mathematics and geometry. Other fields where AR has been implemented are medicine, military, engineering design, telerobotic, robotic, manufacturing, maintenance, repair applications, psychological treatments, and consumer design. It has not only assisted in enhancing one's learning as it allows the object to be viewed from various perspectives but can also make an obscure subject matter more approachable (De et al., 2013). Some of the distinguished contributions of AR are its emphasis on enjoyment while learning, which increases one's engagement. Students tend to focus more when using AR as a learning tool because learning with AR would necessitate using senses and manipulating how they communicate with the world.

Furthermore, AR has the potential to fill the gaps between formal and informal learning while enhancing one's individuality as mobile-AR systems have been developed to support learning processes outside of the classroom (Di Serio et al., 2013). Other features of this system include portability, connectivity, context-sensitivity, and social interactivity (Akçayır et al., 2016). Although similar skills and knowledge can be learned through other technology-enhanced learning environments, but research has shown that AR systems are still more effective in facilitating skill acquisition. We want to fill teaching gaps while using simulation. The AR teaching and learning activities usually involve several approaches, such as participatory simulation and studio-based pedagogy, emphasize cooperative and collaborative activities, and tend to be entirely dissimilar to the conventional teaching method (Lemley et al., 2017). In the healthcare

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field, institutional constraints, where a certain amount of topic needs to be covered by face-to-face practice sessions to develop essential skills that may pose challenges in implementing AR into the education system (Ling et al., 2017; Kesim et al., 2012; Tuli et al., 2015).) for instance, in practice sessions for fabricating pharmaceutical formulations to achieve the desired results, clearly defined goals and benchmarks must be set. At the same time, it has to be ensured that students are not overburdened with much information (Ahn et al., 2018). AR technology was developed to enhance the practical skills of students not to replace actual practice sessions. Moreover, the development cost of AR is higher in some cases, addiction and fatality is also major setback of excessive use of electronic devices.

2.0 METHODOLOGY

This study investigated the feedback of Bachelor of Pharmacy (Hons.) and Bachelor of Science (Hons) Pharmaceutical Chemistry (n = 92) of semester two on the use of AR tools in the joint session of pharmaceutics laboratory during surface tension practical. This AR tool was developed using the Blippar app platform, which can be freely downloaded from the play store. Students were instructed to download the app and scan the trigger image provided. The steps to use the AR tools were briefed to the students, Figure 1.

The students were not separated into the control and test group as the content learning may impact their assessment output. Therefore, all the students were exposed to the surface tension practice model for their knowledge enhancement. A relevant briefing was done regarding the purpose of the research, and their consent was taken to provide their feedback. A study questionnaire was developed from literature on AR and quantitative data collection tools. The obtained data were analyzed in the terms of percentage and number of respondents.. The findings were reported in terms of numbers and percentages.

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Figure 1: Steps to use AR tool for surface tension practical.

3. RESULTS AND DISCUSSION

In light of the experiments and the results of the questionnaire evaluation, it seems that students' perception of the relevance of using the augmented reality model (AR model) for practical is beneficial for students' learning before, during the conduction, and after the completion of practical are positive. As evident from Figure 2, approx. 85% of students strongly agreed/agreed that the developed AR tool helped enhance their knowledge and skill. Similarly, 95.6% of students agreed/strongly agreed with the benefits of using AR during a practical, while 94.5% were d that AR was also beneficial after practical recall, Figure 2. Some open-ended questions were asked from students to compare the traditional practice of practical briefing with AR tool. In open-ended questions, students mentioned that these tools are more effective before and after the practical session than during the session as they can use it as a repository to recall key factors pr information related to the practical.

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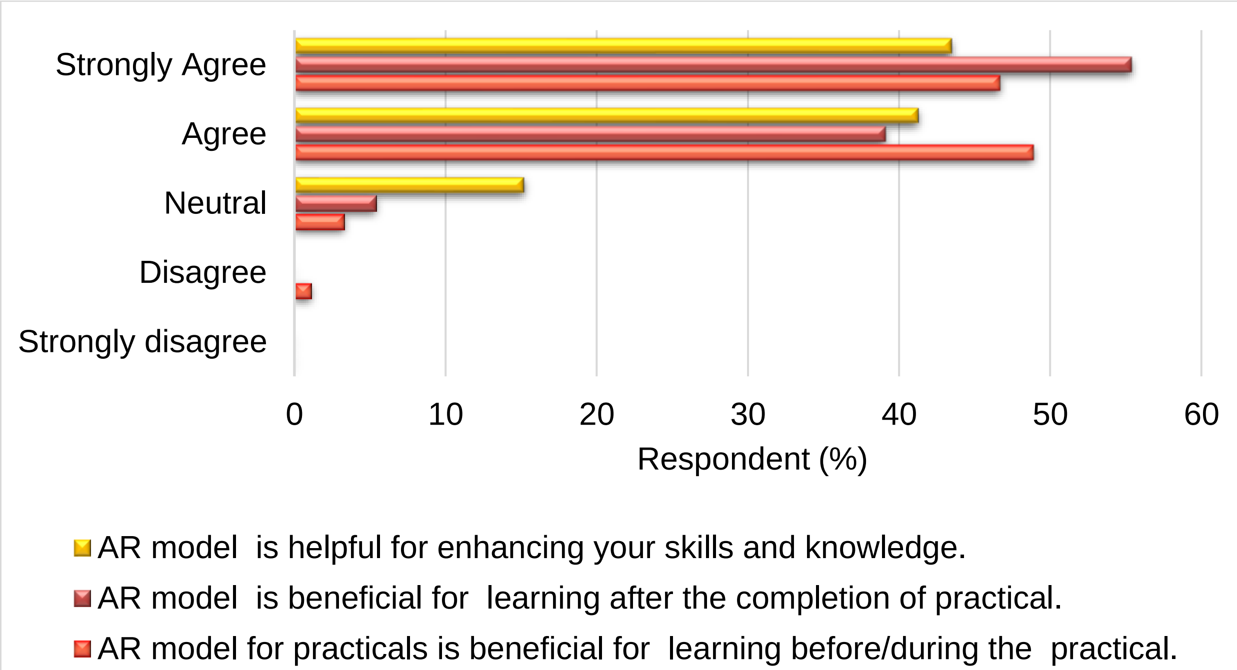

Figure 2: Students' feedback on their learning before, during, or after the session.

This result was similar to a few other research works, which explain that the AR model experimentation is beneficial for the learner to conduct the actual experiments and enhance the skills, knowledge, and future learning (Barma et al., 2015). Barma et al. (2015) divided the student into control and test group. They found out that students in test groups understood the concept and could correlate the idea with the application using the AR model compared to the control group.

Furthermore, all students were satisfied with using the AR model for practical with better understanding. These results were similar to Nielsen et al. work outcome, which indicates that the inclusion of the AR model helps students to understand better a picture of their subject in detail as well as motivates them to have a direct interaction of their studies with 3D models (Nielsen et al., 2016). The facilitator of the practical mentioned that after using the app the students are more independent to perform practicals and common errors were reduced.

An additional component like a quiz and instructions in the AR tool make them understand the content better. According to the results obtained, students strongly agreed (51.1%) that the AR model for practical helped them in self-directed learning in and out of class (Figure 3). These

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results were similar to other research on developing low-cost CPR manikins to deliver tactile information about Basic Life Support and Defibrillation (BLSD) procedures in which all users rarely used an AR application. The general appreciation of the AR application was rated 4.7 out of 5; users also stated that this was easy to use and effective for learning (Bottino et al., 2018).

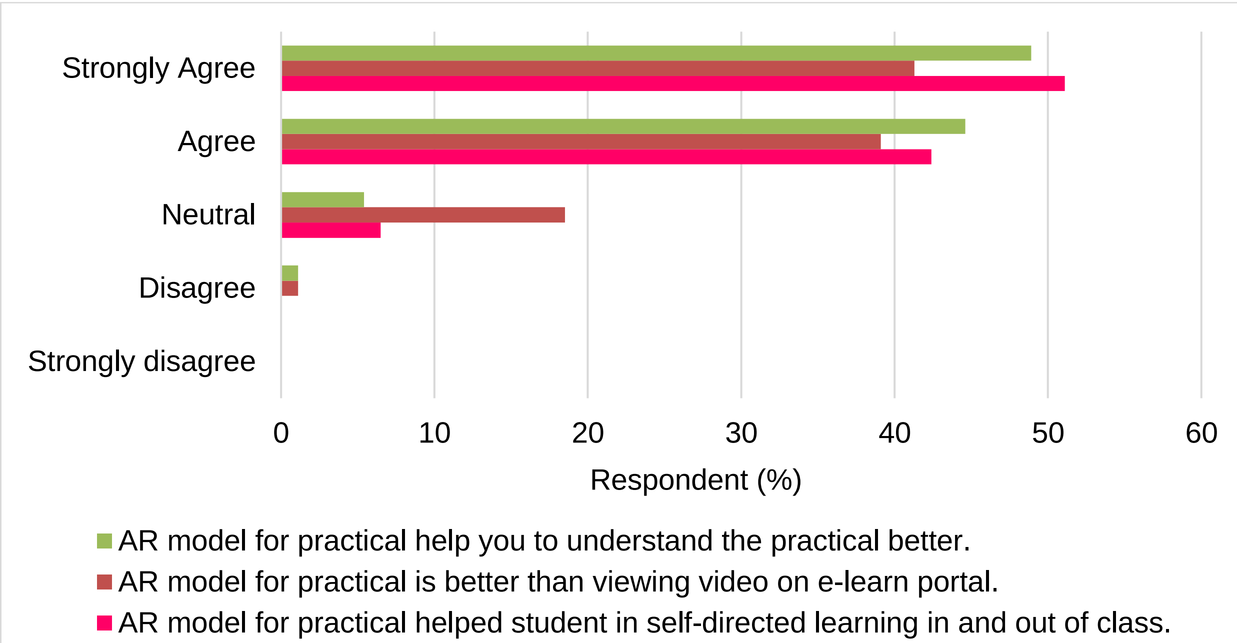

Figure 3: Feedback of students on their learning understanding, compatibility, and self-directed learning.

Regarding the concept of learning practical through AR compared to videos uploaded on the e-learn portal, where around 80% agreed/strongly agreed that the AR model for practical e-briefing is better compared to watching videos on the e-portal (Figure 3) because the AR model contained video along with that theory related to that practical and quiz to evaluate their understanding. Internet evolution leads to the birth of e-learning and online courses. However, there is still a lack of tools to provide effective virtual practical activities for learners. Therefore, based on an AR system, it is necessary to develop a virtual laboratory where all students and teachers can learn from the virtual experiment like in actual practical activity. The major limitation of video is the lack of interactivity, where learners would only learn passively since direct interaction with objects is unavailable (González et al., 2020).

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The lecturer's language was strongly acceptable in the AR model for practical, according to the results obtained (43.5%) (Figure 4). An example was provided by Liu & Tsai (2013), in which an AR app was developed for a campus tour to improve students' English learning ability. It works as such where a text description is overlaid on the screen when students point the camera at one of several predefined locations. The learner would be able to click to receive further detailed information.

Moreover, the aspect of providing information and quiz in the AR model for practical was also tested, and it was strongly welcomed (45.7%) by the students, which might be due to better learning of any lesson (Figure 4). This will eventually help students become masters in each learning unit before proceeding to a more advanced learning task, unlike traditional instruction environments. Traditional practical sessions are faculty-centered, and a cluster of information was provided by faculty in a short period. As we know, every student has their own pace of learning, so they can't recall all the information provided at the time of evaluation. AR tools provide a platform for students to revise the instruction provided during the practical session.

Lastly, the students strongly agreed (50.0%) that the quality of teaching and learning experience in AR tools was good. Across the studies, high variability could be seen in the aim of research and usability of AR tools in the healthcare sector. Improvement of learning by AR tools was evident in several studies. These research results show AR tools' impact on learner knowledge acquisition and skill development (Bottino et al., 2018; Tuli et al., 2015). In addition, different aspects were notified in several studies, for instance, improved learner's attention, low failure rate, high-performance accuracy, self-paced learning with more experience, and critical thinking.

Apart from that, the application of AR technology in anatomy teaching benefits the students, who can get book scanning apps using a smart device. The authentic heart images can be scanned and will appear as a 3D image which is flexible to size change and rotation of the image to view the heart from a different angle (Zhu et al., 2014; Goo et al., 2020).

While comparing their understanding of practical procedures by faculty observation, we found that the cohort that used the AR tool were more explicit about their procedure, performing

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practical with minor errors and asking less doubt from faculty. This concludes that developed AR tools enhanced students learning.

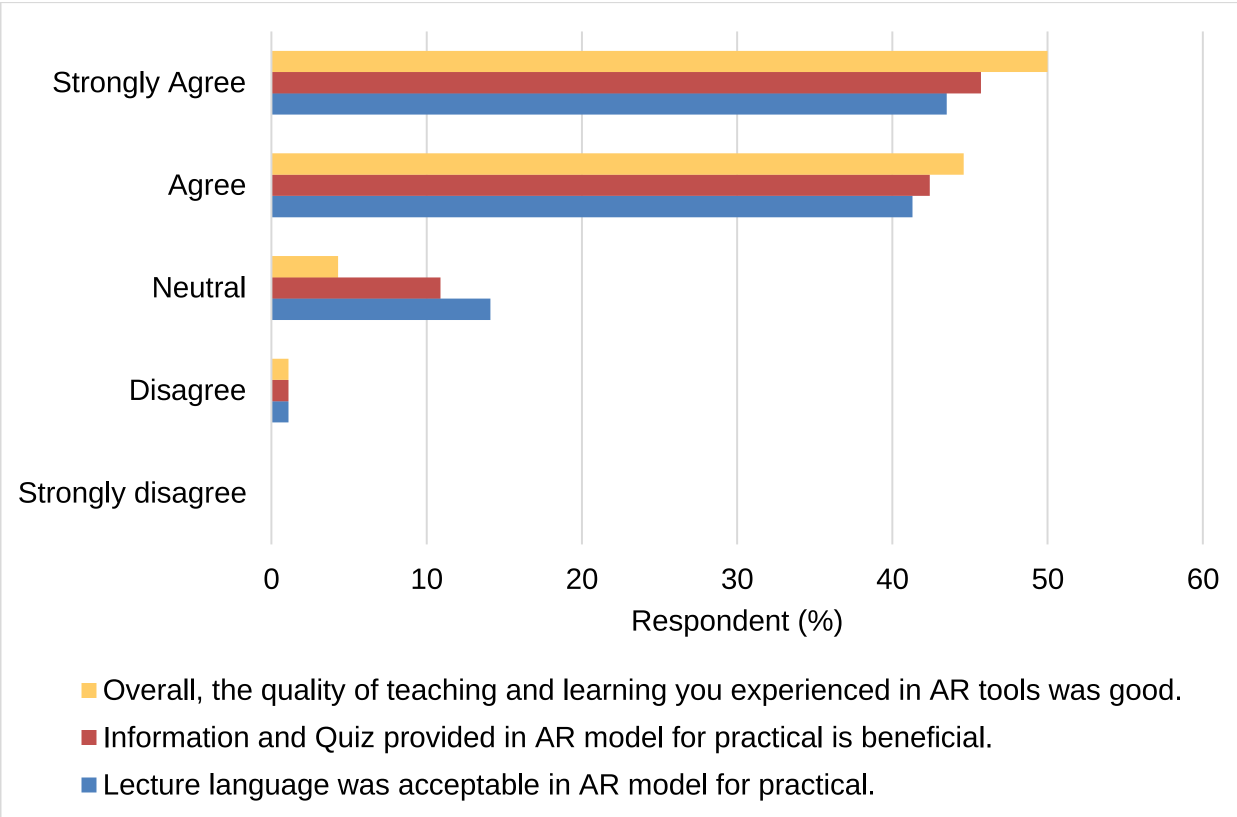

Figure 4: Students' feedback on their experience, additional material, and audio quality.

4. CONCLUSION

It can be concluded that AR provides concise, timely, and convenient information that simulates authentic experiences and shortens the learning curve. The major limitation of videos on YouTube or e-learn is the lack of interaction where learners would only learn passively since engaging tools are unavailable. Results showed the effective implementation of AR could improve student engagement, understanding, and learning process on practical skills and could effectively impact the quality of teaching and learning. The learning quality was affected by the use of technology-enhanced learning as observed by the facilitator of that lab session.

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5. REFERENCES

Ahn E, Lee S, & Kim G. (2018). Real-time adjustment of contrast saliency for improved information visibility in mobile augmented reality. *Virtual Reality*, 22 (3), 245–262. https://doi.org/10.1007/s10055-017-0319-y

Akçayır M,& Akçayır G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, 20,1-11. https://doi.org/10.1016/j.edurev.2016.11.002.

Akçayır M, Akçayır G, Pektaş H, & Ocak M. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. *Computers in Human Behavior*, 57, 334-342. https://doi.org/10.1016/j.chb.2015.12.054.

Barma, S., Daniel, S., Bacon, N., Gingras, M.-A., & Fortin, M. (2015). Observation and analysis of a classroom teaching and learning practice based on augmented reality and serious games on mobile platforms. *International Journal of Serious Games*, *2*(2). https://doi.org/10.17083/ijsg.v2i2.66

Bottino, A., Ingrassia, P., Lamberti, F., Salvetti, F., Strada, F., & Vitillo, A. (2018). Holo-BLSD: an Augmented Reality self-directed learning and evaluation system for effective Basic Life Support Defibrillation training. *18th International Meeting on Simulation in Healthcare (IMSH 2018)*, available at: http://hdl.handle.net/11583/2687521

De Jong, T., Linn, M. C., & Zacharia, Z. C. (2013). Physical and virtual laboratories in science and engineering education. *Science*, 340 (6130), 305–308. https://doi.org/10.1126/science.1230579

Di Serio, Á., Ibáñez, M., & Kloos, C. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education*, 68, 586-596. https://doi.org/10.1016/j.compedu.2012.03.002.

Received: 18 November 2021, Accepted: 23 August 2022, Published: 20 December 2022
https://doi.org/10.17576/ajtlhe.1402.2022.04

Dominguez Alfaro, J. L., Gantois, S., Blattgerste, J., De Croon, R., Verbert, K., Pfeiffer, T., & Van Puyvelde, P. (2022). Mobile Augmented Reality Laboratory for Learning Acid–Base Titration. *Journal of Chemical Education*, 99, 2, 531–537.

González Vargas, J.C., Fabregat, R., Carrillo-Ramos, A., & Jové, T. (2020). Survey: Using Augmented Reality to Improve Learning Motivation in Cultural Heritage Studies. *Applied Sciences*, 10(3), 897. https://doi.org/10.3390/app10030897

Goo, H. W., Park, S. J., & Yoo, S. J. (2020). Advanced Medical Use of Three-Dimensional Imaging in Congenital Heart Disease: Augmented Reality, Mixed Reality, Virtual Reality, and Three-Dimensional Printing. *Korean Journal of Radiology*, 21 (2), 133–145. https://doi.org/10.3348/kjr.2019.0625

Kesim, M., & Ozarslan, Y. (2012). Augmented Reality in Education: Current Technologies and the Potential for Education. *Procedia - Social and Behavioral Sciences*, 47, 297-302. https://doi.org/10.1016/j.sbspro.2012.06.654.

Lemley, M. A., & Volokh, E. (2017). The Real Law of Virtual Reality. Stanford Public Law Working Paper, 51 UC Davis Law Review 51(2017). http://dx.doi.org/10.2139/ssrn.3050233

Ling H. (2017). Augmented Reality in Reality. *IEEE MultiMedia*. 24(3),10-15. https://doi.org/10.1109/MMUL.2017.3051517

Liu, P.H. E, Tsai, & M.K. (2013). Using augmented-reality-based mobile learning material in EFL english composition: an exploratory case study. *British Journal of Educational Technology*, 44: E1-E4. https://doi.org/10.1111/j.1467-8535.2012.01302.x .

Martin-Gutierrez, J., Guinters, E., & Perez-Lopez, D. (2012). Improving Strategy of Self-Learning in Engineering: Laboratories with Augmented Reality. *Procedia - Social and Behavioral Sciences.* 51, 832-839. https://doi.org/10.1016/j.sbspro.2012.08.249.

Received: 18 November 2021, Accepted: 23 August 2022, Published: 20 December 2022
https://doi.org/10.17576/ajtlhe.1402.2022.04

Nielsen, B.L., Brandt, H., & Swensen, H. (2016). Augmented Reality in science education– affordances for student learning. *NorDiNa*, 12(2), 157-174. https://doi.org/10.5617/nordina.2399

Tee, N. Y. K., Gan, H. S., Li, J., Cheong, B. H. P., Tan, H. Y., Liew, O. W., & Ng, T. W. (2018). Developing and demonstrating an augmented reality colorimetric titration tool. Journal of Chemical Education, 95(3), 393-399.Tuli, N., & Mantri, A. (2015). Augmented Reality as Teaching Aid: Making Chemistry Interactive. *Journal of Engineering Education Transformations*. 28:188-191. https://dx.doi.org/10.16920/jeet/2015/v0i0/59624

Wu, H., Lee, S., Chang, H., & Liang, J. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education.* 62, 41-49. https://doi.org/10.1016/j.compedu.2012.10.024.

Zhu, E., Hadadgar, A., Masiello, I., & Zary, N. (2014). Augmented reality in healthcare education: an integrative review. *Peer J*. 8, 2:e469. https://doi.org/10.7717/peerj.469