A Preliminary Analysis of Novice Science Teachers Towards the Integration of Virtual Reality (VR) in Science Laboratory

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ABSTRACT

Since the pandemic has led to a new norm in our daily lives, there is an urge to implement more technology-based teaching aids in school teaching and learning management. This is especially so for subjects that involve hands-on, like laboratory (lab) work. For this reason, among all the technology applications, Virtual Reality (VR) seems potentially an emerging tool. A virtual world is described as a digital world intended to look and experience just like the real world. VR is a technology that enables users to interact with their settings. Since learning institutions must adapt to the rapidly changing educational environment to use integrated technology in their lessons, they need to create effective learning methods. To ensure students can continue their studies in these new norms, the education system in Malaysia has to adapt to accommodate the way the millennials learn. New e-learning programmes in classrooms and more computer laboratories would help teachers to experiment with new ways of teaching. To better understand scientific concepts, a group of novice science teachers will be investigating the use of VR in the science lab. The study employs a Design and Development Research (DDR) design. This paper serves as the initial phase that identifies early perceptions from these novice science teachers towards applying a VR learning tool for science lab activities during their pre-practicum teaching programme. One hundred and seven (107) respondents from each of the three Science Education programmes responded to a series of questionnaires in a survey posted to them. This was followed by an interview session with five (5) science novice teachers and three (3) science instructors. The survey responses were studied, and their data were compared and verified. The initial findings showed that VR was seen positively as a need in a hazardous and complex situations. It is also recommended that types of VR applications should be low-cost and low-maintenance.

Keywords: Virtual reality, Science lab, Novice science teachers

Article Info:
Received 21 Sept 2021
Accepted 25 Nov 2021
Published 30 Nov 2021

INTRODUCTION

Considering the many advantages that virtual reality (VR) provides for both reality and academic research, there are several educational settings in which it may be used to enhance the traditional way of teaching. Although VR is presently used mostly in the fields of healthcare, engineering, and manufacturing, it has already begun to be used in high school education due to the technology's suitability for the huge millennial demographic (Au et al., 2017). Students can also benefit from VR because they will have the additional ability to view objects not only in an immersive setting but also in more detail and from numerous angles. VR is instrumental in education and training since it allows learners to acquire similar simulated senses as if they were in the real world while being influenced by any implications in the simulated world. This is doubly useful in specific situations and crucial practical learning experimentation (Sulaiman 2011, 2019). Rather than being concerned about the repercussions of their actions in the actual world or making many errors, students are given a chance to expand their knowledge gradually. The use of VR may help increase students' enthusiasm, engagement and motivation in the science classroom setting. Students may utilise the VR programmes at any time without a limited time pace while pursuing their learning in virtual reality (Pirker, 2019). VR is the technology that many educators should embrace to learn because hands-on activities can still be continued in any situation, including during the Covid-19 pandemic.

Using VR not only allows students to perform their own experiments but can also help them to understand abstract scientific concepts. According to Wong (2018), students have difficulty conceptualising certain notions like a gravitational pull, force, pressure, and heat in the context of a science experiment. This is because they are not able to observe these invisible concepts with their own eyes, which in turn may cause them to become disengaged from the subject matter. The use of VR can enable students to conduct simulated tests in the telepresence of science labs, investigate procedures in an experiment and get a more in-depth knowledge of how procedures and processes function in science subjects. However, for VR to be designed effectively, it is necessary to first evaluate students' and teachers' preconceptions and their grasp on the subjects that portray the toughest challenges in discovering science subjects. Only then can they select the most suitable virtual reality gadgets to use for their learning (Saleh, 2011; Sulaiman, 2012).

BACKGROUND OF STUDY

Science Education and Laboratory (Lab) Practices

Science is a subject that encompasses the knowledge of examining the structure and behaviour of all the physical and natural world through observation and experiment. Science education is most commonly broken down into the following three fields of study: (i) biology – the study of the structure, the function of all living organisms and their interactions (ii) chemistry – deals with the composition, structure, and properties of substances and their transformations (iii) physics – deals with matter, energy and their interactions. Central to science learning is inquiry. When students engage in inquiry, they need to observe, ask questions, attempt to construct explanations, test their explanations against the current scientific knowledge, and finally communicate their ideas to others. One of the ways to engage in the inquiry process is through conducting their own science experiments. Science experiments require specific conditions, like a science lab equipped with scientific apparatus, chemicals, safety facilities. In most countries around the world, science labs are where students begin their journey as science students.

The importance of science lab work in the science education curriculum has changed significantly during the last few decades. There has been a wide range of educational objectives attributed to lab teaching throughout history. Findings from previous research found that while lab investigations provide valuable opportunities for students to make connections, lab inquiry alone will not be available to ensure learners create the complex conceptual understandings required by the scientific community in the contemporary world. This is due to the relationship between both scientific knowledge models and theories explored in the school setting and curriculums and inferences of phenomena and systems. In an attempt to transform students' understandings in the direction of established scientific knowledge, science lab and hands-on activities are encouraged in the science education programme (Dohn et al., 2016). In addition, Ural (2016) posited that in basic science learning, active participation with concepts such as analogies and notion bridges could have benefited in the formation of more scientific perceptions. Embedding laboratories into other cognitive strategies, active learning, and including concept interaction could assist learners successfully.

Science Laboratory as Learning Environment

As inquiry-based learning provides an opportunity for students to develop a better understanding of science through scientific investigation, lab education has traditionally taken place in specially constructed realms known as teaching labs. As explained by Hofstein (2007), as an inquiry learning platform for learners to gain a greater understanding of science through investigation, lab education has been shown to have the potential to positively impact student interest in learning science. According to research conducted by Dohn et al. (2016), students' understanding of theoretical ideas and lab techniques seems to be aided by the tactile quality of the experience in a teaching lab. Despite this, research has shown that such experiences have little impact on future scientific performance and success (Ural, 2016).

The term "learning environment" denotes the real objects in which students learn; it extends to the whole environment where learners engage. There are various tools and information resources provided and positive correlations between students and teachers, including the standards for learning and behaviour. The science lab is an essential component of the learning environment because it is where the majority of the scientific activities intended for learning take place.

Virtual Reality (VR) for Science Laboratory

Several researchers have found that digital technology may be a possible adjunct to conventional technology to the conventional learning lab while searching for new methods to enhance lab education (Angel, 2015). Increasing evidence suggests that the use of VR labs affects student outcomes (Reeves & Crippen, 2021). However, while studies of this phenomenon have been carried out, most of them have been evaluative and have given limited information about what students are feeling (Reeves & Crippen, 2021). Rodriguez (2018) highlighted the need for a shift in the techniques used to research lab education, emphasizing the need for outcome-based approaches that are mainly focused on quantifiable results. A more open-ended, exploratory design, they argue, would be more suited to coping with the complexity of the lab setting.

The application of VR in subjects related to science, technology, engineering, and mathematics (STEM), among other things, is the subject of the overwhelming majority of articles published at this time (Jimenez and colleagues, 2019; Rakhmawati et al., 2020). While many STEM-related studies were conducted, only a limited number of STEM-related studies were found for STEM-related subjects which did not explicitly address the need for lab activities.

VR for Science Novice Teacher

Following a study of the available literature within Malaysia, it was found that science courses were considered the most challenging subjects for novice science teachers (Halim et al., 2016; Sumintono, 2017). One of the struggles was that science novice teachers have difficulty in transferring their cognitive understanding towards their teaching of skills in science laboratory (Affeldt et al., 2018). In light of VR implementation, especially in science education programmes, the realism of the environment for novice science teachers allows them to learn from modelled real-life situations (Lamb & Etopio, 2020). On the other hand, Weston & Amador (2021) suggest that VR helps novice science teachers to develop their teaching personality, especially in conducting labs. This is because VR allows mistakes to be made in a safe environment. For this reason, understanding the expectations of science novice teachers on this new trend of using VR as a learning aid in science laboratories is essential for further implementation of VR in science laboratories (Pearl, 2019).

This study is part of a bigger project to finally design and develop a VR programme where students in schools can conduct their experiments in virtual science labs. To ensure that the VR programme developed is effective, feedback is needed to help in its implementation. Thus, the aim of the study is to gain insights, views, opinions and perceptions of novice science teachers as well as their science instructors on VR as a feasible aid to studying science and doing lab work in schools. This will allow the researchers to fully understand whether both novice science teachers and instructors perceive VR as a study aid for science subjects that include lab work. The responses obtained can help to prepare and establish the groundwork as well as the framework for the development of the VR programme.

METHOD

Research Design

This study utilises a mixed-method approach. The feedback needed to proceed with the implementation and development of VR programmes in schools will be obtained via a two-stage process. In the first stage, questionnaires in a survey form are sent online to participants in this study. The data obtained from this survey is analysed quantitatively. This is followed by the second stage where online interviews conducted on selected participants are used to explore ideas and further explain the results from the questionnaire in the survey. The participants for this study are selected via purposive sampling because they serve as the primary source of data due to the nature of the research design and aims and objectives.

Research Participants

This study is conducted at the Faculty of Education, Universiti Technology MARA (UiTM). The research participants are three (3) instructors from each of the science education programmes at the university, namely Physics, Biology, and Chemistry, as well as one hundred and seven (107) novice science teachers from the programme. Novice science teachers refer to students from this faculty who have completed three years of the science teaching programme, have gone for their practicum and return to the faculty for their final semester to complete their degree in science teaching. These novice science teachers, as well as the three instructors in this study, will be referred to as participants henceforth in the following discussion.

In the first stage, the one hundred and ten (110) participants (107 novice science teachers and 3 instructors) are provided a link to an online survey during their pre-practicum teaching seminar conducted online organised by the faculty. They are required to answer the questionnaire in the Google form provided. At the end of the seminar, five (5) representatives from the novice science teachers together with the three instructors from each programme, Physics, Chemistry and Biology, are interviewed using the Google Meet platform.

Data Collection

The entire project of developing the VR programme involves 4 phases of design and development. As this is the initial stage of this study, the data collected is mainly to gain insights from the survey questionnaire, which includes both closed-ended and open-ended inquiries. Four (4) five-point Likert-type items are supplied for novice teachers to respond to. A series of questions are then posed to the participants about the aim of using virtual reality in scientific laboratory courses. These cover the anticipation, applicability, and acceptance of VR, as well as their perspectives on VR. There is also a science lab topic that is considered fit for learning utilising infographics aids provided. In the Google form, participants are also asked questions regarding their teaching background and their perspectives on VR technology. They are also asked to suggest what kind of VR devices they feel would be most helpful to students in schools.

In the second stage, eight (8) participants (3 instructors and 5 novice science teachers) are interviewed online via Google Meet. The interviews are conducted by the research team and each interview session lasts an hour. The interview questions probed the following:

1. What is your view about VR in a science lab?
2. Which would you prefer? A fully VR class or partially VR?
3. What is your preference of a device-related to VR, VR simulator lab or simply VR using a smartphone?
4. Why do you think this science education programme should include the introduction of VR usage?
5. What is your opinion that VR will replace other media (like YouTube, video, and movies) for future Science teaching and learning?

Once all the responses from the participants are collected, additional comments and recommendations from peer reviews are obtained from experts in the areas of VR.

RESULT

The survey questions sent out received 100% responses of which 49.5% of respondents are male and 50.5 % are female. The responses and opinions obtained are important because these respondents have had first-hand experience studying science subjects via conventional methods when they were in their former institutions. They would be in a better position to recommend themes that are considered appropriate for learning through VR. The responses from the survey questions reveal that 42 % of participants think VR is mainly used for entertainment while 60.8 % claimed it is also used for education. The rest believed it is used for work-related reasons, amusement, and interaction.

Next is the perceptions of the participants on the possibility of using VR to perform science experiments. They are questioned on their level of curiosity, comprehension, and enthusiasm for VR. From the feedback on the Google form, participants express that learning science topics in general with the use of graphics and images is engaging. Learning to conduct science laboratory experiments through graphics and animation is helpful, and learning to conduct science lab experiments through VR would aid them in better understanding the subjects. The participants also commented that conducting laboratory experiments through VR would be intriguing.

Most of the questions received from the survey questionnaire gave an average response rating of between 4 and 5 on the Likert scale, indicating that novice science teachers are generally in agreement, with some firmly embracing the usage of VR technology. The learning of broad science and chemistry topics utilising visual, graphic, and animation techniques produced the highest mean score. According to the results of an open-ended structured interview with the instructors, it is discovered that participants would resort to utilising animations, sketching ideas in graphical form, and YouTube videos to help their students grasp topics better than they would otherwise. However, the participants were doing it randomly without understanding the role and function of each media.

From the interview sessions, it is found that most participants do not have a technical understanding of each type of technology implementation in terms of efficiency and usability. Conceptual understanding in learning science and laboratory activity requires comprehension that cannot be seen with eyes. Science must be visualised in order for them to be of interest and appreciated by both teachers and students in both the classroom setting as well as in the lab. For this purpose, simulation and modelling using technology like video, graphic and simulation aid is needed. When the programme on VR is designed and developed, it will detail the interphase, immersion and interaction aspects to ensure the science experiments and other activities in the lab be more engaged and effective. In the last section, when participants (novice science teachers) are asked which VR gadget they thought would be the most appropriate to use as a learning tool aid, most replied that the most ideal would be a smartphone that is integrated into a VR device. Others suggest using one that is connected to a personal computer (PC) and a completely immersed VR device. The devices described are all typical means of utilising VR for a variety of purposes, and they are all readily accessible on the market. The participants would be better able to recognize the gadgets if they had a visual to go along with them.

On the factors that lead them to choose the device they did, nearly 40% of participants choose to use VR PCs in school. These participants believe that VR PC involves VR equipment that is linked to a computer, while others think VR PC is desktop VR in which they may see virtual world simulations on a computer screen. They assume that using VR programmes on computers is faster than on smartphones because they are more acquainted with working with computers. The participants also believe that VR is better suited for more challenging and complex simulations, hence computers make it more effective to run such simulations. Furthermore, in comparing VR devices, the model offers greater computational power and graphical processing capabilities than phones or standalone VR headsets. Since users can share their input with a multitude of other users through their computer screens, it is crucial to ensure that the results are clear and understandable. While having the ability to access and review several applications, the participants believe that they will have the option to observe the interactive virtual simulation concurrently while taking notes or accessing information.

The use of a smartphone in conjunction with VR equipment receives the second-highest number of votes, garnering 33 percent of the total vote. One of the major reasons for choosing the smartphone is its affordability to students compared to a PC. In addition, because the majority of the participants already have smartphones, it will be easier for them to access VR using the current technology, rather than acquiring new equipment which could be more expensive and less accessible. One participant even proposed that schools should encourage teachers to use their smartphones for teaching reasons if they have access to a VR programme. As another participant pointed out, utilizing smartphones for VR avoids the need to purchase other expensive VR equipment or peripherals, which would otherwise be necessary.

Convenience and accessibility are also cited as factors in the decision to use smartphone VR. The participants believe that using a smartphone for VR is appropriate since it allows them to access VR from any location and at their convenience. In addition, there should be no geographical restrictions on participants' ability to access VR using their own mobile devices rather than those provided by the school in the future, if they so want. To begin with, they may see utilising technology at schools or even in their own space, such as their own house because the main gadget is theirs.

The last option chosen is the usage of completely immersive VR. Immersion in VR is the sensation of being physically present in a non-physical environment. Visual and auditory inputs and additional stimuli such as haptic feedback, smell, and taste are used to create an immersive overall experience for the user of a VR system. High levels of immersion allow students to pay careful attention to the subjects being taught while immersed in a realistic 3D world and interacting with the items in real-time while utilizing VR technology.

When asked to select which of the three gadgets would be their choice to use, the three instructors picked a VR device linked with a computer. The VR system linked with a computer is selected because of the possibility of having a dedicated computer in the classroom exclusively for VR instructional reasons. Two participants chose a VR experience that is immersive. A thought-provoking response from participant 3 on why fully immersed VR is selected is as below:

> *"The device is portable, does not interfere with the use of cellphones or laptops, and is highly popular since it provides an experience that is as close to the actual world as possible."* (Participant 2)
>
> *"I hope that this approach is easy to maintain technologically and economically too."* (Participant 1)

Some of the participants feel that the smartphone option is not viable because not all the students in schools possess smartphones that are capable of supporting VR. This is especially true since students all over the country would come from various economic backgrounds, each with a different amount of accessibility and a varied level of household income.

DISCUSSION

Specifically, this research aims to determine how school teachers will perceive the use of VR in a scientific lab. However, although the findings are not typical of all science teachers, they provide valuable insights into how a VR programme is perceived in a science lab. The overall consensus among the participants in this study is that the opportunities provided by a VR lab will be beneficial to their educational experience. This idea of guided learning experience and visual depiction encourages the continuation of the development of VR Labs as a tool to aid in student learning and an effective method of imparting knowledge. It is possible to optimise the teaching capabilities by becoming creative with the lab setup, such as implementing a VR experiment in the classroom or in a science lab.

The participants in this study believe that using VR to conduct science experiments as compared to the traditional way of performing them in real science labs has several advantages. VR labs can give school students not only experiences that could not be re-created in a normal lab, but it can also provide them with the opportunity to access the technology they could not get in a regular lab environment. VR also appears to serve as safe personalized learning. This is due to the attribute of VR itself that serves immersive learning experience which it is able to engage and bring the real experience to the learners. Even while we must agree that an isolated learning experience may be beneficial in certain situations, the collaborative character of science in a research lab is not represented by this kind of experience in most cases. As a result, autonomous experiences may complement more conventional lab learning methods.

The implementation of VR as a learning environment for lab activity could allow more mistakes to happen in a safer way. There would not be any danger of chemical spillage, explosions, burns from heated glassware, cuts and wounds from broken scientific apparatus that can happen when performing experiments in a traditional science lab. Therefore, with this understanding, the design component of VR learning environment for the science lab will consider the interaction that may need artificial intelligence features which could allow response and action that is programmed and non-programmed.

CONCLUSION AND RECOMMENDATION

This research aims to explore novice science teachers' and instructors' first views on their outlooks on how VR may be used in the realm of science education, including core topics of biology, chemistry, and physics, particularly by concentrating on laboratory activities. The research discovers that novice science teachers prefer science education delivered via more engaging and fascinating visuals that assist in comprehension and retention. These teachers appear to be excited with the idea to use VR to better perform scientific experiments. When it comes to the selection of VR devices, the findings are varied. While the majority of novice science teachers favoured VR in conjunction with computer settings, a significant number of novice science teachers preferred utilising their smartphones connected to the VR headgear. The findings of the empirical investigation, when combined with appropriate VR equipment, can be used as a new educational option that is consistent with the government's aim to digitally change high school education. Future studies can be a mixed method to see how effective VR programmes to help enhance student's understanding in science concepts and the reasons for their effectiveness.

ACKNOWLEDGMENT

Thank you to the Faculty of Education Universiti Kebangsaan Malaysia (UKM). This is part of a postdoctoral project under the collaborative research project between the Faculty of Education Universiti Teknologi MARA, UiTM, and UKM

DECLARATION STATEMENT

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest in this study.

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