Exploring Teachers' Perspectives on the Use and Effectiveness of Virtual Labs in Science Classrooms: A Qualitative Study

Introduction

In recent years, the integration of technology into science education has revolutionized traditional classroom practices, offering new and exciting ways to teach and learn. One such innovation is the incorporation of virtual labs into science classrooms to enhance student engagement and learning. Virtual labs are a type of digital tool that provide students with interactive simulations that mimic real-world laboratory experiences. Using virtual labs is a great way to actively engage students, develop mastery over a subject and in developing science literacy skills. However, they must be fully integrated into the lesson in such a way that students can actively construct knowledge using them (Yildirim & Sensoy, 2018). To achieve this end, teachers should not only demonstrate competence in utilizing virtual labs but also in using them in ways that enhance students' knowledge and skill. It is very important to understand how teacher's perceive the effectiveness of and utilize the virtual labs in their classrooms, what are the challenges they face and how they address them. Their perspective can provide valuable insights into integrating virtual labs in science classrooms and explain their potential impact on students learning and how they can be incorporated in science curriculum in the future.

Purpose of the study

Virtual labs are computer simulations that replicate the experience of traditional experiments in classroom settings and offer an innovative approach to teaching. The purpose of this qualitative study is to investigate science teachers' perspectives on the integration of virtual labs into their classrooms. By exploring teachers' experiences, attitudes, and challenges related to

the use of virtual labs, this study seeks to gain insights into the factors influencing their adoption and implementation in science education.

Research Questions

The study aims to answer the following questions:

1. How do science teacher's perceive the usage and effectiveness of virtual labs in facilitating student learning in their classrooms?
2. What factors influence science teacher's decision to incorporate virtual labs into their curriculum?
3. What challenges do science teachers encounter when using virtual labs in the class and how do they address these challenges?

Significance of the Study

The majority of research on the use of virtual labs in science classrooms indicates that they are effective in promoting student learning, their achievement, and retention (Gambari et al., 2013 and Al-Duhani et al., 2023). Studies have also indicated that virtual labs also have a positive effect on the student attitudes toward learning by virtual labs (Ambusaidi et al., 2018). A study in Indonesia by authors Pramono et al., (2019) studied the impact of virtual lab on science process skills of students in 4th and 5th grade. Their test results proved that the utilization of virtual labs had a direct correlation to student's improved science processing skills. Research also suggests that using virtual laboratories has a generally positive affect on students and they become better learners (Jain & Kaur, 2022).

However, studies that explore teacher's perspective on utilization of virtual labs are sparse (Kuehne, 2020). Existing research mostly occurred in countries outside the United States and indicated that teachers are not using these digital tools much in their classrooms (Alneyadi, 2019; Hechter & Vermette, 2014; Maharaj-Sharma et al., 2017). Since teachers are often the key determinants for how and when virtual labs are used in the classroom, it is crucial to investigate how teachers are using digital technologies to promote student learning and the factors that affect their use (National Science Board, 2018). Studies have also proved that teacher attitudes and teacher beliefs are the strongest influences for successful use of digital technology (Buabeng-Andoh, 2012; Ertmer et al., 2012). A study by Bohr (2014) explored the perceptions of the quality and effectiveness of high school virtual labs compared to traditional hands -on labs and found that while the virtual labs are valuable supplements, they could not completely replace hands- on experience. However, studies on the quality and effectiveness of virtual labs are limited despite their widespread use.

This study holds significant implications for both theory and practice in science education. By examining teachers' perspectives on virtual labs, the findings will contribute to the theoretical understanding of how virtual labs are perceived and utilized in educational settings. The study also aims to uncover insights into challenges faced by teachers in implementing virtual labs and how they address those challenges. Information gathered from this study may be used to assist science educators in the local school district as well as the others in making decisions about incorporating virtual labs in their classrooms in future.

Research Design

The study will be conducted on a sample of middle school (6^{th}-$8th^{th}$) grade science teachers from diverse educational backgrounds and experience who utilize virtual labs in their classrooms. The study will use an opinion survey along with open-ended questions which will aid in determining the perceptions these teachers regarding the use of and effectiveness of virtual labs in facilitating student learning. Semi – structured interviews will be conducted with each participant where they share their insights, beliefs, and experiences in their own words about the challenges they encounter when using virtual labs in the class and how do they address these challenges. The interviews will be audio recorded and the transcripts will be analyzed using the thematic analysis method of Braun and Clarke (2006). The data will be coded to identify recurring themes and patterns related to teachers' perspective, experiences, and challenges regarding the use of virtual labs and themes will be analyzed. The themes will be reviewed, defined, and the report will be presented.

Definitions of Terms

The key terms used in this study are:

1. **Effectiveness:** It is the extent to which virtual labs are able to bring about desired results or are able to increase students' learning outcome and engagement.
2. **Science Teachers:** educators who specialize in teaching science subjects at the elementary, secondary or post-secondary levels.
3. **Teachers' perspective:** Teacher perception refers to the beliefs, attitudes, and understandings that teachers hold about their profession and their role in the classroom. It

encompasses their views on teaching as a job and their understanding of the nature of science and its influence on teaching and learning.

4. **Virtual labs:** Virtual labs are an e-learning tool where activities, that typically take place in physical laboratory settings, are digitally simulated (Badillo et al., 2020). They provide an interactive learning experience in various scientific disciplines.

Limitations

The study is limited in scope based on sample size, as it may not be feasible to include a large number of teachers due to time and resource constrains. Having a small sample size may influence the internal and external validity of the study. Also due to the time and resources constrains, the study will focus primarily on teacher's perspective and will not investigate the perspectives of other stakeholders such as students, administrators, or policymakers. It will also not focus on the larger systemic issues such as funding, curriculum requirements, or technological infrastructure that affect the use of virtual labs in science education. The research design relies on self-reported data from teachers which may be biased and may be influenced by the participant's background, experiences and teaching contexts.

Delimitations

The study will be conducted with middle school teachers in grades 6^{th}-8^{th} that use virtual labs in their classrooms. Although there are many teachers that use many different types of digital tools in science classrooms, this study will only focus on teacher's using virtual labs. It will also focus specifically on science teacher's perspective and experiences excluding other subject areas and educational contexts. The research will primarily target teachers from New Jersey, potentially

limiting the diversity of perspectives represented in the study. Issues concerning virtual labs, availability of lab materials, student behavior and lack of participation will not be addressed by this study.

Assumptions

This study was based on the following assumptions:

1. The study assumes that understanding teachers' perspectives is essential for improving the implementation of virtual labs in science education.
2. The study assumes that all the teachers who participated in this study have been trained and certified in the field of science and have the content knowledge and skills needed to effectively use virtual labs in their classrooms.
3. The study also assumes that teachers have access to the necessary technology and resources required for implementing virtual labs in their classrooms.
4. The study assumes that all teachers will provide honest, candid and reflective responses during the interviews, offering valuable insights into their perspective on virtual labs.

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