The Impact of Virtual Labs on Middle School Students' Learning Experience in Science Classrooms: A Mixed – Methods Approach

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. Laboratory work in science is important as it provides hands-on experiences to students where they are able to directly interact and physically manipulate materials and equipment. It provides an immersive experience that motivates the students to explore scientific concepts. In recent years, advancements in technology have revolutionized educational practices, offering innovative tools and resources that are helpful in enhancing the learning experiences of the students. One such innovation is the integration of virtual labs into elementary school classrooms. Virtual labs provide students with interactive simulations that mimic real-world laboratory experiences, allowing them to engage in hands-on experimentation in a virtual environment. Using virtual labs is a great way to actively engage students, develop mastery over a subject and in developing scientific reasoning ability. They help gather data quickly and accurately in a safe environment (Marble, 2017).

Purpose of the Study

The aim of this study is to assess the impact of virtual labs on the academic achievement and student perception in middle school science education. By examining both quantitative academic outcomes and qualitative student perspectives, the study aims to provide a comprehensive understanding of the effectiveness and challenges associated with integrating virtual labs into science curriculum at the middle school level.

Research Questions

The study aims to answer the following questions:

1. How does the use of virtual labs impact middle school students' academic achievement and retention of science concepts?
2. What are the perceptions, experiences and attitudes of middle school students towards virtual labs in science education?
3. How do the quantitative data concerning academic achievement and the qualitative insights into student perspectives work together to offer a comprehensive understanding of both the effectiveness and challenges presented by virtual labs in middle school science education?

Significance of the Study

Intrinsically, traditional approaches to physical labs, might be unable address all aspects of a physical phenomenon due to lack of equipment and resources. This might lead to gaps in student's engagement and achievement. Al-Duhani et al., (2023) explored 8th grade students' achievement in learning topics related to electricity. The results of study indicated that using the virtual lab significantly enhances the students' achievement. A study conducted by Gambari et al., (2013) investigated the efficacy of virtual labs on the achievement and attitudes of secondary students in Physics in Nigeria. They found that using virtual labs had a positive effect on student's achievement, retention and attitudes when compared to using physical laboratories. Another study conducted by Ambusaidi et al., (2018) investigated the impact of using virtual labs on 9th grade students' achievement in Turkey. They explored the students' attitudes towards science and using virtual lab for learning. They found that while virtual labs did not have much

impact on the achievement of the students, the students had a favorable attitude towards learning by virtual labs.

While there are many studies that have studied the impact of virtual labs on students' achievement, most of them are done with high school students. Not much data is available regarding middle school education. Studies that explore students' experiences with and perception of virtual labs are also sparse. A study conducted in Turkey by Tuysuz (2010) found that using virtual labs in 9th grade chemistry class contributed positively to students' attitudes and improved students' motivation towards lessons. Penn and Ramnarain (2019) conducted a study in South Africa on university students' attitudes towards chemistry learning in a virtually simulated environment. They found that the students' experiences in the virtually simulated environment improved their visualization of chemistry concepts and improved their conceptual understanding. Students also experienced autonomy and enjoyment during their virtually simulated lab activities.

This proposal is based on a similar thought process and aims to add to research on the integration of virtual labs in science classrooms and to investigate their impact on student's performance and retention in science education. By exploring the impact of virtual labs, this study seeks to address the experiences, perceptions and experiences of virtual labs and how it affects their attitudes towards learning. Findings from this research can inform educators, curriculum developers and policymakers on the potential benefits and challenges associated with using virtual labs in science classrooms.

Research Design

This study will involve students from 6th grade from multiple science classrooms within the same school district. It will employ an explanatory sequential mixed-methods design that will involve

a two - phase collection of quantitative and qualitative data (Creswell & Creswell, 2023). The quantitative data collection precedes the qualitative data collection and the data from the qualitative phase will be used to help explain the quantitative results. A mixed-method design is an ideal approach as it integrates the strengths of qualitative and quantitative methods to gain a deeper understanding of the issue (Creswell & Creswell, 2023).

In this study, the quantitative data will be collected through pre-test and post-test questionnaire and will be analyzed to assess the impact of middle school students' academic performance and retention of science topics. Qualitative data collection will be collected after quantitative data and will use interviews and focus group discussions to explore the experiences, perceptions and attitudes of middle school students towards virtual labs. Analysis of the qualitative data will be done by the thematic analysis method of Braun and Clarke (2006) to identify recurring patterns, themes and insights from interview transcripts and focus group recordings. It will provide deeper insights into the reasons behind the quantitative data findings and offer a richer understanding of student's' perspectives. Lastly, comparing and contrasting the findings from both components to identify areas of convergence and divergence. By integrating the findings of both quantitative and qualitative data, a comprehensive understanding of the effectiveness and challenges of using virtual labs in middle schools can be gained.

Definitions of terms

The key terms used in this study are:

1. 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.

2. Students' achievement: Students' achievement refers to the level of knowledge, skills, and competencies acquired by students overtime through their educational experiences and can be measured by tests and other assessments.
3. Students' retention: Student retention of concepts refers to the ability of students to remember and apply the knowledge or skills they have learned over time.
4. Students' perspective: Students' perspective refers to the viewpoints, beliefs, attitudes, and experiences of students regarding various aspects of education.

Limitations

The study is limited in scope based on sample size, as it may not be feasible to include a large number of students due to time and resource constrains. Having a small sample size may influence the internal and external validity of the study. The time spent on doing the virtual lab could be limited by the school schedule and it may have an impact on student achievement and retention. The study relies on interviews and focus groups to measure perception, experience and attitudes, which could be responses that are expected or socially desirable and may not express the true opinion of the students. Access to technology and disparities in students' digital skills could also impact the study.

Delimitations

The study will be conducted with 6th grade middle school students in a science classroom in one school district. Delimiting the study to specific grade and school district will allow for a more targeted investigation within a particular developmental age of students. Delimiting to a school district may help eliminate factors such as curriculum, resources and school policies which may vary from one school district to another. The investigation will be carried on in a

science classroom to provide a focused examination of the effectiveness of a specific type of virtual lab within one discipline to ensure depth and consistency in data collection and analysis.

Assumptions

The study assumes that using the virtual lab in science classrooms will have a positive effect on students' achievement such as increased conceptual understanding and retention of science concepts. The study also assumes that during the investigation, the students will remain actively engaged with the virtual labs and complete interviews and focus group discussions as intended. The study also assumes that all the participating elementary schools have adequate technology support such as access to computers and reliable internet connectivity. Lastly, the study assumes that the teachers involved in the study have sufficient knowledge and training in integrating virtual labs into their instructional practices.

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