Utilizing Experimental Simulation Software to Enhance Student Involvement In Chemistry Practical Experiments

Ugah Chukwuemeka Stanley
Department of Science
National Institute of Construction Technology and Management, Uromi, Edo State, Nigeria

Abstract

Technological advancements have created the potential to enhance teaching and learning across all levels of the education system. Computer simulation technologies have enhanced students' motivation, enthusiasm, and involvement in science instruction. The study investigated how ChemLab simulation software could impact students' involvement in secondary school chemistry laboratory experiments. Two hundred and nine senior secondary school students in science classrooms participated in the study. The result established a statistically significant effect of ChemLab simulation software on the respondent's intention to engage in chemistry lab experiments at F (1,207), 4.60 P< .05 with adjusted R^2 indicating that ChemLab simulation software contributed about 9.11% of the variance in student's intention to engage in a chemistry lab experiment. The finding has implications for developing chemistry laboratory experiments in secondary schools.

Keywords: ChemLab, simulation, chemistry, secondary school, students

Introduction

Nigeria's educational system is working toward a more technologically advanced and innovative approach to teaching and learning at all levels. Regarding the recommendation made by the National Policy on Education (2004) for increased investment in high-quality science and technology, this is particularly pertinent. According to Anaeto et al. (2016), the development of a society is judged based on its technological progress. This is because technological progress enables wealth creation, improved quality of life, and genuine economic growth and transformation in any community. Numerous studies have established a connection between technological innovation and the advancement of Nigeria's national progress (Ajah & Chigozie-Okwum, 2019; Ajibo et al., 2019; Akpojedje & Ighodaro, 2019; Bubou, 2011; Mashi et al., 2014; Nwankwo & Njoku, 2020; Oghogho, 2013; Oladeji & Adegboye, 2019; Oloruntoyin & Adeyanju, 2013; Siyanbola et al., 2016). In the body of research that has been conducted, there is a preponderance of evidence suggesting that education in the field of science is vital for improving scientific opportunities and cultivating the skills necessary for attaining the desired technical position. According to Upahi et al. (2020) research, the primary goal of science education in any given sector is to emphasize scientific awareness and comprehension. Chemical education is an essential part of the scientific curriculum in Nigeria, and it makes a substantial contribution to the advancement of the industry as well as to the overall development of the country (Nnamdi, 2014).

According to Ottor et al. (2015), chemistry is a subfield of physical science that focuses primarily on matter's properties, composition, and reactions. According to Mahdi (2014) and Hailemariam (2017), chemistry is an essential scientific discipline that is the basis for the biological sciences. In addition, Oladeji and Adegboye (2019) state that chemistry is one of the scientific disciplines that play a significant function in science. This is because it enables one to comprehend molecules' intricacy and characteristics. Education in chemistry is essential for supporting human growth and ensuring sustained economic advancement, according to Eya and Ezeh (2020), who stressed the importance of their findings. According to Chepkorir et al. (2014), children must be exposed to chemistry principles to foster scientific attitudes that are universally applicable to other aspects of life.

Chemistry education in Nigeria faces challenges such as student apathy, unfavorable attitudes, low enrollment rates, inadequate laboratory resources, and insufficient teaching quality. The subject is considered complex for students and has been linked to poor performance, especially in laboratory experiments (Gladys et al., 2017; Salame et al., 2019; Abudu & Gbadamosi, 2014; Jack, 2013; Nbina, 2012). Laboratory tasks are mainly intended to examine specific patterns and develop scientific skills. Engaging in hands-on experimentation with chemical laws and seeing natural phenomena in a laboratory enhances a student's scientific ability (Chang et al., 2015).

Lab experiments are essential for high school scientific instruction (Sharpe & Abrahams, 2020). Many secondary school curricula highlight the significance of laboratory experiments in science subjects like chemistry and physics (Šorgo & Špernjak, 2012). Students can conduct basic experiments on fundamental laws and principles and learn skills with various measurement equipment and other physics-related gear through practical laboratory experiences. Experiments

enhance fundamental learning abilities (Babalola, 2017). Physics laboratory experiments are conducted in a controlled environment to enhance learners' motivation and involvement with learning activities based on common experiences and occurrences. Laboratories are crucial and dynamic in chemistry education. It is crucial to have a firm grasp of the basic principles and concepts to uncover buried ideas and articulate underlying laws and theories by utilizing advanced reasoning skills.

The current study investigates how experimental simulation software can enhance student engagement in laboratory experiments in response to previous research indicating low participation rates (Lawrie et al., 2009). Top-notch software enabling student interaction with a designated environment is becoming more common in active learning. Utilizing computer simulations of laboratory operations has been a significant advancement on chemistry, serving as a preparing tool or a method for conducting virtual inquiries. Several studies have utilized computer simulations to enhance chemistry learning in recent years (Ahmad et al., 2021; Alkan & Koçak, 2015; Haase & Matthes, 2019; Jabeen & Afzal, 2020; Kempf et al., 2002; Mihindo et al., 2017; Nkemakolam et al., 2018; Olakanmi, 2015; Peechapol, 2021; Shibata, 2021; Sui & Yao, 2016; Zendler & Greiner, 2020). The present focus is on the ChemLab laboratory experimental simulation tool.

ChemLab is a simulation tool for chemistry that allows students to do experiments as if in a natural laboratory. It has a list of experiments from which users can access the preferred experiment to conduct. Each experiment consists of three sections encompassing introduction, method, and observation. This section will provide an overview of the investigation. All the reactions that will occur in an experiment are described in detail. The user is encouraged to read the entire introduction to understand what will happen in an investigation. This section features step-by-step instructions for experimenting. On the toolbar of this chemistry simulator, students can find all of the equipment and chemicals, including a beaker, funnel, etc. HCL, Nitric Oxide, etc.

ChemLab is a low-cost, commercially available software that does not require sophisticated hardware and is exclusively suited for teaching chemistry in schools (Rossi et al., 2012). The software includes simulations for titration, decantation, pouring, and heating, among other things. Temperature, weight, volume, pH, and other data are also included. New chemicals can be added, and different reactions can be combined. The software allows the user to participate in a live lab simulation. It has a wizard that simplifies the process of creating simulations. Demonstrations are possible, and they can be used in a variety of settings.

In contemporary science education in Nigeria, growing intimation suggests a decline in laboratory experiments in secondary schools. The trend has been attributed to various factors, including inadequate laboratory equipment, poor funding, teacher factors, and students' attitudes and motivation. Indeed, the surge in technological innovations has offered varying opportunities to enhance science learning. For instance, chemistry laboratory simulation software describes a problem-solving activity with a playful attitude. Thus, it might potentiate students' engagement in laboratory experiments in secondary school. However, numerous scholars have tested different virtual methods for enhancing chemistry practical in the Nigerian context (Aliyu & Talib, 2019; Chado et al., 2021; Gambari et al., 2018; Nathaniel A., 2016; Odewumi et al.,

2019). However, the Modell ChemLab simulations tool, which seems indispensable in increasing students' motivation in learning, has not been utilized for chemistry practicals in Nigeria. Therefore, the present study investigates the software as a tool to encourage students' engagement in the chemistry laboratory.

Hypothesis: ChemLab simulation software would influence student's engagement in chemistry laboratory experiments

Method

The research population comprises secondary school students from Edo State, Nigeria. Participants were male and female high school seniors from five public and private secondary schools in the state. Two hundred fifteen students who satisfied the inclusion requirements (such as being enrolled in a science class and having participated in a laboratory experiment) were pooled from their respective schools with the assistance of schoolteachers and administrators between April and July 2022. Before the commencement of the study, the students were prepped and informed of its aim. In particular, all ethical issues were considered.

Procedure

The schools were categorized into sch1 – sch5, and authorization was received from the school authorities. In particular, the respondents were assembled in a controlled laboratory setting within their school premises. They were briefly exposed to a simulation laboratory concept using the ChemLab software. The activity lasted three days in each of the schools. However, three days gap was given after they witnessed the simulation practice before they were made to respond to a self-report measure assessing their intention to participate in a real-life laboratory experiment. The 215 participants were given the questionnaire to complete on the spot. Intention to engage in laboratory practicals was rated on a 10-item Linkert form scale with 5-point ratings ranging from 1 (not likable at all) to 5 (very likable). The scale was validated following a pilot study, and a Cronbach alpha .78 reliability coefficient was obtained. A higher score indicates a high intention to participate in experimental practice**.** Upon inspection of the returned questionnaires, 209 were correctly completed, while six were incorrectly completed. Thus, the 209 correctly completed forms were used for statistical analysis.

Result

Testing the study hypothesis

The primary assumption of the study is that ChemLab simulation software would exacerbate engagement in a chemistry laboratory experiment. The data from 209 respondents, 15.8% (sch1), 16.3% (sch2), 21.4% (sch3), 19.5% (sch4), and 27% (sch5) were computed using a simple linear regression model. The result established a statistically significant effect of ChemLab simulation software on the respondent's intention to engage in chemistry lab experiments at F (1,207), 4.60 P< .05 with adjusted R^2 indicating that ChemLab simulation software contributed about 9.11% of the variance in student's intention to engage in a chemistry lab experiment.

Table 1: shows the regression analysis of the result.

	B	SEB	β	t	R^2	Sig
Constant	3.45	.013		26.49	.911	.000
ChemLab	.35	.016	.15	2.15		.000

Discussion

The present study examined ChemLab simulation software as a tool that could influence students' engagement in chemistry laboratory experiments in secondary school. Two hundred and nine senior secondary school students enrolled in the science classes participated in the study. The regression analysis revealed that ChemLab simulation software statistically significantly predicted engagement in lab experiments among the respondents F (1,207), 4.60 P< .05. Thus, the finding suggests that the students exposed to ChemLab simulation software are more likely to engage more in lab experiments than others. Most importantly, the result indicated that exposure to the simulation tool explained about 9.11% of the differences in students' intention to engage in a chemistry lab experiment. Thus, the result offers support to previous findings, which applauded the use of simulation tools in chemistry learning (Dalgarno et al., 2009; Donnelly et al., 2013; Jabeen & Afzal, 2020; Kotoka & Kriek, 2014; Nathaniel A., 2016; Nkemakolam et al., 2018). They discovered that simulations boost students' chemistry achievement more than the lecture method does. The fact that computer simulation offered virtual laboratories and feedback on the chemical concept may have contributed to its superiority over the lecture technique. Users can interact with computer simulations, which minimizes the abstractness of hazardous chemistry concepts to the students. Simulation activates experimental awareness and will enable students to visualize, explore and formulate scientific explanations in chemistry that were otherwise impossible to understand and comprehend in the conventional lab experiment. This implies that computer simulation improves students' willingness more when compared with the traditional method. Similarly, the result indicates that students who experience simulation exercises in relation to chemistry experiments are more suitable to acquire a positive attitude toward chemistry practicals. Thus, ChemLab might potentiate curiosity in lab experiments and probably instigate private investigations. Accordingly, they progress in the direction expected to achieve the goal of a scientific-driven society.

Limitations, strengths, and future directions

Because the study did not adopt an experimental approach, it becomes difficult to establish the cause-effect relationship of the variables. More so, the self-reported intention to engage in experimental practices might trigger biases constraining the generalization of the finding. Despite the practical limitations, the present study contributes to the literature by identifying Model ChemLab simulation software as a positive predictor of students' engagement in a chemistry laboratory experiment in secondary schools. Thus, the result broadens our knowledge about the positive impact of technological innovation relative to science education. Moreover, indications suggest a scarcity of literature investigating the predictive variables in chemistry experiments in secondary education in Nigeria based on ChemLab software. Thus, justifying the current study. Future researchers should utilize experimental methods to identify cause-effects and adopt multiple data collection approaches.

Conclusion

The linear regression analysis conducted on the study data proved the critical effect of ChemLab simulation software in predicting students' engagement in chemistry lab experiments at the senior secondary school level. Indeed, the research hypothesis was supported by the result of the study. Therefore, it is concluded that ChemLab simulation software is a critical determinant of students' participation in lab experiments. The finding provides valuable data suggesting that ChemLab simulation software can be used to conduct digital experiments to support science education on the cloud visually and interactively. Through digital simulation, a significant part of laboratory experiences such as observation, analysis, and discussion can be delivered on a large scale. Thus, the technology can potentially broaden participation in experimental chemistry, especially for students and teachers in underserved communities who may lack the expertise, equipment, and supplies needed to conduct specific experiments. Indeed, a platform that enables anyone to store, process, and disseminate experimental data via the digital revolution is proposed. Also, the result of the study implicates ChemLab as a possible innovative teaching technique for sustaining chemistry laboratory experiments in Nigeria's secondary schools.

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