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APPLICATION OF EXPERIMENTAL SIMULATION SOFTWARE TO IMPROVE STUDENT'S ENGAGEMENT IN CHEMISTRY PRACTICAL EXPERIMENTS

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Abstract
The increasing development in technological innovations has offered opportunities that foster teaching and learning at every level of the education system. Computer simulation tools have increased students' motivation, interest, and engagement in science education. 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 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 aims for increased technology and innovation in teaching and learning at all educational levels. This is relevant to the National Policy on Education (2004) recommendation for more excellent science and technology funding. In modern society, a society's development is evaluated by its technical progress since it allows wealth creation, enhanced quality of life, and real economic growth and transformation in any community (Anaeto et al., 2016). Numerous studies have linked Nigeria's national progress to technological innovation (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). There is a consensus in the literature suggesting that science education is essential for enhancing scientific opportunities and fostering the abilities necessary for achieving the desired technical position. Indeed the fundamental objective of science education in any given field is to emphasize scientific literacy (Upahi et al., 2020). Chemistry is an integral component of science education in Nigeria that contributes significantly to industrial progress and national development (Nnamdi, 2014).

Chemistry is a branch of physical science essentially concerned with matter's characteristics, composition, and reactions (Otor et al., 2015). Chemistry is a crucial field of science and the foundation of the biological sciences (Mahdi, 2014; Hailemariam, 2017). In addition, Oladeji and Adegboye (2019) assert that chemistry is one of the science disciplines that play a crucial role in science because it provides the ability to understand the complexity of molecules and their properties. Eya and Ezeh (2020) emphasized that chemistry education is crucial for fostering human development and achieving sustainable economic progress. Exposure to chemistry fundamentals is essential for promoting scientific attitudes in kids that are transferrable to other areas of life (Chepkorir et al., 2014).

Consequently, chemistry in the Nigerian environment has been plagued by difficulties associated with lack of student motivation, negative attitudes, low enrollment, limited laboratory facilities, and instructional competency (Edomwonyi-Otu & Avaa, 2011; Emendu & Okoye, 2015; Muhammad, 2017; Ojukwu, 2016). Conceivably, the subject is often seen to be a complex area of study for students (Gladys et al., 2017; Salame et al., 2019) and has been associated with low performance (Abudu & Gbadamosi, 2014; Jack, 2013; Nbina, 2012), particularly in laboratory trials. Thus, laboratory exercises are primarily designed to investigate individual patterns and establish scientific competencies. Practical experimentation with chemical laws and observing a phenomenon in a laboratory improves a student's scientific aptitude (Chang et al., 2015).

Experiments in the laboratory are crucial components of secondary school science education (Sharpe & Abrahams, 2020). Numerous post-primary curricula emphasize the importance of laboratory experiments in the syllabi of science topics, such as chemistry and physics (Šorgo & Špernjak, 2012). Students can conduct basic experiments on fundamental laws and principles and gain skills with various measuring equipment and other physics-related apparatus through practical laboratory experiences. Experiments improve essential learning skills (Babalola, 2017). Laboratory experiments in physics represent learning undertaken in a particular setting to increase learners' motivation and engagement with relevant learning events derived from everyday experiences and phenomena (Stanley, 2000). Laboratories play a very active and vital role in chemical education. Understanding the fundamental principles and concepts required to detect hidden ideas and describe and explain underlying laws and theories is essential through applying sophisticated reasoning abilities.

With increasing evidence of poor engagement in the practical component of the course (Lawrie et al., 2009), the present study examines the role of experimental simulation software in expanding students' participation in a laboratory experiment. High-quality software that allows students to interact with a specific environment is becoming increasingly frequent in the field of 'active learning.' The use of computer simulations of laboratory procedures, either as a preparatory step or as a process of delivering a virtual inquiry, has been a significant advance in chemistry. For example, several disparate studies have employed computer simulations to improve 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). However, the current emphasis is on 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 provides an overview of the investigation that will be shown. 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., and 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 factor, 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 a laboratory experiments in secondary school. Though 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 Enugu 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 school teachers 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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