Research Article

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Students' perceptions towards the use of computer simulations in teaching and learning of chemistry in lower secondary schools

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Abstract: The study aims to explore how students perceive the use of interactive computer simulations (ICS). The mixed-method approach under a converging design was employed to collect quantitative and qualitative data. A sample of 160 participants were purposively selected. The questionnaire consisted of four sections, including Behavioral Intention to Use, Attitude Toward Usage, Usefulness, and Perceived Ease of Use. The collected data was analyzed in MS Excel. 83 % of participants believed that their learning experience has improved and become easier. Moreover, a significant number of students 79 % expressed high perceptions towards the ease-of-use ICS in the teaching and learning process, and 77 % demonstrated a strong positive attitude towards the usage. Additionally, 76 % had a highly positive perception of their behavioral intention to use ICS in their chemistry learning. However, 39 % of students expressed low perceptions of ease of use of ICSs due to a lack of basic computer skills. In general, the findings show positive significance in students' perceptions toward the use of ICSs in teaching and learning chemistry. The study recommends that ICSs should be used to supplement chemistry education.

Keywords: interactive computer simulations; chemistry concepts; students' perceptions

1 Introduction

The global recognition of the crucial role of computer simulations in the teaching and learning process has been cut across various disciplines (Beichumila et al., 2022). Nowadays, we are in the rapid growth of using technology. In this context, students and teachers adapt this mode of teaching and learning to enhance students' learning outcomes (Celik, 2022; Faour & Ayoubi, 2018). Furthermore, there is consistent recognition and acknowledgment of this significant contribution of ICS in promoting student interactions (Adeleye & Eboagu, 2019). This significance of ICSs has led to made evaluation of its effectiveness in promoting chemistry teaching and learning (Celik, 2022; Gupta, 2019; Niederhauser et al., 2018). Thus, Interactive Computer Simulations (ICSs) become a teaching approach that improves teaching and learning chemistry in the classroom.

Supriyatman and Sukarno (2014), showed that students play an active role in their learning process, through forming hypotheses, observations, and collecting evidence to gain knowledge and create meaningful projections. This applies also to chemistry education, where the use of a simulated learning environment involves students in their

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learning process and acquiring scientific skills and knowledge (Mukandayambaje & Maniraho, 2021). The studies reveal that the incorporation of ICSs in the classroom, increases access to information and knowledge, promoting social collaboration and connectivity among students (Asedillas et al., 2019; Fernández-Portillo et al., 2020). The integration of ICSs in education in Sub-Saharan African countries, for instance, the study conducted in Zimbabwe, Tanzania, and Zambia affirms that incorporating ICS in the teaching and learning process impact positively students' achievements (Agyei, 2021; Beichumila et al., 2022; De Hoop et al., 2020). In the study conducted by Almasri (2022), Gupta (2019) shows that teachers are still challenged in teaching science subjects, especially chemistry due to their abstract nature. In this regard, different researchers have identified some topics within the field of chemistry that students perceive as challenging, which lead the subject to be perceived as difficult. For instance, Almasri (2022), Gupta (2019), and Iyamuremye et al. (2021) illustrated chemical combination, gas laws and gaseous state, qualitative and quantitative analysis, electronic energy level of atoms, rate of chemical reactions, metals and nonmetal compounds, chemical reactions, and organic chemistry as difficulty topics in ordinary secondary school level.

The study conducted by Almasri (2022); Salame & Makki (2021); Supriyatman & Sukarno (2014); Suratno & Aydawati (2017) show that computer simulations help students to learn difficulty chemistry topics. This is because computer simulations provide visual representation of complex system and abstract concepts that are really hard to understand. For instance, simulations show how atoms and molecules interact with each other. The study further recommended that computer simulations are powerful tool for chemistry education, as they provide with students a dynamic and interactive learning environment that complements what where been difficult to understand in the traditional teaching methods. In study by Salame and Makki (2021) compared the use of a simulated learning environment and traditional methods with respect of students' perceptions found that both approaches have affected students' perceptions.

Chemistry is among of science subjects that taught in lower secondary schools and there are some concepts in chemistry considered as a challenging topics for students to learn (Iyamuremye et al., 2021; Musengimana et al., 2022; Nsabayezu et al., 2022a). These difficulties are commonly brought by its abstract in nature. Therefore, integrating ICS into chemistry teaching and learning in schools is very crucial in solving such addressed challenges in teaching and learning chemistry concepts. Consequently, the impact of ICS as a teaching and learning tool is influenced by users' perceptions and experiences. The assessments of students' perspectives towards the teaching and learning tools is very sensitive because it helps educators to create a more meaningful and engaging learning environment for the students (Adarkwah, 2021; Almossa, 2021). Therefore, the major objective of the current study was to investigate the students' perceptions towards the use of interactive computer simulations in their chemistry learning process.

Different nations established different initiatives in their education system, such as one laptop per child, Smart classrooms in lower and high schools, and e-learning in higher institutions to improve access for computer users in schools for effective teaching and learning process (Beichumila et al., 2022; Das, 2019; Fernández-Portillo et al., 2020; Muniandy et al., 2022; Penn & Ramnarain, 2019; Suratno & Aydawati, 2017). This has been done to provide quality education that equips students with the necessary competencies, values, attitudes, skills, and knowledge that are required in this 21st century. To achieve this objective, the nations put more effort and paying off all required cost to implement Curriculum which support and facilitates a learner-centered approach (Almasri, 2022; Celik, 2022; Faour & Ayoubi, 2018; Nsabayezu et al., 2022a,b). This approach empowers student to take an active role in their learning process, so that they can succeed in the world market.

However, the analysis made on chemistry teaching techniques in lower secondary in some consulted studies in different nations, found that teachers are not using the learner-centered approach, which encourage students to play a vital role in their learning process (Beichumila et al., 2022; Musengimana et al., 2022; Watson et al., 2020; Zendler & Greiner, 2020), rather they use teacher-centered approach that encourages memorization. Hence, affect students' academic achievement and constitutes a major challenge to attain desired goal. This approach has long been a dominant instructional method in the teaching and learning process (Gupta, 2019; Hojeij et al., 2023; Penn & Ramnarain, 2019) and is characterized by focusing on lectures, passive learning, and memorization. Therefore, it has been suggested that the incorporation of interactive computer simulations in the chemistry classes provides a powerful solution to transform the traditional teacher-centered approach into a more student-centered approach (Asedillas et al., 2019; Mwazi et al., 2023). In addition, it is worth noting that no previous studies have been conducted in the specific study area.

2 Significance of the study

The study aims to explore students' perspectives toward the use of ICSs in teaching and learning chemical reaction as one of topics in ordinary level chemistry. These ICSs allow students to manipulate, observe, and experiment with those phenomena in a virtual environment. When students are familiar with use of ICSs will not only help them to enhance their conceptual understanding of abstract concepts but also develop different skills aligned with 21st century skills, such as collaboration, creativity and innovation as far as critical thinking is concerned. This will be done through interaction among universal students and teachers. In a study conducted by Watson et al. (2020) show that a teaching approach that encourages students to share their learning experience helps them to develop their creativity as well as their appreciation of science and technology. The intention of integrating computers at lower secondary schools is to introduce students to technology that encourages scientific innovation and collaboration among students, create and share their own models, as well as to communicate and cooperate with other students and experts from different countries and cultures (Agyei, 2021; Fernández-Portillo et al., 2020; Krüger et al., 2022; Muniandy et al., 2022). These help students to become more informed and responsible citizens, who make evidence-based decisions and participate in scientific debates and discussions across the continents.

The study's results are very useful to all professionals working in the field of chemistry education. The produced information informs decision-makers and policymakers, school administrators, and education management on what needs to be done to improve chemistry education. In addition, teachers will know how to select, integrate, and adapt computer simulations to suit their teaching objectives, students' needs and preferences. This also will assist the ministries in charge of education in achieving their objectives, since the results provide a platform that enhances and supports teaching and learning in schools worldwide. The results will help scholars to understand the opportunities and implications of computer simulations, evaluate the effect of computer simulations on students' learning outcomes, and factors that influence students' perceptions of computer simulations in chemistry learning. This will also assist researchers to design and conduct more inclusive and effective studies on the effectiveness of using interactive computer simulations in chemistry education.

3 Literature review

3.1 Significance of interactive computer simulations in the teaching and learning process

It has been recommended that using different approaches in teaching chemistry subject encourage students' interactions among themselves and teachers. Considering this, existing literature has shown that integrating computer-assisted tools such as interactive computer simulations supports students to understand abstract concepts through their interactions (Almasri, 2022; Gupta, 2019; Nxumalo-Dlamini & Gaigher, 2019). In addition, it provides an active learning environment, clear explanations, visual representation, concrete examples, and opportunities for reflection and practice. Interactive computer simulations (ICS) are software or tools that allow users to actively engage with simulated environments (Krüger et al., 2022).

Previous studies assessed ICS' effects on students' learning outcomes and found that the ICS not only assists in understanding so-called challenging concepts but also motivates students to learn and retain full information (Adarkwah, 2021; Mohafa et al., 2022; Salame & Makki, 2021). In studies conducted by Yadav (2022) and Zendler & Greiner (2020) show that using ICSs attract students' attention as they provide additional insight that is always hard to discover through theoretical analysis and making teaching and learning so meaningful. The studies on the effect of interactive computer simulations on students' self-learning, attitudes towards, and academic achievement in chemistry revealed that students who learn chemistry in simulated learning environment improve self-learning and motivation to learning abstract concepts (Adarkwah, 2021; Penn & Ramnarain, 2019). These findings also further found that students who taught by use of simulations performed better than those who taught by using conventional methods.

Simulated learning environment not only improves academic achievements but also link what they learned in the classroom with the real-world (Agyei, 2021; Almasri, 2022; Blut & Wang, 2020). The studies conducted on the effect of using ICSs in comparison to traditional methods reported that ICS improves students' conceptual understanding and makes teachers become learning facilitators (Najib et al., 2022; Zendler & Greiner, 2020). The research also indicated that for students to understand real-world phenomena, there is a need to merge theories and experimentation through simulations generated by computers. These ICSs are also compatible with various learning objectives, implementation contexts, pedagogical approaches, grade levels, and students (Krüger et al., 2022).

The studies on the effectiveness of using computer-assisted tools and their impact on students' academic achievements in science subjects found that using computer-simulations as a teaching tool facilitate students to feel safe, and able to repeat a given task till they achieve the desired response (Blut & Wang, 2020; Najib et al., 2022; Ndihokubwayo et al., 2020). These results are in line with studies (Almasri, 2022; Penn & Ramnarain, 2019; Ramírez-Mera et al., 2022) show that this teaching approach improves students' interest, motivation, self-confidence, and conceptual understanding.

3.2 Students' perceptions on the usage of interactive computer simulations as a teaching and learning tool

Perception is the cognitive process by which an individual becomes aware of and interprets stimuli through his/her sensory system Suratno and Aydawati (2017). In the context of education, students' perceptions must be considered when planning to integrate a new teaching approach in the teaching and learning process. This helps the organizers get to know students' willingness to accept or reject such integration of a new approach (Aziz et al., 2021). This is because using technological teaching tools in the classroom heavily depends on the willingness and positive perspectives of teachers and students to use such tools. According to (Aziz et al., 2021; Krüger et al., 2022; Niederhauser et al., 2018) found that students' perspectives and their readiness to incorporate computer technology into their learning process are very crucial to their overall success in learning.

The study conducted by Khaleel Younis (2017) on the effect of scientific inquiry simulations of chemistry practicals on students' perspectives at secondary school found that students appreciate the simulated learning environment and develop higher perceptions of their learning. According to Nsabayezu et al. (2022a) found that using computers in the teaching and learning process facilitates students to understand scientific phenomena since they visualize complex concepts. In addition, the integration of ICSs in teaching and learning science subjects particularly chemistry improves students' cognitive and affective domains (De Hoop et al., 2020) conclude that it's the right decision to integrate technology in the education system since students acquire a diverse set of skills that respond to the nation's need to achieve developmental goals.

4 Theoretical framework

This current study was guided by Technology Acceptance Model (TAM) cited by (Milla et al., 2019). The TAM is a theoretical frame work that describe how the acceptance of technological system by individual depends on his/her perceptions towards its ease of use and usefulness. In this view point, the TAM is used to relate the students' perceptions of ICSs with their understanding of chemistry concepts. ICSs allow students to manipulate variables, test hypotheses, and observe phenomena in a virtual setting that are hard to understand in a normal way of teaching (Celik, 2022). The study hypothesizes that students who perceive ICSs as useful and easy to use have positive perceptions toward ICSs. Therefore, the study aims to test this hypothesis by conducting a post-test measure of students' perception of ICS, and understanding of chemistry. The qualitative data also was collected to further explore the relationship between ICSs, TAM, and chemistry understanding. The main purpose of incorporating ICS in chemistry teaching and learning is to facilitate students to understand complex phenomena

(Salame & Makki, 2021). Consequently (Hojeij et al., 2023), argue that when computer-aided tools are incorporated into education, they should effectively support students' learning activities.

Generally, the integration of ICS in chemistry education enhances the social learning environment that assists students in articulating their prior knowledge and presenting what they have learned (Fernández-Portillo et al., 2020; Nxumalo-Dlamini & Gaigher, 2019; Suratno & Aydawati, 2017), and it is crucial to gain insight into students' perspectives regarding the use of ICSs as a teaching tools in the education context. On this matter, consulted studies have looked at the positive impact of computer simulations on students' performance and motivation toward learning chemistry. This implies that none discussed on students' perspectives in learning chemical reaction concepts which is considered as a challenging topic in the chemistry subject. Due to this viewpoint, the researcher felt interested in exploring how students perceive the use of ICSs in their learning of chemical reaction concepts during study intervention. Consequently, the objective of current study aims to explore students' perceptions and preference in relation to the use of interactive computer simulations in chemistry teaching and learning process at lower secondary schools.

5 Research question

How do students perceive the use of computer simulations in teaching and learning of chemical reactions in chemistry?

6 Methodology

6.1 Research approach and design

The researcher employed a mixed-method approach. This approach combines quantitative and qualitative data. Within this type of design, the researcher had the flexibility to use both numerical and textual data to describe the participants' views on the subject of interest (Huyler, 2022). Therefore, it was believed that the convergent design would be suitable for assessing students' perceptions of the use of ICS in chemistry teaching and learning. The data generated from quantitative are found in the data repository on this link (https://data.mendeley.com/datasets/vg9ygbf5c6/1). Both findings qualitative and quantitative converge and support each other. This shows that interactive computer simulations are an effective teaching and learning tool for chemistry.

6.2 Sample and sample size

This current study was conducted in four lower secondary schools. These schools were purposively chosen because they possessed computer labs. Among the population of 668 senior two students from four schools, a sample of 320 students were randomly selected to participate in the study. Two classes at each school were selected with 40 students per class. Two classes were chosen to avoid the complexity and scope of the study. For a large number of classes would cause challenges such as being costly, time consuming, coordination, and resources, while for few classes allow the researcher to focus on a specific group of participants and easily in the data collection and analysis process. Hence increases the depth and quality of the research through the exploration of similarities and differences among classes.

All eight chemistry teachers were trained in the use of ICS in teaching and learning chemistry. The topics taught either with ICS or traditional methods were types of reactions, classification of chemical reactions, balancing chemical equations, and writing ionic equations.

6.3 Research instruments

A questionnaire was used to collect quantitative data. In this context, a five-point Likert scale questionnaire was employed ranging from "strongly disagree" to "strongly agree". The questionnaire consisted of four sections, each addressing different aspects; including Behavioral Intention to Use (two items), Attitude Toward Usage (three items), Usefulness (six items), and Perceived Ease of Use (six items). The questionnaire and interview guide items were customized and modified based on relevant literature, specifically drawn from (Milla et al., 2019). The students from selected schools were provided with a questionnaire to complete after intervention.

The qualitative data were obtained from the interviewed students. The research affirms that the purpose of qualitative data in a mixed study design is to provide valuable insights into the issue under investigation (Yadav, 2022), which complements and reinforces the findings derived from quantitative data. During this phase, students were encouraged to share their perspectives on the conducted activities in the chemistry classes when using ICS and overall general opinions on learning with ICS. During this interview, 16 students were selected using a systematic sampling method. This method involves selecting students at regular intervals from the list of the entire population. In this case, we selected every 10th student from the list (Mohsin, 2021). Each interview lasted 15 min to allow for a dynamic exchange between the researcher and the participant to explore the full perceptions and feelings of students about the utilization of ICS in chemistry learning. It was a good way for a researcher to build rapport, clarify questions, and engage in a dialogue that fostered trust and encouraged participants to share experiences more openly.

6.4 Validity and reliability of instruments

After a little modification, the adopted questionnaire and interview guide were administered to two expert lecturers at university college of education in the chemistry department to assess the validity of the instruments. This was made to critically examine the fitness of it to the participants' context. We also assessed the reliability of instruments, the Cronbach's Alpha test was used and found an internal consistency coefficient of 0.82. Then, after all, the instruments were piloted in two secondary schools that shared the same features as those where the study was conducted to confirm their dependability.

6.5 Method of data analysis

The researcher employed descriptive statistics, specifically frequencies and percentages to analyze the quantitative data. This was done to provide an overview of students' perceptions on the use of ICS in chemistry learning. Microsoft Excel was used to analyze collected quantitative data. The "count if" function was utilized to determine the frequency of responses to each statement. The percentage of agreement was calculated by combining "strongly agree" and "agree". We did the same for disagreement, we combined the responses indicating "strongly disagree" and "disagree". For qualitative data, the researchers used thematic analysis. The interview guide was transcribed and coded to identify themes. The codes were then used to identify patterns and recurring themes within the data. The identified themes were organized together, allowing the researcher to draw conclusions related to students' feelings and experiences regarding the use of ICS in teaching and learning chemistry.

6.6 Ethical consideration

The author was granted permission to conduct the study by the University of Rwanda College of Education, the protocol number was 03/DRI-CE/037/EN/gi/2020. We organized an individual consent form and signed it. There was no other remuneration apart from facilitations to teachers who attended the workshop on ICSs. Participants were informed that their participation is voluntary and can withdraw their consent at any time they do not feel comfortable to continue participating in the study. The researcher also announced that the confidentiality and secrecy of given information were matters to consider.

7 Results

The study results are presented in Figures 1–4, involving a total of 160 participants. The dataset supporting Figures (Figures 1–4), are publicly available in the repository, as part of this record at link: https://data.mendeley.

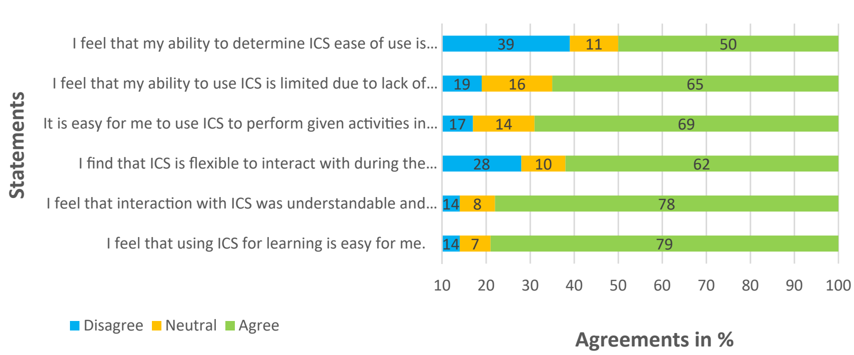

Figure 1: Perceived ease of use ICS.

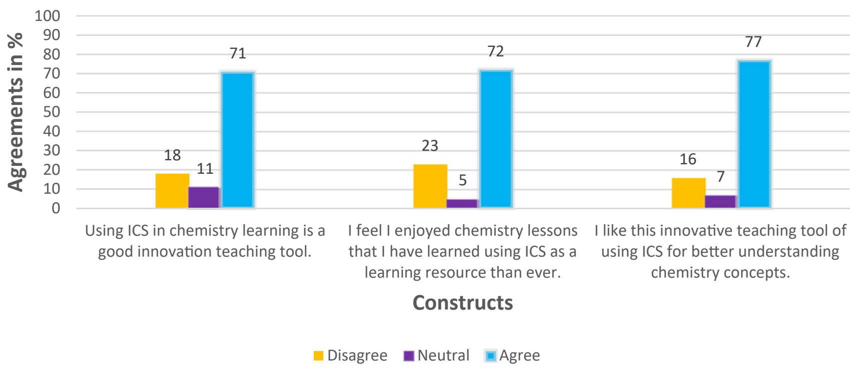

Figure 2: Students' attitudes toward the use of ICS.

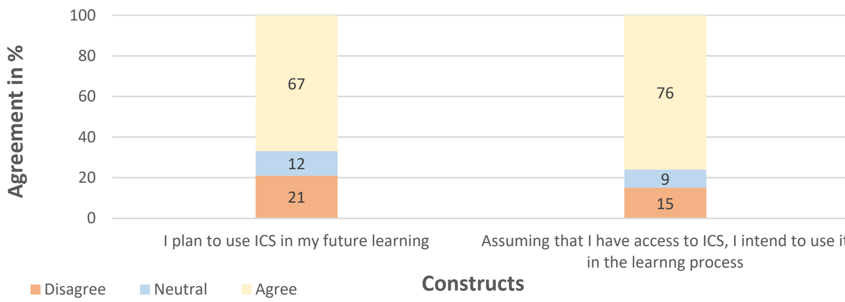

Figure 3: Students' behavioral intention to use ICS.

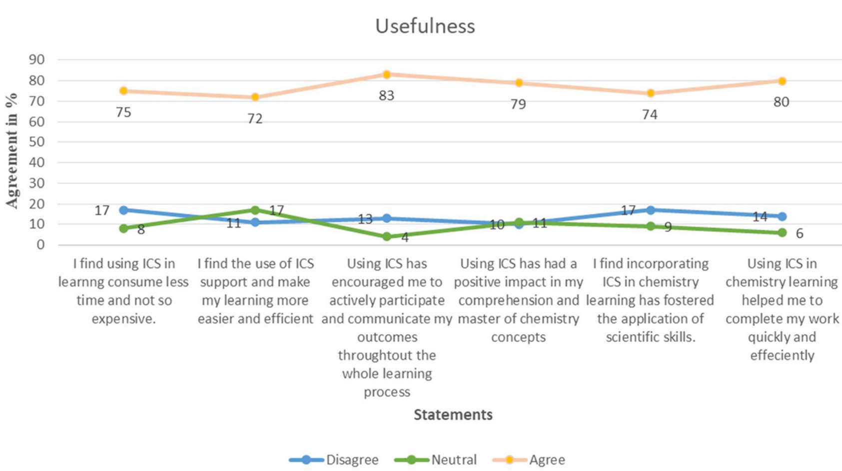

Figure 4: Students' perceptions of the usefulness of ICS.

com/datasets/vg9ygbf5c6/1. The findings reveal how students perceive the utilization of ICS in the chemistry teaching and learning process.

7.1 Perceived ease of use ICS

The research investigated how students perceive their capacity to use ICS during the chemistry teaching and learning process. Figure 1 displays the students' perceptions of their competencies in use of ICS.

The data presented in Figure 1 reveal that most students involved in this study held a positive impression of ICS perceived ease of use ICS as a tool for chemistry teaching and learning. 79 % of the student expressed that using ICS in their chemistry learning was effortless and allowed for collaboration among themselves. The obtained qualitative data from interview revealed the similar findings. For instance, three students from school A said "*We found it convenient to observe the equipment and manipulate material and even to the moment we made mistakes when dealing with simulated activities as we typically do in the classroom expecting failure and low marks given by teacher but here in the simulated learning environment, we had an option of getting a correct answer before proceeding to the next activity*". Other five students from schools named C had given this explanation: "We appreciate the use of ICSs in our learning process because, once we keep following given instructions, the only step followed is to manage ourselves to deal with how we can improve our independent learning capacity to solve related questions".

In general, students asserted that using ICS in the teaching and learning process fosters self-learning and promotes a culture of teamwork, and collaboration and they even not fear manipulating materials during experiments or when presenting learning outcomes. Nevertheless, the results revealed that 39 % of students agreed on less proficiency in using ICS, this was due to their lack of computer skills. This implies that, even if they had computer labs at their respective schools, not all students possessed a foundational knowledge of computers. In addition, despite the availability of computers at these schools, due to the limited number of computers at school, students are not normally frequently accessing them to improve their experience in using computers. Therefore, there were not all students had fundamental computer skills which affected their manipulation of simulated activities.

7.2 Attitude toward usage

Figure 2 presents the students' attitudes towards the usage of ICS during the chemistry teaching and learning process.

These results indicate that 77 % of students expressed a positive attitude towards using ICS in their learning chemistry concepts. 72 % of students claimed that using ICS in learning chemistry makes it a more interesting subject to learn and improves their conceptual understanding. Moreover, 71 % of students appreciated the idea of integrating ICS into the chemistry teaching and learning process. These findings were consistent with the feedback obtained from interviewed students. For instance, the ward of students from school C said *"We acknowledge the idea of incorporating ICS into the teaching and learning process because we are in a world that advanced in technology. So, using ICS has great implications for students to comprehend chemistry concepts. This is because, through this technology, we can engage ourselves in both practical and theoretical at the same time. Like, if we are dealing with chemical reactions, must know the factors that influence that reaction between two elements or compounds. On this point, we can conduct experiments for observation for a better understanding of why these reactions".*

These results also are in line with the findings of Özmen and Naseriazar (2018) reveal that once introduced innovative teaching tool that encourages interactive learning, it creates a positive cycle of motivating students, improves conceptual understanding, and application of knowledge that leads to effective learning experience.

7.3 Behavioral intention to use ICS

This study was also aimed at investigating students' perceptions regarding their future use of ICS in their learning. Figure 3 presents the findings of students' behavioral intention to use ICS.

The results showed a significant number of students equal to 76 % expressed their intention to use ICS once it is easy for them to access such learning tools. This implication is due to the relevance and value that students get in technology in their learning and how they are eager to apply all technological skills they acquired at school as well as surroundings. These results were also supported by data collected during interviews. For example, a student coded as No. Seven from school named A said *"Our computer lab is mostly used by those students who did combination including computer, but if we have enough computers at school learning chemistry in computer labs is very interesting*".

Other Students explained that "at *our schools, we have few computers in the labs, this can limit students to using them in case we feel free to go there, but if got a chance to have more computers with simulations at schools, it could be easy for us to use it at any convenient time and conduct extensive chemistry experiments*".

7.4 Perceived usefulness

The findings presented in Figure 4, indicate students' perceptions of the usefulness of using ICS in chemistry teaching and learning.

The study's results in Figure 4 demonstrated that most students 83 %, expressed that using ICS in the learning process encouraged them to actively participate in the lesson and improved their collaborations through outcome presentation. Furthermore, 80 % of students claimed that using ICS in chemistry learning made their learning experience more accessible and efficient. These findings were supported by the data from qualitative. For instance, the interviewed students from school C said "*We used to learn chemistry theoretically and most of the time, we tend to be passive in the learning process which is not the case in the simulated learning environment. This helps us to share and improve our conceptual understanding and make our learning experience so easier*".

Other students from school A had this to say:

It was easier to grasp chemical reaction concepts as we conducted related experiments that showed us how electrons move during chemical reactions. This was fundamental to comprehending the principles of chemistry, hence making us predict and control the behavior of substances in various chemical processes. They further added that "we could repeat provided task several times at any convenient time and place for further observations and draw conclusions without think of breaking apparatus or wastage of chemicals". Using ICSs reduce working under pressure or inconvenient place and enhances our learning experience.

In general, most students observed that the use of ICS enhanced their learning experience. They further suggested that through a simulated learning environment, they were understanding the principles of chemistry as they grasped its abstract concepts.

8 Discussion

It has been found that the incorporation of interactive computer simulations in the teaching and learning process is essential in the learning process. The conclusion was drawn from four aspects used in terms of assessing students' perceptions towards the use of ICS in classroom settings. The findings from quantitative in all perspectives; Perceived ease of use, Behavioral intention to use, Attitude toward usage, and Usefulness were all supported by data obtained from qualitative data.

For perceived ease of use, results reveal that most students involved in the study held a positive impression of using ICS as a tool that facilitates chemistry teaching and learning. On this note, 79 % of the student expressed that using ICS in their chemistry learning was effortless and allowed for collaboration among themselves. These results were consistent with those obtained from interviewed students which revealed similar findings. These findings agree with the previous research showing that computer-assisted instruction helps students maximize their potential for academic achievement (Almasri, 2022; Nsabayezu et al., 2022a). The students demonstrated an increasing level of conceptual understanding. These findings also are in line with the findings of the study conducted by Nxumalo-Dlamini and Gaigher (2019), Özmen and Akbar (2018), and Ramírez-Mera et al. (2022) show that ICT has several advantages in teaching and learning.

For students' attitudes toward the usage of ICS, the findings also reported that ICSs help students to improve their attitude towards the subject as it improves their conceptual understanding. This was supported by the data collected from interviewed students who expressed much appreciation for the idea of incorporating ICS into the teaching and learning process. They became interested in this initiative of incorporating ICS in the teaching and learning process because they saw it as an opportunity to keep pace with the rapid technological advancements and growth in the world (Krüger et al., 2022). They further added that if there are enough computers in the room so that every student can manipulate simulated activities, this can boost their motivation to learn chemistry and improve self-learning in general. The results agree with the findings of (Gupta, 2019; Muniandy et al., 2022) reveal that interactive simulations are a very essential tool in teaching and learning chemistry, it does not overwhelm students and provide a platform for the interactive learning environment.

For the behavioral intention to use ICS in the classroom settings, the results from quantitative indicated that 76 % of students who participated in the study expressed their intention to use ICS as an easy way of learning by doing and easier to access them as a learning tool. This implication is due to the relevance and value that students have in technology in their learning and how they are eager to apply all technological skills they acquired from school as well as their surroundings. These results were also supported by data collected during interviews which affirm that, if possible, having enough computers at their schools with installed simulation activities, should be very interesting and make their learning so meaningful.

"For the perceived usefulness of ICS in the chemistry teaching and learning process, 83 % of students expressed that using ICS in the learning process encouraged them to actively participate in the lesson and improve their collaborations and presentations. Furthermore, 80 % of students claimed that using ICS in chemistry learning made their learning experience more accessible and efficient. These results were in line with those from qualitative, the interviewed students supported these findings in views of appreciating how they were involved in their learning in the simulated learning environment. They claimed that using ICS helps them to share and improve their conceptual understanding and make their learning experience easier".

However, 39 % of students agreed on less proficiency in using ICS, this was due to their lack of computer skills. This implies that, even if they had computer labs at their respective schools, not all students possessed a foundational knowledge of computers. In addition, even if there are a limited number of computers at these schools, students are not frequently accessing them to improve their experience in using computers. Therefore, there were not all students had fundamental computer skills which affected their manipulation of simulated activities. Similarly, these findings agree with Penn and Ramnarain (2019) results, which reported that students did not connect with the simulated learning environment due to unfamiliarity with fundamental computer skills. The research findings show that employing interactive computer simulations as a teaching tool in conjunction with other teaching strategies makes the science teaching and learning process more successful and increases students' motivation to learn (Almasri, 2022). This is also supported by a study conducted by De Hoop et al. (2020) who reported that both traditional and technological teaching methods have comparable outcomes in certain areas because some factors may affect students in using one approach or another.

9 Conclusions

The study findings show that students had much appreciation for using ICSs. In this perspective, the results show that students' perceptions of behavioral intention to use computer simulations, usage, ease of use, and usefulness are significantly impacted by their prior knowledge and computer self-efficacy. These findings supported the TAM model since students preferred active and visual style in their learning. Among the participated students, 83 % affirm that learning chemistry with ICS is very useful and encourages individual learning which would support interactive learning. 77 % of students expressed a positive attitude towards the use of ICS and that they no longer experienced difficulties in chemistry concepts. However, the results revealed that 39 % of students agreed on less proficiency in using ICS, this was due to their lack of computer skills since it is not all students possessed a foundational knowledge of computers. These results assist in identification of factors that affect students' adoption and acceptance of computer simulations, hence provide necessary guidance and support for the students to use effectively and efficiently computer simulations. Therefore, the study findings help educators and instructional designers to design and implement simulations that are user-friendly and relevant for students. The findings also contribute to the existing body of knowledge on computer simulations and acceptance of technology in education and provide empirical evidence and insight on how computer simulations improve students' learning outcomes.

10 Limitation and recommendations

The current study was conducted only in rural schools. Therefore, the obtained data cannot be generalized to other schools like urban and private-based schools. Consequently, we further recommended that future studies involving a mixed-methods approach include urban and private schools of different geographical locations in the study so that the effect of computer interactive simulations on students' academic achievement in chemistry and other sciences in general, can be explored more. We also recommended that there should be an increase in the number of computers at schools so that all students have a chance to access and develop fundamental computer skills that may not become a challenge to them once they need to apply such skills in different instructional tools.

Research ethics: The researcher submitted a research proposal to the African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS) in 2019. Then after successfully defending the research proposal, the researcher submitted an approval proposal to the Innovative and Research Unit at the University of Rwanda College of Education requesting ethical approval for data collection. We obtained the ethical clearance with an ID number [03/DRI-CE/037/EN/2020] to seek district permission to conduct our study.
Author contributions: Jane Batamuliza: investigation; writing original draft; conceptualization; methodology; data curation. Dr. Gonzague Habinshuti: visualization, editing, validation, and supervision. Dr. Jean Baptiste Nkurunziza: visualization, editing, validation and supervision.
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Data availability: Data for measuring the possible effect of interactive simulations: CRAT (original data, Mendeley Data) are available at https://data.mendeley.com/datasets/p3sztty6nx/1.

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