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Use of PhET Simulations as A Virtual Laboratory to Improve Students' Problem Solving Skills

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Abstract: In the Radiochemistry course so far there have been no experimental activities because there are no laboratory facilities. However, with the use of technology, students can now easily access a wealth of educational resources online. This research aims to determine the effect of using the PhET Simulations as a virtual laboratory on students' problem solving skills. This research used mixed methods that combines quantitative and qualitative research. A quasi-experiment was carried out using a one group pretest-posttest design then continued with in-depth interviews. The instruments used in this research consisted of written tests to collect data on problem solving skills, questionnaires to collect student response, and interview guides to collect data on the problem solving process. Data in the form of problem solving skills were analyzed statistically using the SPSS 22.0 program while data obtained through questionnaires and interviews were analyzed descriptively. The results of the hypothesis test using Wilcoxon signed rank test show a significant value of 0.001, which means that PhET simulations as a virtual laboratory improve students' problem solving skills. Students are divided into high-medium-low groups based on problem solving ability and the majority of students are in the medium-ability group. Students responded positively to PhET Simulations as a virtual laboratory. In addition, interview transcripts provide an overview of how students think when solving chemistry problems.

Keywords: PhET Simulations; Virtual Laboratory; Problem Solving Skills.

Introduction

One of the prevailing challenges in education today is the low problem-solving abilities exhibited by students. This issue poses a significant obstacle to their academic success and future professional endeavors. Students with inadequate problem-solving skills are often unable to effectively navigate complex tasks and think critically, hindering their ability to understand and apply concepts across various subjects. The development of problem-solving abilities is essential for students as it equips them with the cognitive tools needed to tackle real-world challenges and make informed decisions. These skills encompass a range of cognitive processes, including identifying and defining problems, generating potential solutions, evaluating alternatives, and implementing effective strategies to solve them. Meanwhile, according to Rahman (2019), the process of problem-solving entails methodical observation and critical thought in order to identify a suitable solution or path to the intended outcome.

Several factors contribute to the low problem-solving abilities observed among students. One possible cause is the overemphasis on rote memorization and standardized tests in the education system. This focus on regurgitating information rather than developing critical thinking skills leaves students ill-prepared to handle complex problem-solving tasks. Learning experiences greatly influence students' problem solving skills (Wahyudiati, 2021). Another contributing factor is the lack of opportunities for students to engage in hands-on and experiential learning. Many traditional educational approaches prioritize passive learning, with students simply absorbing information rather than actively

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applying it. As a result, students do not have the necessary opportunities to enhance their problem-solving abilities through practical applications and real-world experiences. The change from a teacher-centered approach to a student-centered one in the curriculum significantly influences students' thinking abilities (Ichsan et al., 2019).

In the Radiochemistry course so far there have been no experimental activities because there are no laboratory facilities. The laboratory is an essential learning resource for students to develop a deep understanding of chemical concepts through hands-on experiments (Prabha, 2016). By conducting experiments in the laboratory, students are able to observe and analyze chemical reactions and phenomena, allowing them to apply theoretical knowledge to real-world scenarios (Chen et al., 2019)(Ramírez et al., 2020). One of the key benefits of the laboratory is that it provides students with the opportunity to engage in active learning (Trisusilosakti & Aisyah, 2020). Instead of simply memorizing facts and formulas, students can actively participate in the scientific process by designing experiments, making observations, and drawing conclusions (Laelasari et al., 2019)(Leopold & Smith, 2020). This hands-on approach allows students to develop critical thinking (Rachmawaty et al., 2021)(Bahtiar et al., 2022) and problem-solving skills, as they are challenged to think critically and make decisions based on their observations and data.

In the laboratory, students also have the chance to develop important laboratory skills, such as proper laboratory techniques, safety procedures, and data analysis (Nainggolan, 2020). These skills are not only valuable for future careers in the scientific field but also promote a sense of responsibility and professionalism in the laboratory setting (Esposo et al., 2023). Moreover, the laboratory fosters an environment of collaboration and teamwork. Students often work in groups to conduct experiments, which encourages them to communicate and collaborate effectively. Through group work, students can learn from each other's perspectives and experiences, enhancing their overall learning experience (Leopold & Smith, 2020). Additionally, the laboratory provides a platform for students to explore and discover their own interests in the field of chemistry. By conducting experiments and engaging in scientific inquiry, students may develop a passion for a particular area of chemistry, sparking their curiosity and motivating them to pursue further studies or careers in the field (Armstrong et al., 2019).

Several approaches have been tried so that students play an active role in building concepts and developing problem solving abilities. However, their difficulty in understanding radiochemical concepts related to the nature and activity of the atomic nucleus hampered the educators' efforts. Problem solving is influenced by conceptual understanding, students with high conceptual understanding are able to solve problems correctly and vice versa (Kholid et al., 2021)(Samosir et al., 2023). The ability to solve problems does not just come naturally but is based on the ability to understand the problems faced and have the provisions to overcome these problems. The provision for solving chemical problems is of course the ability to master chemical concepts. Addressing this problem requires a multifaceted approach. Embracing technology in the classroom diharapkan dapat menjadi solusi yang tepat.

The use of technology in teaching has become increasingly necessary. In today's digital age, technology plays a crucial role in enhancing the educational experience and preparing students for the future (Haleem et al., 2022). Limited learning facilities, such as lack of access to textbooks, libraries, and quality teachers, can hinder students' learning opportunities (Onyema, 2020). In many educational institutions, resources such as textbooks and laboratory equipment are often limited or outdated. However, with the use of technology, students can now easily access a wealth of educational resources online. This not only makes learning more accessible but also allows students to learn at their own pace and in their own time (Lowenthal et al., 2020)(Paudel, 2020). They can access multimedia materials (Mayer, 2017), interactive tutorials (Ng et al., 2019), and virtual simulations (Tabatabai, 2020) that provide a more engaging and immersive learning experience.

Technology in teaching also plays a crucial role in improving students' thinking skills. Traditional teaching methods often involve passive learning, with students being passive receivers of information. However, with the integration of technology, students are encouraged to actively engage in their learning through interactive platforms and multimedia presentations. This promotes critical thinking, problem-solving, and creativity, as students are required to analyze information, make connections, and apply their knowledge in practical ways (Ra et al., 2019)(Alsaleh, 2020). Through the use of educational apps, online forums, and collaborative tools, students can actively participate in learning activities, exchange ideas, and work on projects together. These experiences help to develop their analytical and problem-solving abilities, as well as their ability to communicate and collaborate effectively (Onyema & Deborah, 2019). By utilizing technology, educators can create an environment that fosters independent thinking and lifelong learning (Kontostavlou & Drigas, 2019).

Chemistry learning generally requires the help of technology to visualize abstract concepts to make them more real and easy for students to understand (Hadisaputra et al., 2019)(Won et al., 2019). On the other hand, chemical concepts are born from the results of experiments or proof in the laboratory so students need to have learning experience in the form of experiments. Currently, laboratories can be simulated in virtual form. One form of visualization and computer simulation that can be used in teaching Radiochemistry courses is PhET (Physics Education Technology) Simulations.

PhET Simulations is one of the virtual laboratory options available online for students and professionals in the field of physics. These simulations have been developed by the University of Colorado Boulder and are widely used in educational settings around the world. PhET Simulations offer a wide range of interactive physics experiments that allow users to explore various concepts and principles in a virtual environment. These simulations are designed to be highly realistic, providing users with an immersive and engaging experience (Perkins et al., 2006). They cover topics such as mechanics, waves, electricity, magnetism, quantum mechanics, and more. One of the key advantages of using PhET Simulations is their accessibility. They are available for free on the PhET website, which means that anyone with an internet connection can access and use them. This makes them especially valuable for students who may not have access to physical lab equipment or who want to supplement their in-class learning with additional hands-on experiences (Susilawati et al., 2023).

Using PhET Simulations, students can conduct experiments, collect data, and analyze results, all without the need for expensive or specialized equipment. They can manipulate variables, observe how changes affect outcomes, and gain a deeper understanding of complex physics concepts. This allows for a more interactive and engaging learning experience, enabling students to grasp difficult concepts with greater ease (Taibu & Mataka, 2021)(Salame & Makki, 2021). Additionally, PhET Simulations provide teachers with a valuable tool for facilitating instruction and assessment. Teachers can incorporate these simulations into their lesson plans, assigning specific experiments or scenarios for students to explore. They can also use the simulations to create virtual laboratories, allowing students to work independently or collaboratively on physics-chemistry experiments (Ouahi et al., 2022).

Based on the description above, this research aims to determine the effect of using the PhET Simulations as a virtual laboratory on students' problem solving skills and to describe these students' problem solving skills. It is important to carry out this research so that the learning media used in the Radiochemistry course is appropriate, and the description of problem solving skills will provide an overview of how students think so that teachers can take the right approach to continue developing these skills.

Method

This research used mixed methods with concurrent embedded design, namely a combined research method that combines quantitative research and qualitative research. Quantitative research used pre-experimental methods because the number of students used as samples was very limited and the samples were not chosen randomly. A quasi-experiment was carried out using a one group pretest-posttest design. The initial test was given before treatment. The treatment consists of learning using the PhET Simulations as a virtual laboratory. The final test was given after treatment. After the quasi-experiment was carried out, qualitative research was then carried out with in-depth interviews to confirm the answers to the final test and obtain information on how the problem solving process was carried out.

The subjects of this research were 13 students taking Radiochemistry courses. Data collection was carried out in natural conditions and primary data sources using test techniques, filling out questionnaires and in-depth interviews. The instruments used in this research consisted of written tests, questionnaires, and interview guides. The written test used is in the form of an essay (description) to collect data on problem solving skills. Questionnaires were used to collect student response data about learning. Meanwhile, interview guidelines were used to collect data on the problem solving process.

Data in the form of problem solving skills were analyzed statistically using the SPSS 22.0 program. This data analysis was carried out to test normality, homogeneity, and hypothesis testing regarding the comparison between students' problem solving skills before and after treatment. This analysis can answer the effect of learning using the PhET Simulations virtual laboratory on students' problem solving skills. Problem solving skills were also grouped into three categories according to the classification in Table 1. In addition, data obtained through questionnaires and interviews were analyzed descriptively.

Tabel 1. Classification of problem solving skills

Value range	Category
$x \geq (\bar{x} + s)$	High
$(\bar{x} - s) < x < (\bar{x} + s$	Medium
$x \leq (\bar{x} - s)$	Low

Description: x is the value of the test questions, $\bar{x}$ is the average value, s is the standard deviation

Result and Discussion

Chemistry learning using PhET simulations has been carried out on the half-life concept. PhET simulations are a valuable tool for conducting half-life experiments in a controlled and precise manner (Marpaung et al., 2021). These simulations provide a virtual environment where students can explore the concept of half-life and its application in various fields such as carbon dating, nuclear medicine, and environmental science. To conduct a successful half-life experiment using PhET simulations, it is important to follow a systematic approach. First, students should familiarize themselves with the simulation and its features. This may include understanding the different isotopes available, their decay rates, and the accompanying graphical representations. Next, students can start by selecting an isotope and determining the initial quantity of the isotope in the simulation. They can then observe and record the decay process over time, measuring the remaining quantity of the isotope at regular intervals. By plotting this data on a graph, students can visualize the exponential decay curve and calculate the half-life of the isotope.

The PhET simulations also provide additional tools and features to enhance the learning experience. Students can adjust the decay rate, explore the effects of different initial quantities of isotopes, and even simulate radioactive decay in real-world scenarios. This allows for a more comprehensive understanding of the concept and its relevance in practical applications. Furthermore, PhET simulations offer the advantage of repetition and flexibility. Students can repeat the experiments multiple times to verify their results and solidify their understanding of half-life. They can also modify parameters and variables to investigate specific scenarios or conduct comparative analyses. Half-life experiments using PhET Simulation show a high level of accuracy (Masfaratna, 2022).

Description of problem solving skills

Data on students' problem solving skills obtained from the essay test can be seen in Table 2. In general, the lowest score, highest score, and average problem solving ability have increased before and after treatment. To make it stronger, the data was analyzed statistically using SPSS 23 at a confidence level of 95%. The analysis results are summarized in Table 3.

Tabel 2: Description of problem solving skills data

Category	Pretest	Posttest
Lowest score	25	50
Highest score	75	100
Average score	55.38	76.92

The first prerequisite test is a normality test using the Shapiro Wilk test and the result was that the pretest and posttest data are not normally distributed. The second prerequisite test was a homogeneity test using a test that shows both data are homogeneous. Because the data did not meet normal assumptions, the hypothesis test was decided to use the Wilcoxon signed rank test. The results of the hypothesis test show a significant value of 0.001, which means that the ability to solve problems after treatment is different from the ability to solve problems before treatment. This significant difference is certainly caused by the use of PhET simulations as a virtual laboratory in chemistry learning. Conducting half-life experiments using PhET simulations is an effective way to engage students in the exploration of radioactive decay and its implications. The simulations provide a user-friendly platform for data collection, visualization, and analysis, making the learning experience more interactive and meaningful.

Tabel 3. Results of statistical analysis of problem solving skills data

Test type	Significant value		α	Conclusion
	Pretest	Posttest		
Shapiro wilk	0.009	0.006	0.05	Not normally distributed
Levene	0.329			Homogeneous
Wilcoxon signed rank test	0.001			There is a difference between the pretest and posttest

PhET simulations offer students a virtual environment that enables them to engage in hands-on experimentation, explore complex scientific concepts and understand it (Doloksaribu & Triwiyono, 2020). Students who used the simulations as part of their coursework showed greater improvements in their ability to solve complex problems and apply theoretical concepts to real-world situations. The simulations also helped students develop a deeper understanding of the underlying principles of chemistry (Watson et al., 2020). These simulations are designed to provide an interactive and immersive experience that brings abstract scientific ideas to life. This makes it easier for students to understand these abstract concepts so that their cognitive abilities increase. The research results show that students' cognitive abilities correlate with their ability to solve problems (Bayani et al., 2023).

One of the key benefits of using PhET simulations is that they allow students to conduct experiments that may be too difficult, time-consuming, or costly to carry out in a traditional laboratory setting (Salame & Makki, 2021). Students can manipulate variables and observe the outcomes in real-time, which helps them develop a deeper understanding of scientific principles. Students can manipulate variables, observe changes, and test hypotheses through diverse experiments (Yulianti et al., 2021). This interactive nature encourages active learning and fosters a deeper understanding of scientific concepts (Prima et al., 2018; Verawati et al., 2022), enhancing problem-solving skills (Doloksaribu & Triwiyono, 2020). Students can freely experiment without the fear of making mistakes or causing any harm. This is not surprising because students feel comfortable changing variables in virtual simulations, which are generally safe (Taibu & Mataka, 2021). This freedom allows them to take risks, build critical thinking skills (Yulianti et al., 2021), and develop innovative approaches to problem-solving by using a scientific and structured approach (Yuliati et al., 2018).

Furthermore, PhET simulations offer a unique opportunity for students to explore complex scientific concepts at their own pace. The PhET Simulations virtual laboratory offers a wide range of interactive and engaging activities (Perkins et al., 2006). They can pause the simulation, rewind, and repeat actions to observe the cause and effect relationships more closely (Howie & Gilardi, 2021). This iterative process fosters critical thinking skills and encourages students to ask questions, make predictions, and draw evidence-based conclusions. Virtual laboratories provide instant feedback and guidance (Santos & Prudente, 2022), which is invaluable in enhancing problem-solving abilities. Students can analyze their experiments in real-time, observe cause and effect relationships, and make adjustments as necessary. This immediate feedback helps them understand the consequences of their actions and identify potential errors in their thinking.

Another advantage of PhET simulations is their accessibility (Moore & Perkins, 2018) and flexibility (Price et al., 2018). They can be accessed through a web browser, eliminating the need for specialized software or equipment. This means that students can engage with the simulations anytime, anywhere, on their own devices. It doesn't require a lot of time to use (Riantoni et al., 2019). Regardless of their location or available resources, students can access the simulations at any time, allowing for independent practice and reinforcement of problem-solving skills.

Problem solving skills groups based on categories

The indicators used in measuring the problem solving skills are based on the Polya completion steps, namely understanding the problem, devising a plan, carrying out the plan, and looking back. In order to assess students' problem-solving abilities, this study divided them into three distinct groups: high, medium, and low.

Tabel 4. Categories of problem solving skills

Value range	Category	Frequency
$x \geq 92.94$	High	3
$60.91 < x < 92.94$	Medium	8
$x \leq 60.91$	Low	2

The high-ability group consisted of students who consistently demonstrated above-average problem-solving skills. This group consists of three students who are able to do problem solving well. They complete the understanding problem, devising a plan, carrying out the plan, and looking back stages correctly. This is in line with the research results where only highly qualified students complete all problem solving processes when answering questions (Malawau, 2023). These students showed a strong aptitude for critical thinking, logical reasoning, and the ability to approach complex problems with innovation and creativity. Their problem-solving strategies were consistently effective, and they exhibited a high level of perseverance in overcoming challenges.

The medium-ability group comprised students who displayed average problem-solving skills. A total of eight students answered questions up to the carrying out the plan stage correctly but they did not looking back at all. While their performance was neither exceptional nor deficient, these students possessed a solid foundation in problem-solving techniques and showed the potential for improvement with further education and practice. They approached problems systematically and demonstrated a willingness to learn and adapt their strategies.

The low-ability group consisted of students who struggled with problem-solving tasks. Two students carried out the understanding the problem and devising a plan stages correctly but did not do the next stage well. These students often displayed limited critical thinking skills, struggled to grasp complex concepts, and had difficulty applying logical reasoning to real-world scenarios. They exhibited a lack of creativity and were often unable to overcome obstacles or suggest alternative solutions.

Understanding these different problem-solving ability groups allows educators to tailor their teaching methods and interventions accordingly. For the high-ability group, it may be beneficial to provide more challenging and complex problem-solving tasks to further enhance their skills and foster their creativity. The medium-ability group may benefit from targeted instruction and intervention to help them refine their problem-solving strategies and bridge the gap between their current abilities and higher-level performance. The low-ability group requires special attention and support to develop their critical thinking skills and problem-solving techniques through targeted interventions and remedial programs. Critical thinking and problem-solving skills are tightly associated. The capacity to critically analyze and consider a range of potential solutions that are suitable for the current challenge is a prerequisite for problem-solving skills. On the other hand, problem-solving exercises present challenging circumstances that serve as catalysts for the growth of students' critical thinking abilities (Khairani & Aloysius, 2023).

Student responses

Student responses to the use of PhET simulations as a virtual laboratory in learning are summarized in Figure 1. All students agreed that PhET simulations were interesting to learn. Before or at the beginning of learning, PhET simulations provoke students' curiosity. This is their first experience using the application. From the beginning to the end, the majority of students showed interest in and attention to PhET simulations learning (Yulianti et al., 2021). Then in the learning process, most students feel happy and enjoy it. This is in accordance with research results which state that studying PheT Simulations feels fun, real, simple and easy (Batuyong & Antonio, 2018). Only 7.69% said the learning process was unpleasant. This is likely because they have difficulty accessing and using PhET simulations.

As many as 76.92% of students stated that PhET simulations were easy to access because they only required a computer device and internet access, while the rest stated that PhET simulations were not easy to access because there was no internet connection, especially when they studied at home. Ease of access is a positive aspect of PhET Simulations (Taibu & Mataka, 2021). Judging from ease of use, 53.85% of students said PhET simulations were easy to use while 46.15% said the opposite. This difficulty can be understood because there are students who are not familiar with the various existing tools. After doing half-life practicum using PhET simulations, students felt their understanding of the concept of half-life was better. The concept of a decaying atomic nucleus is an abstract concept. This concept becomes more real thanks to visualization from PhET simulations. This makes students experience an increase in understanding concepts as recognized by 84.62% of students. According to several studies, PHeT Simulations can indeed improve understanding of concepts (Lestari & Mansyur, 2021)(Verawati et al., 2022).

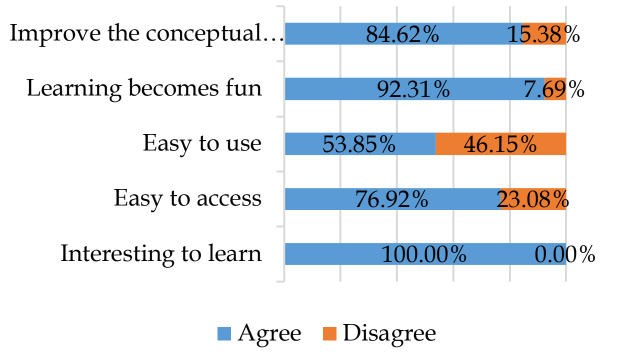

Figure 1. Student response to learning

Problem solving process

Solving integrated problems in chemistry requires a specific process and a certain way of thinking (Alam, 2020). It is important for students to develop these skills in order to effectively tackle complex chemistry problems. A simple interview was conducted after the posttest. Students are asked to describe their thinking process when answering posttest questions. Questions are focused on each stage of problem solving while student answers are summarized according to similarities. Therefore, excerpts from the interview results were created based on problem solving stages and ability categories.

Question: How do you understand the problem?
Answer of all groups:
I read the questions over and over again and wrote down the information given in the question.

Question: Are there any difficulties in understanding the problem?
Answer of high and medium groups:
None. Practicums with virtual laboratories are very helpful in understanding half-life problems.
Answer of low-ability group:
At first I forgot the symbols for writing known data, but finally I remembered.

The first step in this process is to thoroughly understand the problem at hand. Students should carefully read and analyze the problem statement, making note of any information that is given and any concepts that are relevant to the problem. This step is crucial, as a solid understanding of the problem is essential for developing an appropriate solution. Once the problem has been understood, students should then identify the key concepts and principles that are involved (Kartini et al., 2021). This may involve recalling prior knowledge and reviewing relevant course material. By doing so, students can determine which concepts are relevant to the problem and can begin to think about how to apply them.

Question: How do you devising plan to solve the problem?
Answer of high and medium ability groups:
I remember the formula that connects the known data with the question.
Answer of low-ability group:
I wrote the half-life formula

Question: Are there any difficulties in devising a plan?
Answers of all groups:
There isn't any.

With a clear understanding of the problem and the relevant concepts in mind, students can then develop a plan of action. This may involve breaking the problem down into smaller, more manageable parts or determining the appropriate equations and formulas to use. Developing a plan not only organizes the student's thinking but also provides a roadmap for solving the problem.

Question: How do you carrying out the plan?
Answers of all groups:
From the formula that I have written, I enter the numbers and then calculate until finished.
I calculated according to the formula I had thought of.

Question for the low-ability group:
What happens when you count or carrying out the plan?
Answer:
I find it difficult to calculate exponent numbers. I'm actually not sure about my answer.

After developing a plan, students can then execute it by performing any necessary calculations, applying the relevant principles, and critically thinking through each step. It is important for students to approach each step with precision and attention to detail, as even the smallest error can have significant consequences in chemistry problem-solving.

Question for high ability group:
How do you evaluate or looking back?
Answer:
I reread the questions while matching them with my writing. I checked whether the information I wrote was correct, then I checked the formulas and calculations, then finally I wrote the answer to the question in sentence form. I looked at what was asked and the answer to the results of my calculations then I wrote the conclusion sentence "so the half-life of the radioisotope is..."

Question for high-ability group:
What made you think you should write the word “so”?
Answer:
I felt like I had finished checking my answer after the word “so” came into my head and then I wrote it down. I feel I have made a conclusion with the word "so" which means my work in answering the question is finished.

Question for the medium-ability group:
Did you check your answers again?
Answer:
No, because I have found the answer and I am confident in my answer.
Yes. I check to see what the question is and what my answer is. I think both are appropriate so I have finished answering that question.

Question for the medium-ability group:
Why don't you write a sentence like this "so the mass of the remaining radioisotope is 20 grams"?
Answer:
I don't think it's necessary because my last post was the answer requested.

Question for low-ability group:
Did you double check your answers?
Answer:
No.

Finally, once a solution has been obtained, students should double-check their work and ensure it is logical and consistent. It is common for students to make mistakes during the problem-solving process, so this step is crucial to ensure accuracy. When examining their work, students should assess the logical progression of their reasoning and ensure that each step aligns with the overall problem-solving strategy. They should evaluate whether their solution aligns with the information provided and satisfies the given constraints. By critically analyzing their work, students can ascertain whether their reasoning is sound and their solution is logically valid. During the double-checking process, students should scrutinize their calculations and computations to verify their accuracy. This involves reviewing their mathematical operations, checking for potential mathematical errors, and ensuring that all necessary calculations have been executed correctly. Any mistakes or miscalculations should be immediately identified and remedied to maintain the integrity of the solution.

The process of solving integrated problems in chemistry requires a systematic approach and a logical way of thinking. By following this process, students can effectively tackle complex problems and develop their problem-solving skills in chemistry. Students can enhance their problem-solving skills in chemistry by regularly practicing and applying their knowledge to a variety of problems. Chemistry is a subject that requires a solid foundation of knowledge and an understanding of key principles. By consistently practicing problem-solving techniques and tackling different types of problems, students can reinforce their understanding and develop their ability to apply concepts in new and unfamiliar situations. To effectively tackle complex problems in chemistry, students should also utilize available resources, such as PhET Simulations. These resources can provide additional guidance and insights into the problem-solving process, helping students navigate through challenging concepts and develop effective strategies for problem-solving.

Conclusion

In conclusion, the utilization of the PhET Simulations as a virtual laboratory has proven to have a significant positive impact on students' problem-solving skills. By creating a safe and interactive learning environment, providing immediate feedback and guidance, and offering various engaging activities, virtual laboratories enhance students' problem-solving abilities and contribute to their overall academic success. Students responded positively to PhET Simulations as a virtual laboratory. These interactive simulations have been shown to engage students in active learning, enhance conceptual understanding, and promote critical thinking. Educators can confidently integrate PhET Simulations into their teaching practices to foster the development of problem-solving skills among their students.

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Conflicts of Interest
The authors declare no conflict of interest.

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