Exploring Interactive Simulations For Teaching Physical Science: Effects On Learners' Motivation, Self-Confidence And Conceptual Understanding

Meryam Khiari[1*], Abderrahmane El kharrim[2], Abderrahman Mouradi[3]

[1] Laboratory of applied sciences and didactics, Ecole Normale Supérieure de Tétouan, Abdelmalek Essaadi University, Morocco meryam.khiari@etu.uae.ac.ma

[2] Energy, Materials and Computing Physics Research Group, Higher Normal School (ENS), Abdelmalek Essaadi University, Tetouan, Morocco,elkharrim@gmail.com

[3] Energy, Materials and Computing Physics Research Group, Higher Normal School (ENS), Abdelmalek Essaadi University, Tetouan, Morocco, abderrahman.mouradi@uae.ac.ma

Abstract. A study on the exploration of interactive simulations for teaching physical science highlights the positive impact of these tools on learners' motivation, self-confidence and conceptual understanding. Using the Crocodile Clips simulator, results showed that the majority of students improved their understanding of physics concepts, found the tool useful, increased their interest in physics and strengthened their motivation. What's more, the simulator's ease of use was highlighted by 82% of participants. However, improvements are needed in terms of environmental conditions, particularly with regard to brightness. Students also identified the objectives of the courses taught by their teachers through the use of the simulator for simple electrical circuits and series and parallel connections. . This study underlines the importance of interactive simulations in enhancing learning in the physical sciences, and highlights the benefits of these tools in making abstract concepts more concrete and accessible, thus promoting greater understanding and interest in the subject.

Keywords: Interactive simulations, Physical science teaching, Motivation, Self-confidence, Conceptual understanding.

1. Introduction

Society has concentrated in recent decades on groundbreaking technology developments that have made it easier, faster, more flexible, and more efficient for individuals to interact and seek information. Taking use of the advantages provided by new information technologies, education has also adjusted to the new technological landscape. In order to enhance teaching and learning procedures, a number of cutting-edge pedagogical strategies have lately been developed. [1] Enhancing teaching and learning processes using interactive simulations is one such educational method. [2]

Apart from aiding educators in achieving their own goals, simulations offer a scenario-based environment where students work together to apply their prior knowledge and practical skills to actual circumstances.[3] In this regard, numerous writers have

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observed that dynamic simulations aid instructors in helping students master challenging and abstract physics ideas and help them hone their virtual laboratory experimenting skills[4]. Simulations in science education have the ability to enhance learning in ways that were not previously achievable.[5]. Additionally, one strategy for enhancing students' perceptions of themselves and helping them comprehend scientific ideas is through simulation-based interactive physics lessons. A learning approach that results in conceptual knowledge is necessary for science instruction to be effective. As a result, scientific instructors ought to use an inquiry- and discovery-based methodology, along with laboratory exercises, simulations, and other practical activities, to teach their subjects. Even though certain scientific ideas are theoretical in nature, understanding them requires physical or visual models and representations. [6]

Reasons that may encourage teachers to use computer simulations include: time savings, allowing them to spend more time with students rather than setting up and supervising experimental equipment; the ease with which experimental variables can be manipulated, enabling hypotheses to be stated and tested. [7]

Few studies have examined the effects of interactive simulations on learners' motivation, self-confidence, and conceptual understanding, despite the fact that the use of simulations in science education has been extensively studied [2].

In this synthesis, we will highlight the study of the use of interactive simulations in physical science education, focusing on their impact on learners' motivation, self-confidence and conceptual understanding. In particular, we will examine the effect of the Crocodile Clips simulator on college-level learners. The study methodology will involve pre-test and post-test questionnaires to assess the effectiveness of these simulations.

The structure of the study is organized as follows: Section 2 provides a review of the literature concerning the use of interactive simulations in teaching, highlighting their impact on learners' motivation, self-confidence and conceptual understanding, while examining previous research. Section 3 explores the specific context of the study. Section 4 details the research methodology used. Section 5 presents the results obtained during the course of the study. Finally, the study closes with conclusions and a discussion of future research directions.

2. Literature review

Many studies have highlighted the benefits of interactive simulations in science learning. They simplify the physical systems studied, enabling students to concentrate on the crucial information linked to the concept being studied. What's more, these simulations offer an alternative to experiments that are difficult or impossible to carry out in school laboratories due to their dangerousness, high cost, excessive duration, extreme speed or restricted feasibility. [8]

In this literature review, we will explore three main interconnected areas: motivation in learning, the concept of self-confidence and the use of interactive simulations in teaching. We will look at important definitions and concepts, pertinent research, and how each affects student learning for each topic. Lastly, we will talk about how interactive simulations affect students' willingness to learn and their conceptual grasp of the physical sciences.

2.1 Motivation in learning

Since motivation dictates an individual's level of energy and motivation to complete a job, motivation is an essential component of learning.

A person's willingness to commit to the learning process is influenced by a variety of factors. These factors include the personality and skills of the learner, the surroundings, incentives, and the conduct of the teacher. They also include the characteristics of certain learning activities. There is no denying that each student's motivation in the classroom differs greatly from the next. In addition to guaranteeing that students are participating in activities, student enthusiasm for learning also supports successful learning [4].

In the field of learning, there is a multitude of authors who have sought to define the notion of motivation. From this vast array, we have carefully selected the most widely used definitions.

First of all, we cite the definition given by ROLLAND VIAU [9] in his book entitled "La motivation en contexte scolaire". According to him, "*Motivation is a dynamic concept which has its origins in a student's perception of himself and his environment, and which prompts him to choose an activity, to engage in it and to persevere in its accomplishment in order to achieve a goal*". This concept demonstrates how motivation is dynamic and subject to change over time since it is impacted by a variety of internal and external circumstances, including perceptions of one's own self and surroundings. Viau also highlights the correlation between sources of motivation and indicators of motivation.

According to Cuq [10] Motivation refers to the process that initiates, energizes and guides behavior and cognitive activities. It also determines the value attributed to different elements in the environment. The desire for knowledge is seen as a multifaceted process that encompasses biological, psychological and cultural aspects.

It drives learners to give meaning to what they learn, which in turn strengthens their motivation.

Thus, motivation to learn is a psychological state that makes students inclined to participate actively in their learning processes, to implement behaviors aimed at achieving their goals, and to show perseverance in the face of challenges.

Similarly, Ryan and Deci [11] state that: "*To be motivated means to be moved to do something. A person who feels no impetus or inspiration to act is thus characterized as unmotivated, whereas someone who is energized or activated toward an end is considered motivated*". According to this definition, motivation is defined by the incentive to act. A demotivated person is one who feels no impulse or inspiration to undertake an action, whereas a motivated person is one who is stimulated or activated to pursue a goal.

In the light of these definitions, we can say that motivation is the engine that drives students to initiate action and persevere in their efforts, providing them with the vigor to overcome obstacles and challenges encountered along the learning journey. In essence, motivation drives individuals to strive to realize their aspirations.

2.2 The concept of self-confidence and its importance in learning

When it comes to academic success, it's not just about grades, comparing yourself to your classmates or staying motivated. Self-confidence is the key ingredient that shapes our individual paths. Embracing self-confidence allows us to feel good about ourselves, to face moments of uncertainty, fear and anxiety.

Self-confidence is not an inherent trait. On the contrary, it represents a life skill that can be acquired and improved. Among the so-called "socio-behavioral" skills that are increasingly valued in the school curriculum are the ability to communicate well, to work in a team, to organize oneself and to trust one's peers [12].

The Larousse, quoted by De Saint-Paul, defines the term "confidence" as "a feeling of assurance and security". From this, the author adds that it is "a feeling of assurance and security about oneself". Self-confidence thus refers to one of the aspects of self-esteem, which is the "certainty of possessing the necessary abilities to rely on oneself, take care of oneself and cope with the hazards of life [13]".

2.3 The use of interactive simulations in teaching

The learner is emphasized in computer simulations as an active agent in the creation of knowledge. They have tremendous promise for supporting real-world inquiry activities, such as developing hypotheses, creating questions, examining how evidence affects a situation, and changing theories. [2]

Gredler states that a true simulation should propose that the student solve an ill-defined problem, such as those encountered in real life, and he lists the four main characteristics of educational simulations:

"(a) an adequate model of the complex real-world situation with which the student interacts (referred to as fidelity or validity), (b) a defined role for each participant, with responsibilities and constraints, (c) a data-rich environment that permits students to execute a range of strategies, from targeted to `shotgun` decision making, and (d) feedback for participant actions in the form of changes in the problem or situation." [14]

Landriscina [15], for her part, specifies the particularity of a simulation. In her words:

The main characteristic of a simulation is the reproduction of certain aspects of an observed or possible reality. However, it is not a static reproduction, but an active, even interactive reproduction.

From these definitions, we can see that simulation in education is an effective method for reproducing aspects of the real world. Students can learn in a manner that is comparable to what they would in real-life situations by engaging with these simulations and becoming motivated. Through the removal or modification of key elements, simulations make reality more approachable for students, who can use them to learn methods, solve issues, comprehend phenomena and learn how to regulate them, and decide what to do in different scenarios.

Studies report that the use of simulators in learning leads to greater student involvement in learning tasks. They also participate more actively in the course. For some students and teachers, simulations make information more tangible and concrete. [8]

2.4 The impact of interactive simulations on learner motivation

A study conducted by Ze [16] explored the motivation of third-grade students to learn physical sciences in Cameroon, using computer simulators combined with a Hot Potatoes exerciser. Results indicated that these tools facilitated knowledge acquisition by encouraging communication between students, access to resources and skill development. However, two students seemed to prefer playing to learning, highlighting a need for vigilance in the use of these technologies.

Studies by Gani et al [17] showed that when physics and chemistry students followed computer simulations, they enhanced their conceptual knowledge, problem-solving abilities, and motivation.

2.5 Assessing the impact of interactive simulations on conceptual understanding of the physical sciences

Computer simulations are now widely available and are used in many scientific curricula across a wide range of scientific areas. [7]

Based on an experimental investigation with New Zealand primary school students, Fallon [18] concluded that simulations can be useful for teaching fundamental physical scientific concepts and giving kids the ability to engage in higher-order thinking processes.

3. Context of the study

The teaching of physics and chemistry in junior high school occupies an important place in the college curriculum. Its aim is to instill in students an integrated scientific culture that takes into account what is happening in the student's environment and in everyday life. This teaching enables the acquisition of scientific knowledge on the one hand, and the development of know-how in terms of skills and attitudes on the other. [19]

Difficulties in learning physics are one of the causes of young people's disaffection and disinterest in scientific studies and careers in almost all countries.

For Robardet [20] attests that it is: "too abstract, subordinate to its mathematical tool, with outdated programs, cut off from everyday practiced physics and its technological applications "On the other hand A. Einstein, is made up of a collection of natural sciences whose theories and notions may be expressed mathematically and whose concepts are based on measurements. [8]

What's more, the transition to teaching science subjects in French in Morocco, which began in 2017, remains a complex and topical issue. The transition from arabization to francization presents significant linguistic challenges for learners and teachers alike.

The simultaneous use of both languages in lessons and assessments reflects the difficulties encountered in this transition process [21].

The introduction of interactive simulations in physical science education offers a wonderful opportunity to enhance learning experiences. By integrating these dynamic tools, students are empowered to explore and engage with scientific concepts in an immersive way. This approach fosters an optimistic outlook, encourages curiosity and enables a deeper understanding of the subject. With the adoption of interactive simulations in physical science education, we open the doors to an enriching educational experience. By integrating these dynamic tools, students are encouraged to explore and become actively involved in understanding scientific concepts. This approach fosters an optimistic outlook, stimulates curiosity and enables better assimilation of knowledge.

We took into consideration that the use of interactive simulations in physical science teaching can influence motivation and self-confidence while promoting more effective understanding and assimilation of physics concepts among learners in light of the literature review focusing on science learning and the use of information and communication technologies (ICT). As a result, we developed the following research questions to direct our investigation:

1-How does the use of interactive simulations affect the motivation of first-year college students studying physical science?

2-How do interactive simulations influence learners' self-confidence in physics?

3-How do interactive simulations contribute to learners' improvement and conceptual understanding of physics topics?

4-What variables can affect how well interactive simulations are used to teach physical science?

4. Methodology

4.1 Sample and study design

The sample for this study was made up of Moroccan first-year college students from three public schools in the Tangier-Tetouan-Al Hoceïma region.

Over the course of four weeks, four physical science professors participated in the study. Throughout this time, they taught scientific ideas, especially those related to electricity, using simulation-based instructional methods. Students filled out a questionnaire using pencil and paper. Studying how interactive simulations affect students' motivation, self-assurance, and conceptual grasp when teaching physical science was the goal.

Classes were randomly assigned to students of both sexes based on the administrative databases of the program. The research participants were chosen using simple random sampling. A total of 324 students studying physical science answered the questionnaire. There were 143 male students (44%) and 181 female students (56%).

4.2 The simulation resources used

The instructor supported the teaching of physics principles, especially those pertaining to electricity, by utilizing Crocodile Clips V 3.5, an open-access simulation resource that may be accessed at http://www.Crocodile-clips.com . Students can conduct virtual experiments on a variety of electrical issues, tailored to their own ideas, with the help of the Crocodile Clips application.

In this program, the topics are presented as a whole. At the top of the screen are shortcut keys to all the elements that users can integrate into their circuits: batteries, switches, integrated circuits, discrete semiconductors, passive components. These elements enable users to make modifications to the experience mechanism. Users can easily create their own experiments for use in the program, presenting them in the form of images and symbols. [22]

To use Crocodile Clips, users simply select a component by clicking on it, then place it on the worksheet by releasing the mouse button.

Simulations covered topics including simple electrical circuits, series and parallel circuits. As an example, Figure 1 shows an interactive simulation activity designed to teach parallel connection in symbol form, while Figure 2 shows the same activity in picture form.

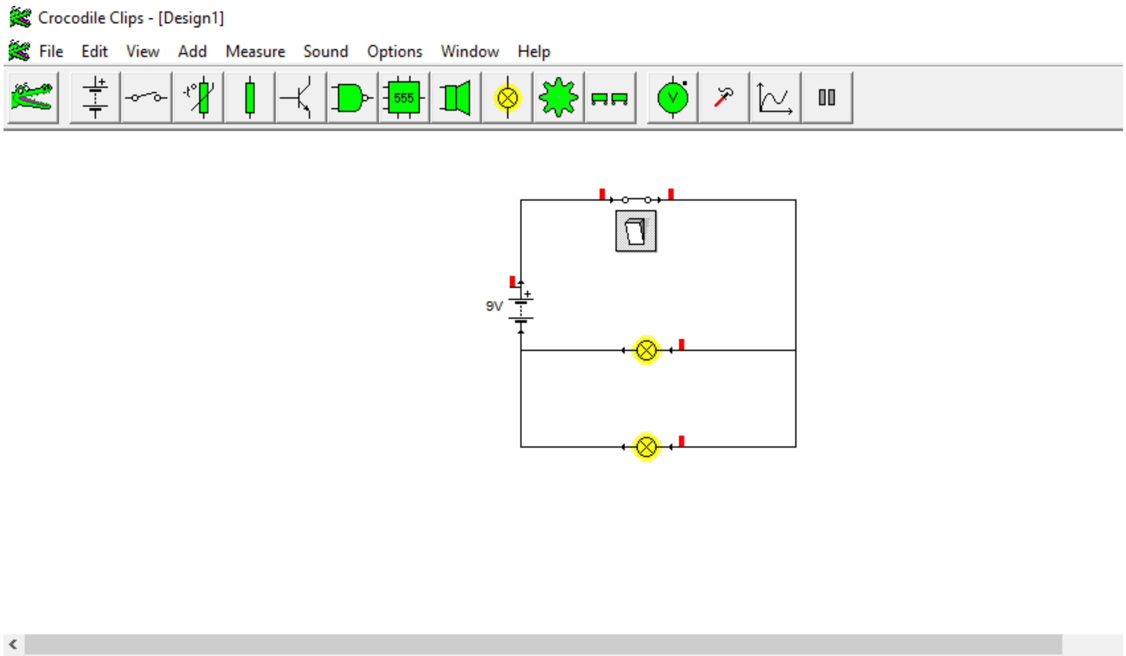

Fig. 1. Teaching parallel connection in symbol form with the help of simulations. (Source: http://www.Crocodile-c lips.com).

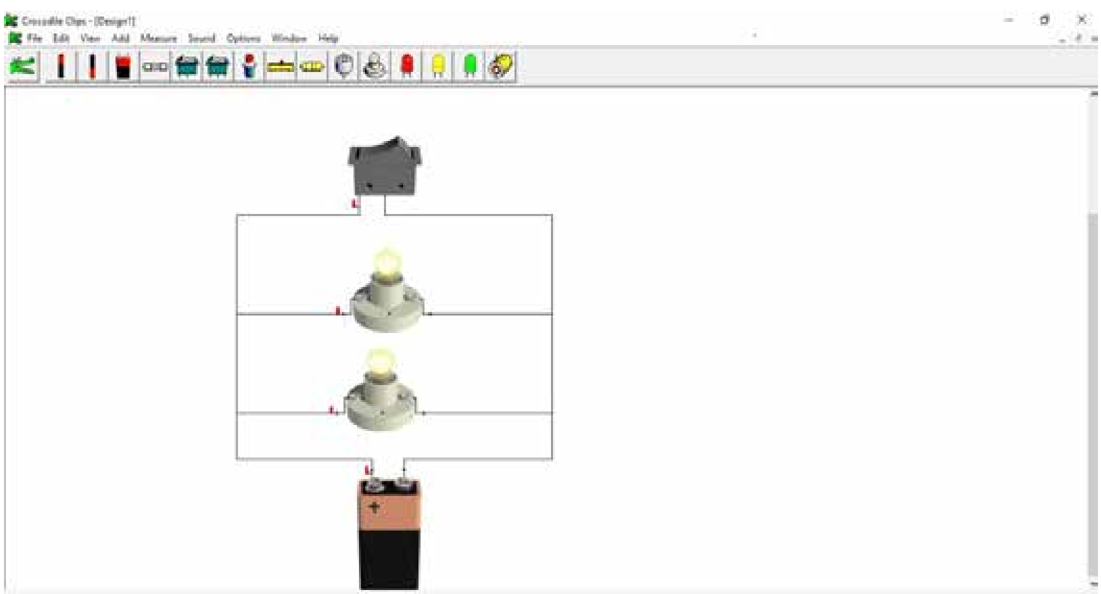

Fig. 2. Teaching parallel assembly as images using simulations. (Source : http://www.Crocodile-clips.com).

4.3 Research instrument

To collect data on our variables, we created two survey questionnaires: a pre-test and a post-test.

The first questionnaire consists of two distinct parts. The first part, consisting of questions Q1 to Q6, is designed to collect socio-demographic information such as gender, age, school status (repeating or not), place of residence, as well as parents' socio-professional category. The second part, represented by question Q7, comprises 17 items, 6 of which are negative (items 1, 3, 7, 9, 12, 14). Responses to the 17 items are evaluated on a 5-point Likert scale (1: strongly disagree; 2: disagree; 3: neutral; 4: agree; 5: strongly agree). This section aims to assess students' attitude, interest and perception of physics prior to using the Crocodile Clips simulator. It also explores their motivation, confidence in solving complex problems and applying physics principles in real-life situations, as well as their commitment to deepening their understanding of physics concepts and their comfort in asking questions and seeking help in class.

The second questionnaire comprises two questions, Q1 and Q2. The first question, Q1, consists of 17 items, 4 of which are negative (items 12, 13, 15, 16).This question aims to assess the impact of using the Crocodile Clips simulator on physics learning. The aims of this part include measuring the simulator's effectiveness in improving understanding of physics concepts, assessing student engagement and motivation, and identifying specific aspects that promote greater understanding and interest in the subject. The second question, Q2, is an open-ended question aimed at understanding whether students are able to identify the main concepts or aspects that their teacher seeks to emphasize when using the simulator for simple electrical circuits, particularly series and parallel connections.

5. Results and discussion

The main objective of this study was to analyze the impact of interactive simulations, in particular the Crocodile Clips simulator, on the motivation, self-confidence and conceptual understanding of college-level physical science students.

In the first part of the pre-test survey questionnaire, data were analyzed by performing a classification of questionnaire responses in order to investigate sample characteristics as a function of control variables. The distribution of students was examined according to various external variables such as gender, age, school status (repeating or not), place of residence, and parents' socio-professional categories. We found a wide range of ages, from 11 to 15. In terms of parents' socio-professional categories, we found that the majority of students came from families where the parents were blue-collar or white-collar workers. According to the responses received, 36 students, or 11% of the total, are returning to the 4th grade. The majority of students, 89%, are therefore in their first year of schooling in the 1st grade.

Distribution of students by Attitude to Physics Before using the Crocodile Clips simulator

With regard to students' attitudes towards physics before using the Crocodile Clips simulator, we determined their overall attitudes towards physics, based on the questionnaire items. Of the 324 or 219 students who responded to the questionnaire, 68% expressed a negative attitude towards physics. This suggests that a significant majority of students have an unfavorable perception of discipline, compared with 26% of students who expressed a positive attitude towards physics. Although this percentage is lower than that of negative attitudes, it still indicates that a notable proportion of students have a perception and 6%declared neutral.

Distribution of students by Attitude to Physics After using the Crocodile Clips simulator

Table 1. Students' statements after using the Crocodile Clips simulator.

Variables	Terms	Percentages
Accessibility of concepts	Favourable opinion	22.5 %
	Negative opinion	61.5 %
	Neutral opinion	16.0 %
Usefulness of the simulator	Favourable opinion	56.6 %
	Negative opinion	29.7 %
	Neutral opinion	13.7 %
Interest in physics	Favourable opinion	63.3 %
	Negative opinion	20.8 %
	Neutral opinion	15.9 %
Motivation	Favourable opinion	73.0%
	Negative opinion	18.9 %
	Neutral opinion	8.1%
Ease of use of the simulator	Favourable opinion	81.4%
	Negative opinion	15.8%
	Neutral opinion	2.8%
Environmental conditions (brightness)	Favourable opinion	38.7 %
	Negative opinion	51.2 %
	Neutral opinion	10.1 %
Students'self-confidence in their ability to understand and succeed in physics	Favourable opinion	35.8%
	Negative opinion	52.5%
	Neutral opinion	11.7%
Perceived understanding of physical concepts	Favourable opinion	69.3%
	Negative opinion	23.1%
	Neutral opinion	7.6%

The post-use study of the Crocodile Clips simulator showed positive results: 69.3% improved their understanding of physics concepts, 56% found the simulator useful, 63.3% increased their interest in physics, and 73% saw their motivation strengthened. What's more, 82% found the simulator easy to use. However, improvements are needed in terms of environmental conditions, with 51.2% of students expressing an unfavorable opinion of the brightness.

For the final, open-ended question: "What aspects or concepts do you think your teacher was trying to emphasize by using the simulator for simple electrical circuits, in particular for series and parallel connections?", the majority of students, 83%, identified the course objectives taught by their teachers.

6. Conclusion

This study explored the impact of interactive simulations on learners' motivation, self-confidence and conceptual understanding in physics. The results highlighted that the use of interactive simulations, in particular the Crocodile Clips simulator, played a crucial role in increasing learners' interest in the physical sciences, boosting their motivation to learn and explore complex scientific concepts. Interaction with this simulator enabled learners to visualize physical phenomena, manipulate electrical circuits and experiment hands-on, leading to better assimilation of knowledge and improved conceptual understanding.

In addition, this study highlighted the importance of designing teaching activities based on this tool to foster a deeper understanding of scientific concepts. The simulator's interactive features enabled learners to simulate real experiments, test hypotheses and explore physics principles in an engaging and immersive way.

The implications of these results for physical science teaching are significant, highlighting the added value of integrating this tool into curricula to enrich learners' learning experience. Teachers are encouraged to use this technological tool to diversify their teaching methods, stimulate learner engagement and foster a better understanding of scientific concepts.

In conclusion, this study highlights the potential of interactive simulations, in particular the Crocodile Clips simulator, to transform physical science teaching by offering learners an interactive, motivating and immersive approach to learning. Successfully integrating this tool into teaching practices can help boost learners' motivation, increase their self-confidence and foster a deeper understanding of the physical sciences, paving the way for innovative and effective teaching practices in science education.

In the field of physical science education, future directions for research into the use of interactive simulations look promising. By considering the exploration of new technologies such as virtual and augmented reality, researchers could enrich the learning experience for students. It is also crucial to design interactive simulations tailored to the specific needs of learners, taking into account their learning styles and skill levels. The more systematic integration of interactive simulations into educational programs, aligned with learning objectives, is an important line of research. Furthermore, it is essential to continue evaluating the impact of these simulations on learners' motivation, self-confidence and conceptual understanding, while developing training programs for teachers to maximize the effectiveness of these pedagogical tools. By exploring these future directions, research could make a significant contribution to improving physical science learning through innovative and engaging approaches.

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