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Effectiveness of Integrating Virtual Physics Simulations into Traditional Pedagogy: An Active Learning Case Study at Oudomxay High School, Lao PDR

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EFFECTIVENESS OF INTEGRATING VIRTUAL PHYSICS SIMULATIONS INTO TRADITIONAL PEDAGOGY: AN ACTIVE LEARNING CASE STUDY AT OUDOMXAY HIGH SCHOOL, LAO PDR

Abstract: This study investigates the effectiveness of integrating virtual physics simulations into traditional pedagogical methods for enhancing problem-solving skills among eleventh-grade students at Oudomxay High School in the Lao People's Democratic Republic. Recognizing the potential of active learning through virtual tools, this case study aimed to harness the strengths of both traditional and digital learning tools to provide a comprehensive physics education. 46 students were selected via simple sampling., this hybrid instructional approach was implemented. The novelty of the used virtual simulations lay in their interactive design tailored to specific physics concepts, ensuring a deep, immersive experience. Post-instruction evaluations comprised a structured achievement test, designed to assess understanding of the specific physics concepts taught, and a satisfaction questionnaire. Results showed an average score increase of 15.61 points, with statistical analyses confirming significant advancements at the 0.01 level. Quantitative feedback from students indicated a heightened conceptual understanding, with many highlighting the simulations' role in clarifying complex physics concepts. Moreover, students reported heightened engagement levels, attributing this to the dynamic nature of the virtual tools. The case study underscores that the combination of traditional methods with virtual simulations can foster enhanced understanding and problem-solving abilities in physics, particularly in the covered concepts.

Keywords: Active learning, virtual simulation, high school achievement, Lao PDR education

Introduction

In today's era of expansive and borderless learning, technology plays a crucial role in various fields, particularly in education. Research indicates that technological media significantly enhances teaching and learning effectiveness (Suvarna K.G., *et al* 2015), notably in subjects like physics that involve understanding natural phenomena. Computer-based teaching aids, especially in physics, allow students to visualize concepts more clearly, aiding in the comprehension of complex topics. This is vital for students with varying levels of physics knowledge, as effective teaching in this subject requires materials that enable all students to grasp and visualize concepts through interactive virtual simulations. Such simulations have been recognized as an effective teaching tool in physics (Khamcharoe *et al*, 2019).

However, recent observations indicate a decline in students' academic achievements in physics, emphasizing the need for more student-centered teaching approaches that encourage practical application (Kongnu, 2019). My experience teaching physics at Oudomxay Secondary School in the Lao People's Democratic Republic reveals that students often lack a fundamental understanding of physics, struggling to connect theoretical content with practical applications. This disconnect can be attributed to inadequate learning media and limited opportunities for hands-on experimentation, as the necessary equipment is often costly and specialized. Consequently, students' comprehension of physics principles, theories, and rules remains superficial, leading to poor academic performance and negative attitudes toward the subject. Additionally, conversations with fellow teachers suggest a prevalent reliance on traditional teaching methods, like lectures and basic experiments, with a lack of innovative approaches to develop students' physics knowledge and skills. However, it is important to consider diverse student learning abilities when organizing physics education, to foster development in various ways and cater to different learning needs (Ramsiri, 2015).

Given this background, it becomes evident that integrating virtual interactive simulation media in teaching is essential for facilitating advanced thinking processes in students. When faced with problems, students can apply the critical thinking skills acquired through Active Learning to find solutions. This approach aligns with how the brain processes and retains information, enabling effective learning through participation and interaction with peers and instructors. Engaging in real-life practice enhances knowledge, skills, and attitudes, leading to the development of key competencies aligned with educational objectives (Yodmanee,*et al*, 2022). Therefore, this study aims to explore effective and engaging teaching methods to enhance high school students' physics abilities.

Research Question

1. How was a model developed for active teaching using interactive physics simulation media for high school students at Udomxay Secondary School, Lao People's Democratic Republic?

2. What is the level of effectiveness of Active Learning using Virtual Simulations in enhancing physics problem-solving skills of high school students at Udomsai High School?3. What is the level of student satisfaction with the active learning model that combines interactive physics simulation media at Somboon Secondary School, Udomxay Province?

Research objectives

1. To develop a proactive teaching model using interactive physics simulation media for high school students at Oudomxay Provincial Complete Secondary School, Lao People's Democratic Republic.

2. To examine the effectiveness of Active Learning using Virtual Simulations in enhancing problem-solving skills in physics among high school students at Oudomxay Provincial Complete Secondary School.

3. To evaluate student satisfaction with the active learning management model incorporating interactive physics simulation media at Oudomxay Provincial Complete Secondary School.

Literature review

1. Active Learning Concept

Active learning, a pedagogical approach that equips students with knowledge, competencies, and desirable citizenship qualities, is vital in the 21st-century educational landscape. It involves students actively in learning processes, encouraging higher-order thinking skills through creation, analysis, synthesis, and evaluation (Funfuengfu, 2019). This approach transforms students from passive recipients to active knowledge creators, with teachers facilitating rather than directing the learning process. Moreover, The Office of the Basic Education Commission (2019) mentioned active learning refers to a broad range of teaching strategies which engage students as active participants in their learning during class time with their instructor. Typically, these strategies involve some number of students working together during class but may also involve individual work and/or reflection. These teaching approaches range from short, simple activities like journal writing, problem solving and paired discussions, to longer, involved activities or pedagogical frameworks like case studies, role plays, and structured team-based learning, which corresponded to Phonthadawit (2018), the definition of active learning "involves students in doing things and thinking about the things they are doing." Simply stated, learners transition from mere "observing" to "actively engaging" with the new information presented to them. When learners are directly engaged with their learning materials, they develop a positive relationship with their training. It allows them to gain a deeper understanding and connection with the material, which helps result in improved learning success.

1.1 Benefits and Definition of Active Learning

Warinporn Funfuengfu (2019) said that active learning management (Active Learning) means learning design. and learning management Emphasis is given to students in actual practice. Create knowledge through advanced thinking (Higher-Order Thinking) Doing the work Create work and present the work yourself Learning that focuses on allowing students to interact with teaching and learning. Stimulate students to have a higher learning process (Higher- Order Thinking). with analysis, synthesis, and evaluation Not only listeners, but students must also read, write, ask questions, and discuss together. Students practice the prior knowledge and needs of students must be considered as important. The role of students will be changed from being a recipient of knowledge to being a participant in creating knowledge.

The researcher concluded that Active learning management or Active Learning is learning that aims to allow students to participate in learning. You can learn through planning. Searching for information, analyzing, and synthesizing searched knowledge. and exchange knowledge in the classroom or outside the classroom through roles of being both a student, a listener, a speaker, and a debater until new knowledge is gained that the students learn on their own. and teachers will adjust their role as instructors to facilitators of teaching and learning.

1.2 Importance of Implementing Active Learning

The Office of the Basic Education Commission (2019) mentioned the importance of organizing active learning (Active Learning) as follows:

Active learning can encourage students to have independent thinking, critical thinking, and creative thinking. Participate in actual practice It aims to create students who direct the direction of their learning. Find your own learning path Being a person who knows how to think and make decisions on your own Therefore, active learning is a learning management approach that aims to enable students to develop advanced analytical thinking. Problem solving, evaluation, decision making and creativity.

Active learning supports and promotes effective cooperation between students and teachers. including between students This cooperation will lead to overall success and promote teamwork for students as well.

Active learning makes students motivated dedicated to studying and make students express knowledge and ability When students actively participate in activities in a conducive environment with various activities provided by the teacher. Students choose to learn various activities according to their own interests and aptitudes. Responsibility arises. and dedicated to achieving success.

Active learning promotes the learning process that creates positive development for both students and teachers, adjusting learning and teaching. Students will have the opportunity to choose to use their aptitudes, interests, and abilities that are individual differences. In line with the concept of Multiple Intelligence (Multiple Intelligence) to express one's own identity and potential. As for teachers, teachers must be aware of the guidelines for supervision to develop and promote active learning management according to the policy to reduce study time. Add time to know where to Change roles Seeking a way A variety of activities to help enhance the potential of each student, these things will give teachers skills in teaching. and have expertise in their roles and responsibilities It is self-development and work development. and develop students together.

In summary, the importance of active learning is organized by learning that is student focused. Organizing learning activities that emphasize hands-on learning for students Teachers play the role of facilitator in organizing learning so that students can practice it on their own. Design activities for students to practice listening, reading, writing, and expressing their opinions together. Active Learning. Encourage learners to have independent thinking having good judgment and creative thinking Learners participate in real practice, aiming to create learners who direct the direction of learning. They choose to study according to their own interests. Can choose your aptitude Ability that is a difference between individuals to express one's identity and potential as for teachers, they must be aware of changing their roles. Seek ways to develop a variety of activities to help build the potential of each learner.

2. Virtual Interactive Simulation Media

PhET INTERACTIVE SIMULATIONS is a program that can be used free of charge. It is designed to make it fun and engaging for students to understand the use of interactive virtual media during learning about physical phenomena and is effective in organizing lecture-based learning Classroom Activities Experimental practice and homework (https://phet.colorado.edu/th/) and it also results in students having meaningful understanding and awareness of various phenomena. that occur in the world (Chansoon *et al*, 2018).

Meaning and Importance of Physics

Physics, a fundamental science, explores the relationships between various physical quantities in natural phenomena, employing observation, experimentation, and logical or mathematical methods. It spans from elementary particles to the universe, contributing to technological advancements and various scientific disciplines such as mathematics, chemistry, biology, engineering, and medical sciences (University of Colorado Boulder, 2014).

Research framework

The research was to develop a proactive teaching model using interactive physics simulation media for high school students, to examine the effectiveness of Active Learning using Virtual Simulations in enhancing problem-solving skills and to evaluate student satisfaction with the active learning management model incorporating interactive physics simulation media at Oudomxay Provincial Complete Secondary School.

The researcher defines the research concept which consists of a proactive teaching model using interactive physics simulation media for high school students to evaluate academic achievement and Students' satisfaction as show research framework following.

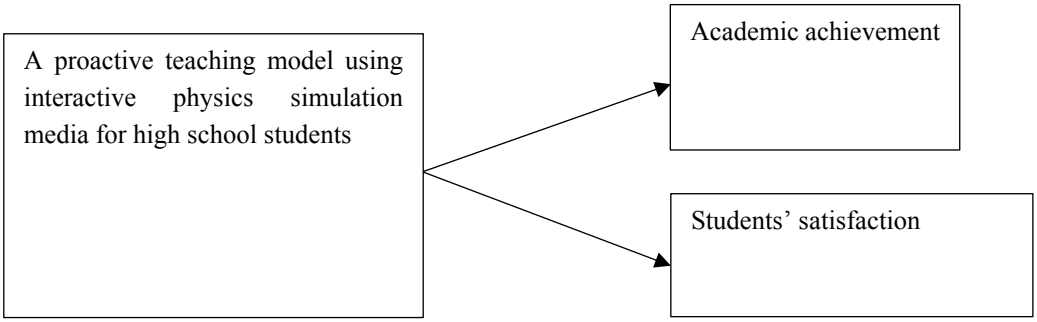

Figure 1: Research Framework

Population

The population is eleventh-grade students at Oudomxay High School in the Lao People's Democratic Republic, Semester 2, academic year 2022, 5 classrooms, 229 people.

Samples

The sample comprises eleventh-grade students from Oudomxay High School, selected through simple random sampling. The lottery method was employed, which includes 46 students.

Research instruments

1. Physics Lesson Plan: This plan focuses on the curved trajectory movement for eleventh-grade students.

2. Academic Achievement Test: A pre-and post-study test measuring understanding of physics concepts related to curved trajectory movement.

3. Student Satisfaction Survey: An assessment tool to gauge eleventh-grade students' satisfaction with the active learning model utilizing interactive simulation media for enhancing problem-solving skills in physics.

How to construct the instrument

The researcher has created the tools used to collect the data. The researcher has carried out the steps in the following steps:

1. Study documents, textbooks, principles, concepts, and research related to proactive teaching model using interactive physics simulation media for high school students. To define the concept in research and as a guideline in creating questionnaires

2. Create a questionnaire according to the conceptual framework to cover the scope of term definitions and use the completed questionnaire. Completed and presented to the advisor to ask for advice or suggestions Then bring it to improve.

Data collection

1. Conduct a pre-test to assess initial physics learning achievement
2. Introduce the experimental learning activities to students.
3. Implement the teaching according to the physics lesson plan.
4. Gather satisfaction data through student questionnaires, followed by statistical analysis to calculate the mean.
5. Conduct a post-test to evaluate learning achievement after completing the lesson plan, with subsequent statistical analysis.
6. Assess student satisfaction with the active learning model using virtual interactive simulation media.

Data analysis

The data were analyzed using statistical methods, including mean, standard deviation, and T-Score, with a significance level set at 0.05.

1. Compare academic achievement scores from the pre-test and post-test using t-test statistics.
2. Analyze student satisfaction data from the active learning model employing physics interactive simulation media.

Results and analysis

Table 1 Comparative Results of Academic Achievement in Physics with Virtual Interactive Simulation Media (n=46)

Test	Mean	SD	t	Sig.(1-tailed)
pre-test	10.70	2.01	16.318	.000
Post-test	15.61	1.31		

Table 1 presents the comparative academic achievements of eleventh-grade students' post-implementation of active teaching using virtual interactive simulation media in Physics. The data show a significant improvement, with the average pre-test score at 10.70 and the post-test average at 15.61. This indicates a statistically significant increase in student performance after the intervention, with the post-test scores being considerably higher than the pre-test scores at a .01 significance level.

Table 2 Analysis of Student Satisfaction with the Active Learning Model using Interactive Physics Simulation Media

Description	Mean	SD	Interpretation
1. Virtual interactive simulation media creates learning as if it were practiced.	3.89	0.80	High
2. Realistic interactive simulation media makes learning content easier to understand.	3.87	0.88	High
3. The interactive simulation media provides a good understanding of the basic principles of trajectory movement.	3.93	1.02	High
4. Virtual interactive simulation media helps develop the ability to think and solve problems.	3.85	0.94	High
5. Virtual interactive simulation media helps to learn new things and generate new ideas.	4.07	0.95	High
6. Virtual interactive simulation media creates a good way to think and solve problems.	4.00	0.79	High
7. Interactive simulation media stimulates students' thinking systematically.	4.02	0.83	High
8. The virtual interactive simulation media is easy to use and convenient to use.	4.02	0.91	High
9. Realistic interactive simulation media are very necessary in learning about trajectory movement.	4.04	0.87	High
10. Students are overall satisfied with the interactive virtual simulation media.	4.09	0.81	High
Average satisfaction level	3.98	0.88	High

Table 2 Analysis of student satisfaction at Oudomxay Provincial Complete Secondary School, Lao People's Democratic Republic, indicates high overall satisfaction (Mean=3.98, SD=0.88) with the active learning model using interactive physics simulation media. Notably, students were most satisfied with the overall experience of the interactive virtual simulation media (Mean=4.09, SD=0.81), and the media's ability to foster new learning and idea generation (Mean=4.07, SD=0.95).

Conclusion

This study aimed to develop an interactive physics teaching model for high school students at Oudomxay district Secondary School, Lao PDR. It examined the effectiveness of active teaching using physics interactive simulation media by comparing student achievement before and after the intervention. The sample included eleventh-grade students from a randomly selected classroom, with 46 participants. Research instruments comprised a proactive teaching plan, physics simulation media, achievement tests, and a post-learning satisfaction survey. The study utilized statistical methods for analysis, including mean, standard deviation, and T-tests. The findings demonstrated significant improvements in students' physics scores post-intervention, with the mean increasing from 10.70 to 15.61, indicating the effectiveness of the teaching model. Additionally, student satisfaction with the active learning model and simulation media was high, suggesting a positive reception of the innovative teaching approach.

Discussion

The study's findings revealed a significant increase in academic achievement among high school students' post-intervention with virtual interactive simulation media in physics, as indicated by the rise in average scores from 10.70 to 15.61. This improvement can be attributed to the proactive teaching and learning approach facilitated by the simulation media, which effectively replaced traditional equipment. This method allowed for a clearer understanding and visualization of physics concepts, specifically in demonstrating curved trajectory movement. As emphasized by Phonthadawit (2018), active learning necessitates extensive student participation, fostering independence and involvement in their learning process.

Furthermore, the analysis of student satisfaction revealed high levels of contentment with the active learning model integrated with interactive simulation media. This could be due to the model's ability to engage students actively in their learning journey, shifting the focus from mere knowledge reception to active participation and application, as advocated by Pruitthikul (2015) and Bonwell and Eison (1991). The integration of virtual interactive simulation with hands-on practices encouraged students to engage more practically, enhancing their understanding of scientific methods and experiments, as noted by Herga and Dinevski (2012). Thus, the study concludes that proactive learning management with physics interactive simulation media significantly enhances students' understanding and satisfaction in learning.

Research Suggestions and Future Research

The study suggests that physics teachers at Oudomxay Provincial Complete Secondary School can incorporate proactive learning plans with interactive simulation media to enhance students' understanding in various physics areas. The simulation media should be systematically organized and include clear instructions for independent student use outside class.

For future research, it is recommended to explore other active learning methods to further develop students' scientific skills and achievements in physics. This could help identify the most effective teaching methods tailored to students' needs, promoting a more comprehensive and engaging learning experience. Additionally, the development of realistic interactive simulation media for various physics topics and other subjects is suggested to support active learning and foster student engagement.

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