# A Comparison Analysis of Physics Teaching using Virtual Reality (VR) in the Classroom and Online before and during the Covid-19 Pandemic

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## Abstract

**Background:** The use of virtual reality (VR) in physics teaching in recent years has become a topic of great interest. Reasons being the ability to re-create expensive experiments countless time with no additional costs and little to no danger to the participants. When the COVID-19 pandemic shutdown classrooms globally starting in early 2020, other methods were needed to move education online due to the pandemic's distancing requirements. When the reasons are combined, the need for online virtual physics classrooms has become even greater.

**Objectives:** The study's objective was to investigate and compare seven main aspects with 41 items concerning classroom and online physics teaching using virtual reality (VR).

**Methods:**Using a quasi-experimental sample of 44 Thai high-school physics teachers from 22 schools in Thailand's north-eastern rural Surin Province, teachers' opinions on their VR use concerning 1) *attitudes*, 2) *acceptance*, 3) *expectations*, 4) *management problems before COVID-19,* 5) *management problems during COVID-19,* 6) *teaching and learning problems*, and 7) *solutions to problems* were analyzed.

**Results:**Results from teachers' *attitudes* revealed that VR made lab experiments and visualizations clearer (*Aspect* 1). *Acceptance* opinions found that VR allows better online learning organization and reduces problems for schools that lack experimental equipment (*Aspect 2*). *Expectations* revealed that using VR helped students better understand due to experimentation repetition (*Aspect 3*). Opinions concerning *management problemsprior to COVID 19* revealed significant agreement that schools lacked sufficient lab equipment and funding (*Aspect 4*). Results for the 13 items for the *management problems during the COVID 19 pandemic* were highly mixed, with funding and budget issues less important than before the pandemic (*Aspect 5*). Under *teaching and learning problems*, the teachers again voiced their concerns that supporting ICT and the Internet was problematic (*Aspect 6*). Finally, in the teachers' *solutions to problems,*

strong belief was expressed for student use of VR to study part-time and online (*Aspect 7*).

**Conclusions:** Implications suggest that funding problems have become lessened due to the movement to online teaching using a VR format and student-purchased smartphones.
***Keywords****:*augmented reality, COVID-19,learning management, physics laboratory, Thailand, virtual science lab.

## 1. Introduction

Science and technology have always played a critical role in developing a nation. With scientific advancement come new technologies, products, and systems, that can help countries overcome barriers and improve their citizens' life quality [1]. This is especially relevant within education and related learning management.

Moreover, technological advancement has changed the constraints which previously governed the classroom, allowing instructors to use new mediums to structure their lessons. When used effectively, new technologies increase student engagement and an understanding of the content [2].

Examples of these developments in online learning which cover a broad scope of techniques and associated terminology include flipped classrooms, blended learning, distant and remote learning, and computer-based learning. The constant variables are the ability to use information communication technology (ICT) and digital devices such as the Internet and smartphones, which allow teachers and students to communicate and collaborate. This decentralizes the learning environment and removes the necessity for education in one physical room. However, it also allows for asynchronous learning and access to information that is not confined to instructional hours—in essence, allowing learning to happen at any time and anywhere [3]. Furthermore, during the COVID-19 pandemic, online learning has been the 'go-to' solution in solving social distancing and remote learning requirements. As governments acted to prevent – transmission, social distancing and school closures became the norm worldwide. Teachers have since turned to online learning tools like video conferencing, video streaming, class message boards, and digital lectures to adapt to ever-changing demands of dealing with the COVID-19 pandemic [4].

For the previously stated reasons, considering the effectiveness of online learning and the increased degree to which educators and teaching management professionals have relied upon it during the COVID-19 pandemic, the authors sought to determine the efficacy and attitudes toward implementing virtual reality (VR) laboratories as an online learning tool. In order to determine this, the researchers investigated and compared seven main aspects concerning classroom or online physics teaching using virtual reality. These included teacher 1) *attitudes*, 2) *acceptance*, 3) *expectations*, 4) *management problems before COVID-19,* 5) *management problems during COVID-19,* 6) *teaching and learning problems*, and 7) *solutions to problems*.In preparation for this analysis of physics teaching VR online vs. in the classroom, the researchers found the following foundational theory to function as the groundwork for this study.

### *1.1 Learning Goals of High School Physics*

High school physics is a compulsory prerequisite for those who wish to study the sciences at the post-secondary level in many countries. Though most of the teaching at the secondary level is heavily focused on the theoretical application of formulas, learning optimization and retention are observed when a wider variety of methodological teaching instruments are used [5], such as laboratory experiments. Though the experimentation process is beneficial to the learner's acquisition of the course material and lesson content, many schools suffer from budgetary constraints that prevent them from keeping up with the high cost of maintaining a lab. This can cause instructors to default to heavily theory-based lesson plans, with little emphasis on diversifying teaching methods or alternative learning styles [6].

According to the guidelines set out by the Thai Institute for Teaching Science and Technology, the core curriculum focuses on learner development to bring them up to a level of competency on par with that of the international community. Textbooks outline the traditional instruction of theoretical components of core concepts of physics, such as including straight motion, resultant force, and the law of motion, while also providing guidelines for conducting hands-on laboratory experiments with a focus on the collection of empirical data and the use of the scientific method [7].

### *1.2Guidelines for Education Management in a Physics Laboratory*

Upon analysis of the Thai curriculum for physics and sciences, we can see that it touches on many of the core competencies required for PISA (*Programme for International Student Assessment)*testing metrics. Unfortunately, this is not reflected in the below-average scores of Thai students compared to other nations. This suggests that a well-structured curriculum alone does not guarantee student success but is instead a component in a larger, well-rounded teaching strategy [8].

However, integration of active learning strategies into the classroom is hindered by large class sizes of one hundred or more using traditional classrooms with fixed seating. These environments are not conducive to active learning practices, as the student is not at the center of the learning process [9].

Fortunately, when active learning techniques are implemented, numerous studies have shown how they positively affect students' desire to learn and willingness to share information. By contrast, more traditional teaching methods increased learning motivation amongst higher GPA students while not eliciting the same desire to share information amongst their lower-performing peers [10].

However, difficulties with the active learning model can come from its loose definition across studies. While there seems to be no specific definition for active learning classroom practices, it encompasses a wide variety of methodological instruments and approaches, usually with positive student satisfaction surveys [11]. Other studies have pointed out that active or student-centered learning benefit introductory science classrooms [12]. When exploration-based learning is combined with a learning management process that allows students to participate in classroom activities, students are granted more significant opportunities to hone their skills in analyzing and critiquing information. Using these methods, teachers can emphasize developing

students' problem-solving abilities. This encourages active learning and student engagement, allowing students to change their self-perceived role as learners, and allowing more self-guided learning experiences [13].

### *1.3Teaching and Learning Management Conditions during the COVID-2019 pandemic*

Due to the COVID-19 pandemic, China was forced to drastically change structures within its education system to combat the spread of the virus [14]. This was accomplished through a joint effort of different branches of government coming together to create a new remote education system. Critical factors in this new system can be identified as pairing with state television broadcasters to augment the dispersion of information. At the same time, teachers directly managed the daily class sessions with their students via online learning.

Strategic implementation of diverse and specialized learning tools is beneficial for promoting student success. Measures such as student performance evaluations and achievement data allow for lesson plans to be tailored for individuals to promote academic achievement. This is particularly demonstrable and important when working towards making accommodations for students with special needs [15].

The parent's role is also critical in successfully implementing a distance or remote learning program for young students. Many factors affect a parent's ability to assist their children and ensure work gets done correctly and on time. Such factors include the parents' workload concerning their careers and stress level. However, we can optimize a parent's chances of successfully guiding their child if we provide them with adequate resources. Professional teacher advice and contact and modified materials targeting student ability are highly likely to increase a parent's efficacy in managing their child's learning from home [16].

Moreover, quality student support is also required in a remote learning environment, with teacher familiarity and access to student information paramount to teacher success. Tools such as child behavioral assessments, student records, and interviews help inform educators and allow them to adequately support students in this new learning environment[17].

## 2. Objectives

To investigate and compare classroom or online physics teaching using VR across seven main aspects, including 1) *attitudes*, 2) *acceptance*, 3) *expectations*, 4) *management problems before COVID-19,* 5) *management problems during COVID-19,* 6) *teaching and learning problems*, and 7) *solutions to problems*.

## 3. Methods

### *3.1 Population and Sample*

The population used in this research was secondary school science teachers in Thailand’s northeastern (Issan) Surin Province during the academic year 2021. There were 85 schools and 486 potential participants [18]. Using purposive sampling, 44 physics teachers from 22 schools were selected to participate in the study (Table 1).

These schools included 1) KaeSuksaPattana School, 2) Sangkha School, 3) KrathiamWitthaya School, 4) Sirindhorn School, 5) BuachedWittaya School, 6) SuraWittayakarn School, 7) NongsanitWittaya School, 8) SikhoraphumPhisai School, 9) Si Samphaolun Secondary School, 10) MuangKaePittayasan School, 11) Thetsaban 3 Anuson School 12) Don Rad Wittaya School, 13) Tha Tum PrachaSermwit School, 14) Suraphinpittaya School, 15) NabuaWittaya School, 16 is Weerawatyothin School, 17) Rattanaburi School, 18) Thung Kula Pittayakom School, 19) PradukaewPrachasan School, 20) Wangkhapattana School, 21) SamrongThapWittayakom School, and finally, 22) the KapChoengWittaya School. After receiving the link from a social media account or the researcher's e-mail account, all targeted participants completed their online questionnaires.

### *3.2 Research Instrument*

The research instrument was a Physics Teacher Opinion Questionnaire concerning the conditions of their physics laboratory. The questionnaire was synthesized from physics teaching using a physics laboratory. The questionnaire included multiple sections, including 41 items concerning their use of a mechanics laboratory, electromagnetism laboratory, and a sound and light wave laboratory.

### *3.3 Instrument Reliability and Validity*

A panel of five experts examined a total of 41 items. There was a combined confidence value of the questionnaire equal to 0.97.

### *3.4 Data Collection*

Data were collected in March 2021 by using an online Google Form questionnaire. Social media, e-mails, and telephone calls were used as contact and follow-up mechanisms. Thus, 44 complete questionnaires were returned from the Surin Province secondary-school physics teachers [19].

### *3.5 Data Analysis*

The sample consisted of 44 teachers, with each question answered as an open-ended question [20]. Therefore, teachers were not forced to answer, so the number of people answering each question differed.

## 4. Results

The opinions of Thai science teachers concerning the use of VR media in science labs and its management both before and during the COVID 19 pandemic are presented in Figures 1-7.

### *4.1 Aspect 1 - Attitudes*

Figure 1 shows the teachers' opinions concerning their *attitude* towards VR media in science labs (Aspect 1). Ranked highest was Item 5, in which VR media use contributed to a better understanding of physics. Item 2 was second, which was VR media helps visualize the science lab. Interestingly and somewhat contrary to other studies, Item 3

was judged to be the least important to the teachers, which was that VR media use stimulates learner curiosity.

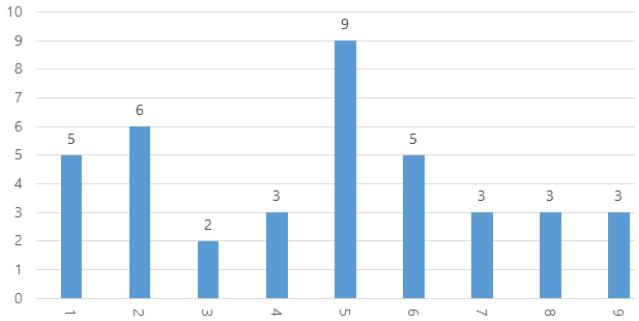


**FIGURE. 1. Attitudes of teachers concerning VR use**

**Interpretation:**

1. VR media is new, exciting, and practical.
2. VR media allows experiment visualization more clearly, resulting in a wide variety of learning.
3. VR media is useful in stimulating learner curiosity.
4. VR media helps solve funding problems.
5. VR media leads to better understanding of physics.
6. VR media can be learned anytime, anywhere, and is not limited to the laboratory.
7. VR media helps to promote and solve insufficient equipment issues.
8. VR media helps simulate virtual experiments.
9. VR media is useful.

### *4.2 Aspect 2 - Acceptance*

Figure 2 shows the teachers' opinions concerning their *acceptance* of VR media in science labs (Aspect 2). Ranked highest was Item 1, in which VR media was stated to be suitable under the COVID 19 pandemic conditions and can be used to support online learning management. This was followed by Item 6, in which the teachers felt that VR media use solved insufficient science lab funding problems. However, in Item 8, the teachers felt that VR media was not that easy to learn and use.

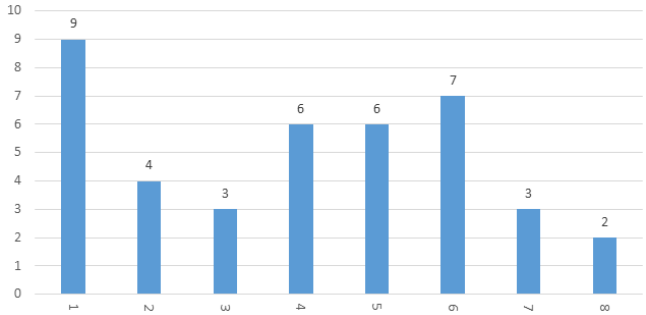


**FIGURE. 2. Aspect 2 – Acceptance of teachers concerning VR use**

**Interpretation:**

1. VR media is suitable under the COVID 19 pandemic conditions and can be used to support online learning management.
2. Students can visualize and relate the virtual images in the media to actual lab events.
3. VR media teaching activities are exciting, allowing students to participate in the activities.
4. VR media material can be enabled for study outside the classroom and is suitable for teaching online.
5. VR media help teachers explain lessons better to students.
6. VR media solves insufficient funding problems.
7. Our school's physics experiment equipment is not enough for the number of students.
8. VR media is easy to learn and use.

### *4.3 Aspect 3 - Expectations*

Figure 3 shows the teachers' opinions concerning their *expectations* of VR media in science labs (Aspect 3). Ranked significantly higher than other items in this category was Item 5, which is their agreement that VR media practice materials helped students learn and understand the content better. All other items were then judged to be somewhat less significant when compared to Item 5.

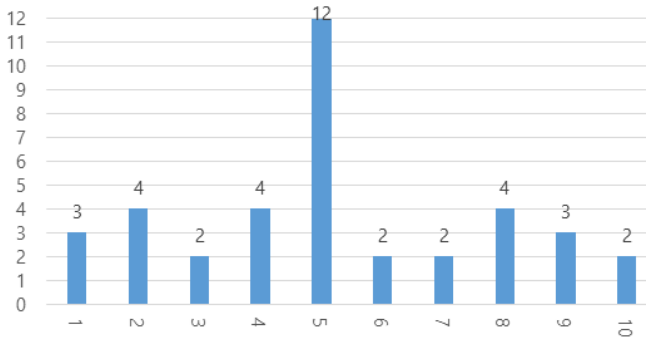


**FIGURE. 3. Aspect 3 – Science teachers' expectations toward VR use**

**Interpretation:**

1. VR media can increase student knowledge, interest, and comprehension of physics.
2. When students use 3D virtual lab materials, their science lab experience improves.
3. VR media can be used to create a variety of teaching and learning activities and design activities.
4. VR media can increase learning achievement.
5. VR media practice materials can help students learn and understand the content better.
6. VR media can be applied to students.
7. Teachers can understand and access VR media easily.
8. VR media can be used on mobile phones to facilitate learning online during the COVID 19 pandemic.
9. VR media helps students to communicate their lab observations and results better.

10. I want a virtual laboratory complete in all content, including physics, chemistry, and biology.

### *4.4 Aspect 4 - Management Problems (non-COVID 19 times)*

Figure 4 shows the teachers' opinions concerning their *management problems before COVID 19* regarding VR media use in science labs (Aspect 4). Under this category, the teachers had a strong agreement on two items. These were Item 2, in which many teachers felt that their schools lacked sufficient lab equipment to meet the students' needs due to lack of funding. This was closely followed by Item 1, in which the teachers felt that the lack of VR media and experimental equipment was a problem.

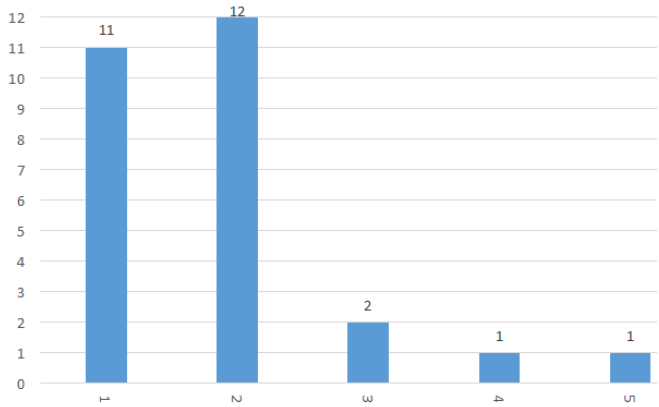


**FIGURE. 4. Aspect 4 – Science teachers' management problems concerning VR use prior to COVID-19**

**Interpretation:**

1. The lack of VR media and experimental equipment is a problem.
2. Some lab equipment is insufficient to meet the students' needs due to a lack of funding.
3. Potential lab experiment dangers make some students wary of their use.
4. There is a lack of qualified teachers compared to the number of students.
5. Students look at science as complex.

### *4.5 Aspect 5 - Management Problems during the COVID 19 Pandemic*

Figure 5 shows the teachers' opinions concerning their *management problems during the COVID 19 pandemic* towards VR media in science labs (Aspect 5). Rather interestingly, none of the 13 items drew strong agreement and were all ranked from 1 to 3. What is not clear is why before COVID 19, funding and budget issues were a significant problem, while during the pandemic, and these issues were judged as less critical.

The researchers' speculation for this change is that as teaching was forced to an online format, lab costs became a non-issue. Also, with students expected to pay their online costs, including the purchase of digital devices such as smartphones and tablets, schools did not have to fund these items.

Therefore, budgets have been shifted from traditional classrooms to online lesson development in Thailand. This policy was clearly stated by Thailand's Ministry of Education (MOE) that education funding under the 'New Normal' (during COVID 19)

would be shifted to online classes and their development [21]. Thus, online VR media use for physics and science education has become MOE sanctioned as a potential solution to meet the challenges of online and remote education.

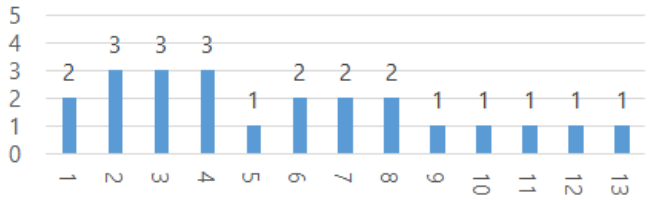


**FIGURE. 5. Aspect 5 – Science teachers' suggestions concerning VR use during COVID-19**

**Interpretation:**

1. Good VR media projects can be successfully implemented.
2. It is essential to have enough computers and hands-on practice in a real lab.
3. There should be an adequate budget for the purchase of equipment.
4. VR media should be a medium that all students can access and clearly explain the experiment results.
5. I am trying to adjust teaching methods during the COVID 19 pandemic.
6. Teachers must create VR media learning sessions that can be used through smartphones.
7. I would like to have more support equipment and additional speakers for my classes.
8. Create virtual experiments solves problems.
9. Learners lack practical physics skills.
10. Executive policy and school direction from the Science-Mathematics Program should support VR media use in the science lab.
11. The creation of VR media labs is essential.
12. Students should use their free time to acquire extra instruction to enhance their skills.
13. Teachers must review the experimental activities in both physical and virtual practice.

### *4.6Aspect 6 - Teaching and Learning Problems*

Figure 6 shows the teachers' opinions concerning their *teaching and learning problems* towards VR media in science labs (Aspect 6). Under this category, the teachers had a moderately strong agreement on two items. These were Item 3, where supporting ICT and the Internet were problematic. Of equal importance was Item 5's teacher's concerns that students only studied theory and the supporting virtual lab did not allow hands-on lab experiments in the current environment. Additionally, the teachers were concerned to a lesser degree with some students' unwillingness to participate in VR lessons because the VR media was not fully ready and had no supporting tools or experiments.

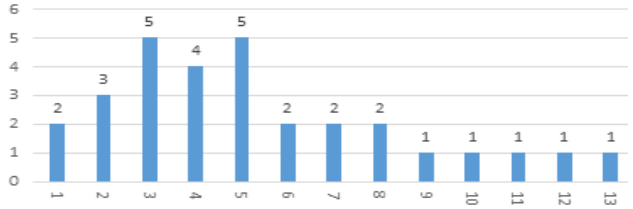


**FIGURE. 6. Aspect 6 – Science teachers' teaching and learning problems toward VR use**

**Interpretation:**

1. There is an inability to assess behavior.
2. Teachers are not tech-savvy and cannot produce VR media by themselves.
3. The Internet or supporting ICT is problematic.
4. Student cooperation and involvement depend on system and VR media readiness.
5. The students only study theory with the supporting virtual lab, not allowing hands-on lab experiments.
6. Finding high-quality VR media helps in student comprehension.
7. Student access and collaboration are essential for success.
8. The VR media content is complex. Therefore, students do not learn thoroughly.
9. No media and experiments are ready for Thai VR physics labs.
10. An active learning method is not practical for middle-level and weak students.
11. Students do not understand the content.
12. Students helping parents with work rarely attend school.
13. Students who do not understand the content and fail to complete assignments cause student depression.

### *4.7 Aspect 7 - Solutions to Problems*

Figure 7 shows the teachers' VR media in science labs' *solutions to problems* (Aspect 7). Under this category, the teachers strongly agreed with Item 7, which was the teachers' belief that using VR to study part-time and online was helpful.

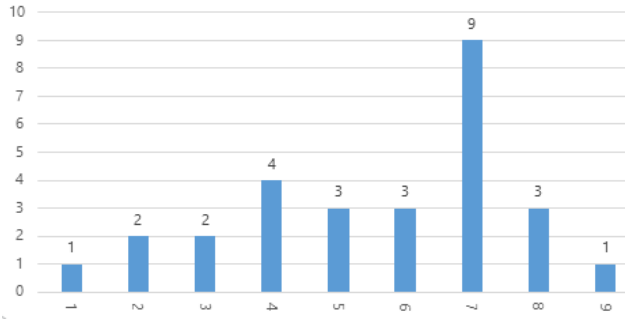


**FIGURE. 7. Aspect 7 – Science teachers' suggestions concerning problems in using VR in science labs**

**Interpretation:**

1. Students should have the same learning materials and tools.
2. Teacher proficiency training should be provided to help use VR technology and related media.
3. Establishing a VR learning system allows students to study anytime and anywhere.
4. Students should use VR media for physics lab experiments.
5. VR media and supporting technology encourage learning.
6. I need additional equipment and help with the Internet to find other learning resources for students to study with.
7. VR media is helpful for part-time and online teaching.
8. Collaboration allows students to relax and acts as positive reinforcement for students.
9. I want to have VR media applications for my science lab experiments.

## 5. Discussion

By reviewing the data collected from education professionals in the self-reported opinion survey on the study's seven key aspects, the study created a reliable data set from which an accurate series of consensus items were derived. From this analysis, the following opinions of the 44 surveyed education professionals on the subject matter can be summarized:

1) When surveying science teachers' attitudes towards the VR media, we see the confidence that this medium can add to learning through increased visualization of the subject matter with more engaging experimentation.

2) With the 3D virtual laboratory environment, teachers see an increase in their ability to organize online learning and have the ability to alleviate constraints that schools may face due to a lack of experimentation equipment.

3) Surveyed expectations for the advantages of the 3D virtual laboratory environment suggest a substantial belief that this technology will enable students to better engage with and thereby learn the subject matter. This is partly due to the inherent repeatability and consistent access to course content that this medium provides.

4) When surveyed on problems with current conventional methods, we see strong concerns that many schools are under-equipped to operate at curriculum standards. Budgetary concerns have left teachers feeling they have insufficient material to meet the needs of students and subsequently see a barrier to students effortlessly engaging in the subject matter.

5) Suggestions to alleviate perceived issues with current methods showed that most instructors would like access to computers in a 3D virtual laboratory environment. The standard view among the sample is that this will help meet students' needs within the classroom while also providing more opportunities for at-home learning.

6) With the recent abrupt transition in teaching methods needed to combat the COVID 19 pandemic (the New Normal), when surveyed, Instructors felt that the currently employed methods left students with incomplete access to the subject matter. Respondents also believed that current methods and the tools they provide cannot accommodate the lab setting as readily and instead rely heavily on theory. Instructors also believed that there were other more general issues with current online learning systems.

7) Supported proposals for solutions to current online learning methods issues showed that an increase in additional learning resources allowing students to study part-time and online was the most favorable solution. Finally, implementing a 3D virtual laboratory environment was perceived as second in overall importance from the survey responses.

### *5.1 Aspect 1 – Attitudes*

The *attitudes* of Thai science teachers toward implementing a 3D virtual laboratory environment agree that this medium will allow students to engage with the content more thoroughly and enable more precise visualization of lab-specific experiments. This premise is in line with the work of Setiawan*et al.* [22], who described learning media as a guiding factor in scientific exploration, helping us explain and scientifically predict

phenomena. Moreover, virtual reality systems are compatible and appropriate for use within learning environments in the 21st century, functioning as physical support to help in teaching and learning [23].

Moreover, integrating multiple learning styles and sensory inputs into one lesson creates a holistic learning environment that leads to more reflective learners [24]. Thus, the core premise of augmented reality (AR) gives us technology that integrates the real and digital world to increase student engagement through the addition of virtual images to the text allowing for a greater ability to visualize and understand information.

### *5.2 Aspect 2 - Acceptance*

The most relevant factors to teachers accepting 3D virtual lab technology into their classrooms were the ability to overcome lab material shortages due to budget constraints or pandemic-related supply chain breakdown. This benefit has been effectively demonstrated in Bogusevschi's[6] physics labs, working directly with students studying the water cycle.

The other most prevalent factor is the increased ability to organize the classroom and online learning by integrating this additional virtual resource. Garduño*et al.*[25] also found that the addition of VR technology was beneficial in stimulating learner interest and student engagement. This was seen as very desirable by the sample group.

### *5.3 Aspect 3 - Expectations*

Concerning the study's findings related to each teacher's *expectations* with 3D virtual reality media in the science lab, it was found that 3D virtual media allows students to learn and understand better. This is consistent with Porter and Heppelmann[26], who wrote that all organizations need to implement an AR strategy, as AR will transform how learners learn, make a decision and interact with their physical world. Science labs also increase learning achievement, which can be accessed using smartphones to facilitate learning under COVID 19 online and remote learning requirements. VR media also allows teachers to create and design various teaching activities that can be applied to students.

In Thailand, multiple studies have also confirmed AR's effectiveness in increasing student motivation and performance compared to non-AR learning methods [27], [28].Moreover, AR/VR improves instructional techniques and develops learning achievements, student observation, and classification skills while increasing instructors' ability to explain abstract ideas[28] better. Additionally, Meesuwan[29] also determined that AR use helped students' academic achievement after school. Elsewhere, Yen *et al.* [30], who studied student achievement while studying astronomy using AR compared to students learning with 3D animation, determined that AR students had higher academic achievement.

### *5.4Aspect 4 - Management Problems prior to the COVID-19 pandemic*

The study also determined from the teacher survey that even teaching under normal circumstances was difficult. The schools lacked experimental equipment, and some labs were insufficient to meet the students' needs. Moreover, in Thai schools, some teachers

were noted as being unqualified to teach the subject they are given, causing students to view science as difficult. This is consistent with Pareek[31], which assessed laboratory facilities' availability and use for teaching science at the secondary level in 21 secondary schools in Rajasthan, India. The authors also concluded that laboratory equipment was inadequate and far less than the researcher expected.

### *5.5 Aspect 5 - Management Problems during the COVID-19 Pandemic*

Online science *teaching management* problems *under the COVID-19 pandemic* lockouts found that students only studied the theory in some schools as labs were insufficient or non-existent. Therefore, student practice was limited due to inadequate tools. Additionally, Internet connections were poor or unavailable.

These problems are consistent with a study from the Philippines, in which nearly 4,000 respondents confirmed student difficulty in complying with assigned learning activities due to limited or no internet connectivityduring the pandemic's online learning requirements [32].

These issues are also similar to problems encountered in Indonesia recently, with Irfan*et al.*[18] reporting that in online mathematics learning, the school's internal learning management system (LMS) was less attractive to instructors than outside resources such as Zoom, Skype, and Google Classroom.

### *5.6 Aspect 6- Teaching and Learning Problems*

The Covid19 pandemic has rapidly reshaped the way schools worldwide carry out education [18]. This has been difficult for those responsible for learner management or the students themselves [33]. However, many hope that virtual lab technology can help alleviate some of the new stressors that teachers face and overcome many of the difficulties teachers are now confronted with [34].

However, further studies from Dunnagan and Gallardo-Williams [35] have shown unique complications with ICT (information communications technology) related technology, specifically in the robustness of connectivity for rural students. When asked about solutions for the problems educators now face, the education management professionals surveyed remained optimistic that 3D virtual lab technology provides more opportunities for student engagement and increases access to learning. Research from Bower*et al.*[36] also supported these beliefs in that online and VR technologies encourage independent learning in students and increase the potential for learning outside the classroom.

### *5.7 Aspect 7 – Suggestions for Problems*

As voiced by the study's participants, possible problem solutions included the need for computers, learning media, experimental media, and VR learning media that students can use outside the classroom. This is consistent with Bower*et al.*[36], who developed virtual reality technology media and stated that VR media encourages students to learn according to their potential and outside the classroom.

However, Zaharah*et al.*[37] have warned that higher education institutions with little to no e-learning expertise or resources will experience difficulties, especially with their

instructors' lack of knowledge of using online applications. Therefore, educator training in online education is necessary for these institutions' teachers and supporting staff.
Unfortunately, in Thailand, the responsibility for teacher training frequently falls back on the shoulders of the teachers. Current Thai MOE statements suggest that the solution to teachers' lack of training is for them to practice more before their classes start [21]. Others have suggested that teacher-led *online professional learning communities* (OPLC) are needed as a possible solution [38], [39].
This study found that teachers would like additional learning resources to support students' part-time study and VR media materials. This is consistent with Nadeak[40], who studied social media to manage distance learning and offered an opinion that theoretical learning management can be carried out effectively, while practical learning management often fails and objectives are frequently not achieved. Therefore, there should be other sources of learning to enhance students' study.

## 6. Conclusion

This study investigated and compared seven main aspects concerning classroom or online physics teaching using virtual reality (VR), both before and during the COID pandemic. From input from 44 Thai high-school physics teachers from 22 schools in Thailand's northeastern rural Surin Province, the opinions of each teacher were analyzed on their opinions on 1) *attitudes*, 2) *acceptance*, 3) *expectations*, 4) *management problems before COVID-19,* 5) *management problems during COVID-19,* 6) *teaching and learning problems*, and 7) *solutions to problems*.
The results revealed that the physics and science teachers' *attitudes* towards VR media were that VR media use made experiment learning and visualization clearer (*Aspect* 1). *Acceptance* opinions found that VR can be used to organize online learning and also solve problems for schools that lack experimental equipment (*Aspect 2*). Opinions concerning *expectations* revealed the most critical element was that VR allows students to better understand due to the ability to repeat the experiments using VR at any time (*Aspect 3*).
Opinions concerning *management problemsprior to COVID 19* in science teaching revealed a high agreement that their schools lacked sufficient lab equipment to meet the students' needs due to lack of funding and VR media and experimental equipment (*Aspect 4*). Results for the 13 items for the *management problems during the COVID 19 pandemic* were highly mixed, with funding and budget issues less important than before the pandemic. Speculation suggests that with the movement of teaching to an online format using student-purchased smartphones, budgets and funding for lesson development for the traditional classroom have become less critical as lessons moved online outside the physical classroom (*Aspect 5*).
Under *teaching and learning problems*, the teachers again voiced their concerns that supporting ICT and the Internet was problematic. They also thought that studying theory and using only a virtual lab was not ideal (*Aspect 6*). Concerning the teachers' *solutions to problems,* the teachers strongly agreed that finding other student learning resources to study part-time and online was important (*Aspect 7*).

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