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# The Development of Grammar Achievement by using a Flipped Classroom through a 3D Virtual Classroom with Metaverse Spatial

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**ABSTRACT**

The objectives of this research were to (1) Develop the lesson plans by using a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial, (2) Compare the grammar achievement after implementing a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial, and (3) Explore the students' satisfaction for using a 3D virtual classroom with Metaverse Spatial. This research was a quantitative experimental research design. The sample group comprised 33 students in Grade 9, semester 2, and the 2022 academic year, obtained from Custer random sampling. Research materials and instruments included (1) Lesson plans, (2) A Grammar achievement test, and (3) Students' satisfaction questionnaire. The data were analyzed using percentages, descriptive statistics (Mean and Standard Deviation), and t-tests. The results showed that (1) The lesson plans using a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial were developed at the "most suitable" level *M*=4.57, *SD*=0.17), (2) To compare the grammar achievement after using Flipped Classroom through 3D virtual classroom with Metaverse Spatial was higher at statistically significant levels.05, and (3) The students' satisfaction was averaged at *M*=4.68, *SD*=0.67 mean the students concern with the highest satisfaction using a Flipped Classroom through 3D Virtual classroom with Metaverse Spatial. The study demonstrated that through a 3D Virtual classroom with Metaverse Spatial, the Flipped Classroom notably enhances grammar achievement and aligns with contemporary educational practices and technological advancements. The Flipped Classroom through the 3D virtual classroom with Metaverse Spatial amended grammar achievement.

**Key words:** Grammar Achievement, Flipped Classroom, 3D Virtual Classroom with Metaverse Spatial, Virtual Reality

## INTRODUCTION

The study aims to enhance grammar achievement using a Flipped Classroom model through a virtual platform. The Flipped Classroom approach, increasingly popular for its effectiveness in boosting student engagement and learning outcomes, addresses the unique challenges faced by learners of English as a foreign language. Unlike the natural acquisition of their mother tongue, learning English involves a conscious study of rules and extensive practice (Ellis, 2018). This process, often more structured and less intuitive than native language acquisition (Krashen, 2017), can be daunting. Zhang and Kim (2019) highlight that these challenges may lead to learner fatigue and discouragement, especially when instructional methods do not align with their learning styles or lack adequate support and motivation (Brown & Lee, 2020; Madsathawee, 2022; Ministry of Education, 2014).

In response to these challenges, the school administration has embraced technology and the Flipped Classroom methodology to create engaging, interactive learning experiences. This model encourages students to study video lessons, educational content, research, and analysis at home, followed by collaborative activities in class. By prioritizing authentic and formative assessments, the model ensures students are not burdened with excessive homework, promoting a balanced lifestyle that allows time for family, work, and extracurricular activities (Johnson & Lee, 2023). This initiative has significantly reduced late-night study hours, alleviated homework-related stress, and fostered family bonding, enabling students to seek part-time jobs and pursue personal interests without the pressure of excessive homework. This approach aligns with the educational objectives of the Secretariat Office of the Teachers Council of Thailand (2022), emphasizing student well-being and holistic development.

The researchers have developed a Homework-Free Teaching Management Model, emphasizing teaching and learning in line with the National Act's spirit. This model aims to cultivate well-rounded individuals with moral integrity, intelligence, knowledge, and cultural awareness,

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enabling them to thrive in today's competitive society without undue stress (Areemit, 2023). The study was conducted in the first semester of the academic year 2022, focusing on enhancing grammar learning through the Flipped Classroom model using the Metaverse Spatial platform. Despite initial challenges, the researchers remain optimistic about the potential of this innovative approach to improve students' grammar achievements. Through this initiative, the study seeks to demonstrate that restructuring the learning process can enhance grammar outcomes effectively.

The Flipped Classroom model significantly impacts grammar achievement, particularly in English as a Foreign Language (EFL) contexts. This approach reverses traditional learning by shifting direct instruction outside the classroom, typically through video lectures and utilizing class time for collaborative and interactive activities. Here's how this model specifically enhances grammar learning:

### Enhanced Engagement and Participation

#### *Active learning environment*

The flipped classroom fosters an active learning environment where students engage with the content before class. This pre-class preparation allows them to come to class ready to participate in discussions, practice exercises, and collaborative activities focused on grammar application (Izadpanah, 2022a).

#### *Increased interaction*

In-class time is dedicated to student-centred activities such as group work and peer teaching. This interaction reinforces grammatical concepts and encourages students to articulate their understanding and clarify doubts in real time, which is crucial for mastering grammar rules (Nabilou & Zarei, 2023).

### Improved Learning Outcomes

#### *Higher academic performance*

Studies have shown that students taught through the flipped classroom model often outperform their peers in traditional settings on grammar assessments. For instance, research indicates that EFL students in flipped classrooms exhibit significantly improved grammatical proficiency compared to conventional instruction (Kong et al., 2024).

#### *Tailored instruction*

The model allows teachers to tailor their instruction based on students' pre-class performance. By assessing students' understanding through quizzes or discussions during class, educators can provide targeted feedback and support where needed, enhancing overall grammar mastery (Izadpanah, 2022a).

### Positive Student Perceptions

#### *Student preference*

Many students prefer the flipped classroom approach over traditional methods. They report feeling more comfortable and engaged when they can learn at their own pace outside of class and practically use class time to apply grammar skills (Aydin, 2022).

#### *Motivation and autonomy*

The flipped classroom promotes learner autonomy by encouraging students to take responsibility for their learning. This increased motivation often translates into better engagement with grammatical concepts and improved knowledge retention (Kong et al., 2024).

### Flipped Classroom and Grammar Achievement

The Flipped Classroom model has significantly improved students' grammar achievement by promoting active learning and engagement. In a study by Izadpanah (2022b), the effects of an ICT-aided flipped classroom on grammar achievement were examined. The results indicated that students who participated in the flipped classroom model performed better in grammar assessments than in traditional classrooms. The study highlighted three key factors contributing to this improvement: prior-to-class activities (like watching instructional videos), interactive in-class activities, and an engaging teaching process that fosters student autonomy and responsibility for their learning. Moreover, integrating technology within the flipped classroom allows personalized learning experiences catering to diverse learner needs. This aligns with findings from Kong et al. (2024), who noted that technology-enhanced flipped classrooms facilitate more significant student interaction and engagement, leading to improved outcomes in language learning.

### Metaverse and Grammar Achievement

The Metaverse presents a novel environment for language learning, offering immersive experiences that can enhance grammar acquisition. Recent research indicates that Metaverse-based platforms can provide interactive scenarios where learners practice language skills in contextually rich settings. For instance, Aydin (2022) found that EFL learners benefit from using Metaverse technologies, as these platforms foster social interaction and communication, essential components for effective language learning. A study by Guo and Gao (2024) explored the effectiveness of merging flipped learning methodologies with Metaverse environments specifically for language courses. The findings suggested that this integration enhances students' academic performance and increases intrinsic motivation by providing dynamic and engaging learning experiences. The immersive nature of the Metaverse allows students to engage deeply with content, which is crucial for mastering complex grammatical structures.

Integrating the Flipped Classroom model with Metaverse technologies can create a powerful pedagogical approach that enhances grammar achievement among language learners. Both methods promote active engagement, personalized learning experiences, and opportunities for social interaction, which are critical for effective language acquisition.

**Learning Management through a 3D Virtual Classroom**

The phrase "3D virtual classroom" represents a groundbreaking shift in educational methodology, moving away from traditional setups to create dynamic, interactive learning environments. As outlined by Laoha et al. (2019), this innovative approach eliminates the need for educators to be physically present, leveraging software to facilitate self-directed learning tailored to students' interests and accessible anytime, anywhere (Sornsiriwong, 2023). By structuring the learning process to replicate a traditional classroom atmosphere, students can engage in meaningful interactions and exchanges as if they were physically present ("Anywhere & Anytime") (Wansri et al., 2023). This model fosters collaborative learning and liberates education from the physical constraints of a traditional classroom. Educators can now design personalized learning activities, curricula, and content, which are effectively disseminated through digital networks, broadening the horizons of educational accessibility.

In today's rapidly evolving educational landscape, 3D virtual classrooms offer unparalleled versatility and diversity, aiming to provide a holistic and individualized learning experience. Teachers must select effective 3D virtual classroom platforms that foster an optimal learning environment. This model allows learning to occur at the student's convenience, transcending the barriers of time and place. Educators are pivotal in overseeing learning, crafting curricula, and customizing content to meet diverse student needs. The flexibility afforded by this model supports both structured and unstructured learning experiences ("Anywhere & Anytime"). Additionally, this approach enhances flipped learning and reverse classroom settings, promoting rich diversity. Digital technology and the Internet facilitate self-directed learning beyond the physical classroom, empowering students to develop self-learning skills and study according to their preferences and schedules (Chowdhury, 2020; Sannatch & Siriwong, 2020).

Virtual Reality (VR) technology, on the other hand, opens up a new dimension in education by creating artificial environments that provide interactive, immersive experiences. VR can either replicate real works or generate entirely imaginative ones to immerse users in a simulated space and evoke a sense of physical presence. As highlighted by Herumurti et al., immersive experience typically requires a head-mounted display (HMD) along with various interface devices for control and interaction within the virtual environment. VR technology's versatility allows it to be used on computers and portable devices like smartphones and tablets, requiring specialized software to create the desired simulated environment. While traditional screens can display VR content, the full potential of VR is realized through HMDs with integrated audio and motion detection capabilities. VR technology has been widely adopted across multiple domains, including gaming, entertainment, business, product design, medical fields, and educational instruction. Creating VR applications involves sophisticated software capable of designing three-dimensional models and environments, enabling the development of rich, interactive content (Guarana Technologies, 2024).

In education, leveraging VR technology to promote local wisdom has shown promising results. A case study in Sakon Nakhon exemplifies this, where a VR learning application was developed to enhance participants' knowledge and satisfaction with local wisdom during the National Science Event 2019 at Rajabhat University, Sakon Nakhon. This application, compatible with Android smartphones and HMDs, allowed users to explore natural indigo dyeing processes in a highly immersive manner. The research findings were impressive, with expert evaluations giving the application's effectiveness a high score of 4.81 and user satisfaction averaging 4.20 (Meesathit & Thopasorn, 2020). These results underscore the potential of VR technology in creating engaging and effective educational tools.

Adopting 3D virtual classrooms and Virtual Reality (VR) technology revolutionizes education by creating dynamic, interactive, and flexible learning environments that surpass traditional classroom limitations. 3D virtual classrooms enable personalized, self-directed learning accessible anytime and anywhere, fostering collaboration and engagement. VR technology immerses students in simulated environments, enhancing their learning experience through interactive capabilities. This approach has proven effective in various fields, including education, where it supports holistic and individualized learning experiences. These advancements align with modern educational objectives, emphasizing student well-being and the development of well-rounded individuals.

**Virtual Reality (VR)**

Virtual Reality (VR) technology creates artificial environments through computer technology, providing users with interactive capabilities. It can replicate real-world environments or generate entirely imaginative, synthetic settings. The primary objective of VR is to immerse the user in the simulated space, creating a sensation of physical presence within that environment. This immersion typically requires a Head-Mounted Display (HMD) to present three-dimensional images and various user interface devices that facilitate control and interaction within the virtual environment (Herumurti et al., 2017). VR technology can be applied to computers and portable devices such as smartphones and tablets, with data processing managed by specific software developed to control the computer and create the desired simulated environment. While the display unit can be a computer or smartphone screen, a more realistic virtual reality experience often involves HMDs for three-dimensional imaging, audio output devices, and input devices for user interaction, such as motion detection devices or remote controllers.

The integration of VR technology has seen wide applications across various domains, including virtual reality games, entertainment, business, product design, medical fields, and educational instruction. Developing applications for VR technology necessitates software capable of designing three-dimensional models. Numerous programs are currently available for constructing virtual reality content, enabling the design of characters, simulation

of desired environments, incorporation of narrative voiceovers, and addition of information and news. These tools also facilitate the creation of virtual spaces for real-time remote meetings, significantly expanding the potential uses of VR technology in diverse areas (Guarana Technologies, 2024).

This approach aligns with research on developing VR learning tools to promote local wisdom. A notable case study in Sakon Nakhon involved creating a VR learning application designed to enhance knowledge and satisfaction regarding local wisdom among students and participants at the National Science Event 2019 at Rajabhat University, Sakon Nakhon. The application, compatible with Android smartphones and used in conjunction with HMD units, enabled users to explore the process of natural indigo dyeing. Expert evaluations of the application's effectiveness yielded an average score of 4.81, indicating high efficiency, while user satisfaction averaged 4.20, denoting a high degree of satisfaction (Meesathit & Thopasorn, 2020). These findings highlight the potential of VR technology in creating engaging and effective educational tools and promoting immersive learning experiences.

Virtual Reality VR technology creates immersive, interactive environments by replicating real-world or imaginative settings, using Head-Mounted Displays (HMDs) and various input devices to provide a sense of physical presence. Applied across domains like gaming, education, and medicine, VR requires sophisticated software to design three-dimensional models and environments. A notable case study in Sakon Nakhon demonstrated the effectiveness of a VR learning application in enhancing local wisdom knowledge, yielding high efficiency and satisfaction scores among users. This underscores VR's potential to revolutionize education by providing engaging, flexible, and highly effective learning tools.

**Research Objectives**

1. To develop the lesson plans using a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial
2. To compare the grammar achievement before and after implementing a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial
3. To explore the students' satisfaction using a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial

**Research Hypothesis**

1. The lesson plans using a Flipped Classroom through a 3D virtual classroom with Metaverse Spatial have been developed.
2. Grammar achievement improved after using a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial.
3. Students' satisfaction with using a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial was the highest level.

**Research Methodology**

The research employed a quasi-experimental design with a control group and an experimental group. The participants were students from a secondary school divided into two groups. The experimental group received grammar instruction through a Flipped Classroom model, while the control group followed traditional teaching methods. Data were collected through pre-tests and post-tests to measure grammar achievement. The researchers will use a mixed method approach, including qualitative and quantitative experimental research, to develop grammar achievement using a Flipped Classroom through a 3D virtual classroom with Metaverse Spatial

**Population and Sample Group**

The population consisted of 166 students in Grade 9 of public school currently studying in the second semester of the academic year 2022. 5 classrooms from 9/1-9/5 comprised 33-35 students at each school.

The sample group used a cluster random sampling method, and participants were selected by drawing lots and utilizing the classroom as the sampling unit. The emphasis on probability sampling considers the likelihood of each unit being chosen and its significance as a representative subset of the target population, influencing the applicability of research findings for generalization (Lindlof & Taylor, 2002; Nachmais & Nachmais, 2008). The classroom 9/1 was a control group, and 9/2 was an experimental group.

**Materials and Instruments**

1. Lesson plans
   There were 5 lesson plans presented in 10 hours. The lesson plans consisted of:
   a. will and be going to,
   b. present continuous,
   c. future continuous,
   d. conditionals type 0-3,
   e. reported statements.
2. The Grammar achievement test
   This test consisted of four multiple-choice tests. There were 30 questions for five grammar topics as follows:
   a. will and be going to = six questions,
   b. present continuous = 6 questions,
   c. future continuous = 6 questions,
   d. conditionals type 0-3 = 6 questions, and
   e. reported statements = 6 questions

3. Students' Satisfaction Questionnaire

There were 15 items in the questionnaire to ask about the student's satisfaction with self-directed learning, engagement, motivation, classroom interaction, and technology use. The students checked a scale of 1-5 according to their opinions.

The process of developing the research instruments was as follows:

1. Lesson plans
2. Grammar achievement test

3. Students' Satisfaction Questionnaire

To validate the Lesson plans, Grammar achievement test, and Students' Satisfaction Questionnaire, the researchers:

a. Studied the concept and development process of the assessment form for the validity of the Lesson plans, Grammar achievement test, and Students' Satisfaction Questionnaire
b. I drafted an assessment form for the validity of the lesson plans, grammar achievement test, and student satisfaction questionnaire using a flipped classroom through a 3D virtual classroom with Metaverse Spatial. The levels of consideration are as follows:
   The rating +1 indicates an opinion that "Corresponds to content."
   The rating 0 indicates the opinion "Not sure it corresponds to content."
   The rating -1 indicates an opinion that is "Inconsistent with content."
c. Considered the suggestions for improvement made by the panel of experts at the end of each item
d. Verified the assessment form for the validity of the Lesson plans, Grammar achievement test, and Students' Satisfaction Questionnaire
e. Modified the assessment form for the validity of the Lesson plans, Grammar achievement test, and Students' Satisfaction Questionnaire according to the suggestion
f. Checked the IOC (Index Objective Congruence): The content consistency standards index should be greater than or equal to 0.50 to be considered suitable for use in research. The analysis result of the IOC for the Lesson plans, Grammar achievement test, and Students' satisfaction questionnaire in a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial was 1.00.

**Data Analysis and Statistics Used**

The data analysis for assessing the improvement in grammar learning achievement through utilizing a Flipped Classroom through a 3D virtual classroom with Metaverse Spatial involved quantitative methods. Statistical analyses will include computing the average, percentage, and standard deviation and conducting a t-test for dependent samples.

**Analysis of the Lesson Plans**

The analysis focused on the lesson plans for enhancing grammar learning achievement by implementing a Flipped Classroom model and learning management via the 3D virtual classroom: Metaverse Spatial. The Quantitative data are analyzed using frequencies, percentages, means *M*, and standard deviations *SD*). The mean value of the suitability score of expert opinions is calculated and compared with the following criteria:

A mean score of 1.00-1.50 means "most unsuitable."
A mean score of 1.51-2.50 means "unsuitable."
A mean score of 2.51-3.50 means "not sure."
A mean score of 3.51-4.50 means "suitable."
A mean score of 4.51-5.00 means "most suitable."

**Analysis of Grammar Achievement**

The analysis involves the examination of learning achievement in grammar. The data will be analyzed using averages *M* and standard deviation *SD* to assess proficiency or improvement in these grammar areas.

**Comparative Analysis of Grammar Achievement Test**

It compared the outcomes of grammar learning achievement between using a Flipped Classroom and the 3D virtual classroom with Metaverse Spatial. The data underwent analysis using the average *M* and standard deviation *SD*. Additionally, a t-test model for dependent samples was employed to examine further and compare the results of both teaching methodologies.

**Analysis of the Satisfaction Questionnaire**

The analysis focused on the satisfaction questionnaire for enhancing grammar learning achievement by implementing a Flipped Classroom model and learning management via the 3D virtual classroom with Metaverse Spatial. The data collection is through five scales of Likert (1932) by allowing the sample group was Grade 9/1 to check the scales as follows:

1= very dissatisfaction, 2= dissatisfaction,3 = not sure, 4= satisfaction, and 5 = most

The Quantitative data are analyzed using frequencies, percentages, means *M*, and standard deviations *SD*. The mean value of the suitability score of expert opinions is calculated and compared with the following criteria:

A mean score of 1.00-1.50 means "highest dissatisfaction."
A mean score of 1.51-2.50 means "dissatisfaction."
A mean score of 2.51-3.50 means "not sure."
A mean score of 3.51-4.50 means "satisfaction."
A mean score of 4.51-5.00 means "highest satisfaction."

## RESULTS

Research on the development of grammar achievement using Flipped Classroom through a 3D virtual classroom with Metaverse Spatial. The results of the data analysis were as follows.

Table 1 showed that the lesson plans developed for grammar achievement by using a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial, in general, were included at the "most suitable" level = 4.57, *SD*= 0.17, indicating that the lesson plans developed learning achievement in grammar by organizing learning in a Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial has been developed at the "most suitable" level.

Table 2 found that the results of the grammar test will be presented as continuous, future continuous, conditionals type 0-3, reported statements, and analyzed data with averages. percentage standard deviatio before learning through a 3D virtual was =11.58, *SD*= 3.10), and after learning through a 3D was =13.15, *SD*= 2.49. It showed the results of developing grammar achievement using a Flipped classroom

**Table 1.** Lesson plans on the development of grammar achievement by using a flipped classroom through a 3D virtual classroom with Metaverse Spatial

| Evaluation list | *M* | *SD* | Quality level |
|---|---|---|---|
| 1. The learning unit has complete and appropriate elements and has details that are consistent with each other | 4.73 | 0.28 | Most suitable |
| 2. Writing important information in the plan, concisely covering the goals. | 4.80 | 0.18 | Most suitable |
| 3. Learning objectives are clear and accurate, covering the content. | 4.67 | 0.34 | Most suitable |
| 4. The learning content/activities are clear and accurate and cover the content. | 4.27 | 0.43 | Very suitable |
| 5. The content of the learning plan is correct according to academic principles. | 4.47 | 0.60 | Very suitable |
| 6. Various learning activities/appropriate to the age of the learners and able to be put into practice. | 4.60 | 0.28 | Most suitable |
| 7. Learning management activities according to the learning management plan emphasize the thinking process. | 4.46 | 0.30 | Very suitable |
| 8. Media/learning resources appropriate to age and content are used. | 4.73 | 0.43 | Most suitable |
| 9. There are various forms of measurement and evaluation. | 4.53 | 0.56 | Most suitable |
| 10 Some measures and evaluations are consistent with the learning objectives. | 4.47 | 0.38 | Very suitable |
| Total | 4.57 | 0.17 | Most suitable |

**Table 2.** The results of the grammar test

| Student No. | Scoring before studying | | Scoring after studying | | Progress | |
|---|---|---|---|---|---|---|
| | Score | Percentage | Score | Percentage | Score | Percentage |
| Total scores | 232 | 38.59 | 477 | 48.18 | 104 | 11.00 |
| Average scores | 11.58 | | 14.73 | | 13.15 | |
| SD | 3.10 | | 2.50 | | 2.49 | |

**Table 3.** Comparative results

| | n | *M* | *SD* | *df* | *t* | *p* |
|---|---|---|---|---|---|---|
| Before implementing | 30 | 11.58 | 3.10 | 29 | 7.27 | 0.00 |
| After implementing | 30 | 14.73 | 2.50 | | | |
| Development | 30 | 13.15 | 2.49 | | | |

* Statistically significant at the level of 0.00

**Table 4.** Shows the students' satisfaction with using a 3D virtual classroom: Metaverse Spatial

| Students' satisfaction | *M* | *SD* | Quality level |
|---|---|---|---|
| 1 I am satisfied with how engaging the Flipped classroom approach was compared to traditional classroom methods. | 4.79 | 0.56 | Highest satisfaction |
| 2 I am satisfied with the accessibility of learning materials in the 3D Virtual Classroom: Metaverse Spatial. | 4.31 | 0.76 | Satisfaction |
| 3 The Flipped Classroom model helped me understand grammar concepts better. | 4.57 | 0.48 | Highest satisfaction |
| 4 I am satisfied with the flexibility of studying at my own pace time and saving cost (free WIFI) in learning with the 3D Virtual Classroom: Metaverse Spatial | 4.97 | 0.89 | Highest satisfaction |
| 5 The 3D Virtual Classroom: Metaverse Spatial integrates digital technologies to enhance interactive activities and reinforce my learning. | 4.88 | 0.85 | Highest satisfaction |
| 6 I was comfortable using the technology required for the 3D Virtual Classroom: Metaverse Spatial | 4.52 | 0.75 | Highest satisfaction |
| 7 The Flipped Classroom approach supported my ability to learn independently. | 4.61 | 0.87 | Highest satisfaction |
| 8 I am satisfied with the level of interaction with peers and instructors in the 3D Virtual Classroom: Metaverse Spatial. | 4.79 | 0.67 | Highest satisfaction |
| 9 The Flipped Classroom approach increased my motivation to study grammar. | 4.69 | 0.87 | Highest satisfaction |
| 10 The ability to review content multiple times by self-learning in the 3D Virtual Classroom: Metaverse Spatial was helpful for my understanding. | 4.93 | 0.69 | Highest satisfaction |

*(Contd...)*

**Table 4.** *(Continued)*

| Students' satisfaction | *M* | *SD* | Quality level |
|---|---|---|---|
| 11 Overall, I am satisfied with the experience of the Flipped classroom and 3D Virtual classroom combined approach. | 4.76 | 0.76 | Highest satisfaction |
| 12 Navigating the 3D Virtual Classroom: Metaverse Spatial was easy. | 4.09 | 0.45 | Satisfaction |
| 13 The learning environment in the 3D Virtual Classroom: Metaverse Spatial was better than a traditional classroom. | 4.78 | 0.73 | Highest satisfaction |
| 14 I am satisfied with the support and resources in the 3D Virtual Classroom: Metaverse Spatial for my learning needs. | 4.69 | 0.80 | Highest satisfaction |
| 15 The Flipped Classroom and 3D Virtual Classroom: Metaverse Spatial helped me develop my grammar skills effectively. | 4.77 | 0.86 | Highest satisfaction |
| Total | 4.68 | 0.67 | Highest satisfaction |

through a 3D virtual classroom, Metaverse Spatial, which was developed.

Table 3 compares the results of learning achievement in grammar by organizing learning in a Flipped Classroom (Flipped classroom) and learning management through a 3D virtual classroom with Metaverse Spatial. Before implementation, it was =11.58, *SD*= 3.10, and after implementation, wait s 14.3, *SD* = 2.50. The progress was 13.15 *SD*= 2.49) from testing the third hypothesis with the t-test model dependent had value T equal to 7.27 (*p*-value.01). It found that grammar achievement after implementing the Flipped Classroom through the 3D virtual classroom was higher than before implementing statistical significance at .05.

Table 4 demonstrates the results of the student's satisfaction with using a 3D virtual classroom: Metaverse Spatial. The average was at =4.68, *SD* =0.67, meaning "highest satisfaction." The three highest scores were 1) I am satisfied with the flexibility of studying at my own pace, time and saving cost in learning with the 3D Virtual Classroom: Metaverse Spatial was at =4.97, *SD* =0.98, which means "highest satisfaction," 2) The ability to review content multiple times in the 3D Virtual Classroom: Metaverse Spatial was helpful for my understanding was at =4.93, *SD* =0.69 that means "highest satisfaction," 3) The interactive activities in the 3D Virtual Classroom: Metaverse Spatial was effective in reinforcing my learning was at =4.88, *SD* =0.85 that means "highest satisfaction."

## DISCUSSION AND CONCLUSION

The results indicated a significant improvement in the grammar achievement of students in the experimental group compared to the control group. The Flipped Classroom model provided more opportunities for active learning and student participation, contributing to better grammar performance. From research the development of grammar achievement using Flipped Classroom through 3D virtual classroom: Metaverse Spatial of grade 9, semester 2, the academic year 2022, public school. The research results are summarized as follows:

The results of the developed lesson plans for grammar achievement using a Flipped classroom through a 3D virtual classroom, Metaverse Spatial, were rated at the "highest" level (*M*=4.57, *SD*=0.17). This indicates that our innovative approach to grammar development, which integrates Flipped Classroom and 3D virtual classroom strategies, has proven highly effective. We believe that by allowing students to study content independently at home and then engage in interactive, knowledge-building activities in the classroom, we are fostering a more dynamic and engaging learning environment. The structured classroom activities—stimulation, review, warm-up, and practice—focus on student-centred learning, practical application, and knowledge synthesis in the Wrap stage. This methodology enhances student engagement and solidifies their understanding of grammar concepts, as supported by the findings of (Phudi, 2021; Gerstein, 2011, as cited in Srihirun, 2020; Amini et al., 2022).

The comparative analysis of learning performance in grammar through implementing the Flipped classroom through a 3D virtual classroom with Metaverse Spatial revealed significant advancements. Conducting a t-test dependent sample for objective 3, we observed a statistically significant improvement, with a T-value of 7.27 (P-value =.05). This indicates that the combined approach of Flipped Classroom through 3D virtual classroom: Metaverse Spatial substantially enhances grammar learning performance post-intervention compared to pre-intervention, with a significance level of.05. These findings align with Cadiao et al. (2020), who reported similar improvements in grammar proficiency using a Flipped Classroom approach via a web application for grade 9 students, showing a significant increase in post-test scores (from a mean score of 11.58 before learning to 14.73 after learning). Additionally, integrating 3D virtual classroom technology has proven effective in developing diverse and engaging learning materials, significantly enhancing student interest in the lessons. This method aligns perfectly with 21st-century teaching methodologies and is consistent with the findings of Onsomkrit et al. (2024) who developed a 3D virtual classroom with Metaverse Spatial for biology lessons for public grade 9 students. Their study showed a statistically significant improvement in learning outcomes after the virtual learning sessions, with a significance level of .05. These results reaffirm our belief in the potential of combining Flipped classroom strategies with advanced virtual classroom technologies to revolutionize educational practices and outcomes.

The student's satisfaction with using a 3D virtual classroom: Metaverse Spatial, the average means "highest

satisfaction." The widespread use of digital technology and the Internet has revolutionized access to information and resources, often at no cost, enabling learners to develop self-learning skills more effectively. The finding supported the researcher's idea by structuring the learning process to replicate a traditional classroom atmosphere; students can engage in meaningful interactions and exchanges as if they were physically present ("Anywhere & Anytime") (Wansri et al., 2023). This accessibility allows students to study according to their preferences and schedules, as Chowdhury (2020); Sannatch and Siriwong (2020) highlight. These technological advancements have facilitated greater autonomy and flexibility in learning. Our study further supports this, showing that the development of learning media applications with virtual reality technology achieved high consistency and effectiveness. These results underscore the potential of integrating advanced digital technologies to enhance educational outcomes effectively.

The study demonstrated that the Flipped classroom through the 3D virtual classroom, Metaverse Spatial, notably enhances grammar achievement and aligns with contemporary educational practices and technological advancements. Finally, this study aligns with previous research, suggesting that the Flipped classroom through the 3D virtual classroom, Metaverse Spatial, is an effective instructional strategy for enhancing grammar achievement. The increased student engagement and interaction in the 3D virtual classroom setting played a crucial role in this improvement. This study also highlights the importance of teacher preparation and technology in successfully implementing flipped classrooms through the 3D virtual classroom and Metaverse Spatial.

### Limitations of this Research

One of the limitations of the current study is socioeconomic bias. The study primarily focuses on public school students in Thailand has a predominantly low socioeconomic status. The findings may only partially apply to students from different socioeconomic backgrounds or educational systems. Another limitation of this study was technological accessibility. The research assumes students can access high-speed Internet and compatible devices. However, this may only be the case for some students, potentially introducing a bias in the sample and affecting the generalizability of the results.

### Recommendation

Implementing the Flipped Classroom through a 3D Virtual classroom with Metaverse Spatial requires students to have devices capable of accessing high-speed Internet to efficiently download data, images, audio, and motion within the 3D virtual classroom. Students' devices must run on the Android 9 operating system or iOS or later to ensure optimal performance during their virtual learning experiences. During the experimental phase, it was observed that one student could not access the 3D virtual classroom from their phone, necessitating a computer at home. Additionally, 2-3 students encountered slow data loading, leading to 3-5 minutes waiting to enter the 3D virtual classroom.

The teachers should genuinely understand the flipped classroom methodology at every stage of its implementation, both outside and inside the classroom. This involves formulating challenging questions and activities for students to respond to after self-study at home. Additionally, instructors should comprehend the advantages, limitations, and precautions of implementing the Flipped Classroom approach.

The teachers evaluate students' satisfaction with 3D virtual classroom learning management by collecting feedback and suggestions for improvement. Furthermore, teachers can use survey data to refine teaching methods. Additionally, explore alternative teaching strategies and activities beyond grammar instruction, assessing a wider range of skills. This comprehensive analysis will help understand the impact of the flipped classroom and virtual learning environments more effectively.

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