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An Analysis of Student Anxiety Affecting on Online Learning on Conceptual Applications in Physics: Synchronous vs. Asynchronous Learning

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Abstract: This study examines the impact of students' anxiety, due to online learning, in different learning environments: a synchronous (Zoom) and asynchronous learning environment (YouTube) to compare students' conceptual understanding of electric circuits. Multiple linear regression and factor analyses were conducted to examine the factor of students' anxiety and conceptual understanding. A sample of 99 vocational students participated in the study, including YouTube (n = 49) and Zoom (n = 50) groups. The DIRECT was used to diagnose test for conceptual understanding in the electric circuits, and OTAI was used to assess anxiety in online learning test. The OTAI consists of three factors: psychological, physiological, and online. The results showed that students' anxiety, in some factors, affected their conceptual understanding of the electric circuits in both groups. However, there was a significant increase in conceptual understanding in both treatment groups. Although the students' conceptual understanding had a slight increase, online learning has to improve to reduce the anxiety of learners.

Keywords: conceptual understanding; students' anxiety; online learning; synchronous environment; asynchronous environment

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1. Introduction

Due to the COVID-19 virus, many teachers have moved their classroom into an online space and upgraded innovation in class [1]. Online teaching can be labelled under distant learning. In theory, there are three subtypes of distant learning: the synchronous, asynchronous, and hybrid environments [2]. They can be differentiated by whether or not the student–teacher interaction takes place simultaneously. The concept of distance learning is not new and has been used since the 1840s. Many teachers are still new to the teaching approaches, and a thorough understanding of the similarity and differences of these three types of distance learning will be paramount to the success of the classroom [3].

Distance learning is a long-established approach that predates the Internet. It originated in the 1840s, in the Pitman Secretarial Diploma [3]. The content for the distance learning program would be in books or other forms of written media that were mailed to students, and the students would then mail their completed assignments back to their teachers. Distance learning is actually a broad term, referring to studying at a distance from university, in its simplest sense. Online learning is, therefore, theoretically a way of distance learning [4]. Online learning might be delivered to students in different learning environments. In the following, synchronous, asynchronous, and hybrid learning environments [5] were reviewed.

In the synchronous learning environment, courses would require simultaneous online interactions between the teachers and the students, allowing them to take part in the course, in real-time, from a distance [6]. Teachers and students engage in the learning through text, voice, and video chat. In several aspects, it is similar to a web conference or webinar. Zoom is an example of a synchronous learning tool, among other video conferencing tools (such as Skype), web-based seminar tools (such as Wimba, Elluminate, iVisit, Blackboard Collaborate, and Adobe Connect), chatrooms, and other instant messages tools. These tools are utilized to facilitate online involvement to augment the learning environment. Hudson maintained that the effectiveness of web conferencing software was that it can enhances the involvement and motivation of students [7].

In the asynchronous learning environment, courses are not offered in real-time [6]. Content and tasks can be in many formats, and they are offered to the students through asynchronous learning tools, with a timeframe to complete classes and examinations. Interactions might occur via blogs and discussion boards, for instance. Therefore, there is typically no time for a class meeting. For students with time restrictions or hectic schedules, the asynchronous learning environment is useful. Blackboard, learning management systems (LMS), and Moodle are part of the asynchronous learning tools. Videos may also be used as auditory and visual asynchronous course content. They offer flexibility for students to receive on-demand instructions and lectures. A great example of an asynchronous learning tool for videos is YouTube. Asynchronous learning tools enable students to communicate in full-time, with open-content, including classes, lecture notes, and even registration tools, with their teachers and classmates. However, as Torun and Gillett-Swan maintained, a low level of students' participation might arise in this type of learning environment, due to the lack of their real-time, interactive experience with teachers [8,9].

Anxiety is a fundamental human emotion, which is often caused by uncertainty and fear, and it generally happens if individuals consider the event a threat to themselves or their self-esteem [10]. Depending on the duration, anxiety can also be a trait or state [11]. Since anxiety constitutes the human feelings experienced by everybody, students are no exception, as they might have difficulty when studying, taking tests, or making important life decisions [12]. According to Gibbs, Habeshaw, and Habeshawn, students would constantly underperform if they were experiencing anxiety [13]. Jegede, Alaiyemola, and Olebukola have also shown that anxiety is negatively linked to student success. Importantly, as Jegede et al. maintained, anxiety has a negative association with students' accomplishment of critical cognitive and emotional outcomes in distance learning [14].

Scholars found that the perceived differences between online learning and face-to-face learning, as well as the associated environmental factors affecting students, could lead to anxiety, which will likely impair students' learning. Among other scholars, Ajmal and Ahmad examined students' anxiety in online learning, utilizing the purposive sampling technique [12]. The findings showed that several factors caused anxiety among the students, such as assignments, distribution of materials, support services, and the admission process. In comparison with female students, the average values for anxiety-related factors were greater among male students. Ajmal and Ahmad, thus, argued that there was a substantial impact of anxiety on students' academic performance, as students were significantly anxious about their academic achievement under the online learning environment [12]. It was advised that universities help students via counselling and behavioral approaches to managing their anxiety. Furthermore, a recent study, during the COVID-19 pandemic, by Fawaz and Samaha, also showed that online learning has led, among undergraduate students, to anxiety and depression [15]. Students' satisfaction and prevalence of anxiety were significantly correlated in the heavy workload involved; anxiety and depression symptoms, among a large number of students, were generated by the rapid move to online learning.

Conceptual understanding is generally characterized as an in-depth understanding of the underlying mathematical concepts and their connections to the problems [16]. To explore the importance of inquiry-based learning for conceptual understanding, Korganci, Miron, Dafinei, and Antohe focused on the electric circuit models for their study [17]. Based

on the notion that analogies might help students in their conceptual understanding of the electric circuit, through the visualization of abstract concepts, comparison between the real world, and new concepts, thereby increasing students' motivation to learn. Korganci et al. investigated whether water circuit analogies and conceptual models could be utilized as additional tools in physics lectures to dispel the misconceptions of students [17]. The results showed that the analogy of the water circuit was obviously effective in helping the students grasp and understand electricity-related concepts. The authors, thus, proposed to construct and apply more relevant analogies to enable students to understand abstract processes and enhance their conceptual understanding.

2. Students' Anxiety on Conceptual Understanding

Concerns about online learning often arise from a lack of understanding of the material being studied. Students are afraid that they will not be able to study in time and worried that their grades will drop, especially at the grade level that has to change educational institutions, such as taking the entrance examinations for elementary and secondary schools or university. The stress increases, as the students are worried about the scores. Online and onsite learning are in different conditions; therefore, teachers should not use the same assessment method because the results are in no way the same.

Learning in the home environment does not allow for personal space as the child's age begins to require more privacy. They may feel that they are in the eyes of adults all the time, and this may affect them.

Another issue is homework. This is a heavy burden for children who have to study online. Alone, adjusting to a new learning style is already stressful. If they have to do more homework, they will get more stress. Some children may not understand the entire lesson and have to do homework on the lesson that is not yet understood. This can create pressure, as well.

The Research Institute and Academic Services, Assumption University (2021), has conducted a survey of online learning in the situation of COVID-19. Of students in Bangkok, it was found that more than 75% of the samples felt stressed from online learning. The top three causes of stress are: (1) online learning impairs focus and concentration, (2) a lack of understanding of the subject matter being taught, and (3) some subjects have content that is not suitable for online teaching.

A total of 75.1% of respondents felt stressed from online learning in the COVID-19 situation. The top three causes of stress were online learning, which caused a decrease in concentration and focus on studying (52.8%), followed by a lack of understanding of the subject matter. A total of 45.7% of the subjects studied, and 31.4% of the subjects had content that was not suitable for online teaching, while other stressors were found to be due to increased costs (which accounted for 29.0%), the speed of the internet signal is insufficient (representing 25.3%), and the burden of parents to take care of their children's online learning (which accounted for 22.6%).

Khoule, Bonsu, and Houari explored the impact of conceptual and procedural knowledge on conceptual understanding (mathematic) anxiety among students [18]. The authors examined the links between the anxiety of the students and their conceptual understanding of the topic. They studied two clusters of students, exposing them to conceptual teaching, in comparison to those who were taught in a fashion that stressed procedural teaching, in order to explore the students' anxieties about mathematics. The findings indicated a substantial link between the teaching approach (conceptual/procedural) and students' anxiety about mathematics. In comparison to procedural teaching, conceptual teaching was found to have a greater favorable impact on students' anxiety. For the conceptual cluster, the mean anxiety difference was less than the procedural cluster. This showed that the conceptual teaching had an effect on the conceptual cluster's mathematical anxiety ratings. The procedural teaching, which resembles the traditional methods of mathematics teaching, did not reduce the impact of the procedural cluster's anxiety.

3. YouTube and Zoom Programs in the Classroom

YouTube was launched in 2005 and is currently the world's largest video sharing website [19]. The potential of YouTube, as an instructional tool, should not be underestimated, since many teachers had successfully integrated YouTube into their classrooms; YouTube seems to be well-aware of this. In fact, not long ago, YouTube has initiated a section that is entirely devoted to educational videos, i.e., 'YouTubeEDU' [20]. This section of YouTube contains educational videos on a wide array of topics across many different disciplines such as economy, poetry, philosophy, and more.

Many researchers reported that they have successfully used YouTube videos to teach various subjects at differing levels. In one study, the relationship between using YouTube videos as teaching instruction and the proficiency of EFL (English as foreign language) students at the college level was investigated, the results showed a significant improvement in students who were exposed to YouTube videos; therefore, it can be concluded that YouTube videos should be considered as instructional tool in the field of EFL [21]. Another example of such study which is similar in design and concept but was conducted in a different field; this study from 2012 investigated the YouTube platform as a tools of teaching anatomy, the result is similar to the prior study that the students strongly agreed that the YouTube contents have helped them learn anatomy [22].

There is already a few academic research on how the YouTube platform might influence the students' understanding of physics. The most interesting one of these being a study conducted in 2020, the study investigated the effectiveness of PhET (Physics Educational Technology) simulation, and the YouTube videos in. There are also studies that focus on analyzing the physics teaching videos available on YouTube, the papers stated that the materials available in YouTube on the subject of physics are mostly made for college-level physics, and contents for primary schools are still lacking [23]. However, there are also studies that warn us about the potential pitfalls of using YouTube to teach physics and science. One study, unfortunately, found that the students tend to watch the video passively, when the subject called for active learning; the researchers suggested that the lessons should be more interactive, and questions and quizzes should be used to foster active learning of the subject [24]. Another study reported that, in the subject of physics, some concepts are inherently unintuitive, and the students might still lack deep conceptual understanding and confidence on the subject [25].

The Zoom program, unlike YouTube, is used by most teachers and students out of necessity, rather than as a complimentary learning aid. The pandemic came abruptly and so does the need to transit from face-to-face learning to the online space; therefore, it is safe to say that most teachers were inexperience in teaching and designing learning activities in remote learning.

Since the pandemic started, there have already been many studies that investigate the effectiveness of Zoom, as well as the attitude of the students toward remote learning with the Zoom program. In one study, the transition from FTF (face-to-face) learning to remote learning using Zoom was investigated, and the researcher found that the students are not fully satisfied with learning in this fashion, which might be the result of the lack of experience in this style of learning on the teachers' part [24]. While some studies have found that the students responded positively to using Zoom to learn, the criteria that are used in these studies are the effectiveness of communication, course material, and studying process. The researchers reported that the students are able to work together during group activities through breakout room functions, and the class material can be easily accessed and understood; however, even with all that said, the students still would rather go back to FTF learning [26].

Distance learning of the physics subject has, likewise, been studied quite extensively. In one study, the implementation of Zoom and other social media, as a means of e-learning the physics subject, was studied, and the researcher stated that smartphone and social-media can be the key to e-learning in physics, since many physics experiments can be performed safely at home by using them. For example, the slow motion function, available

on most phones, can be utilized, in order to perform an experiment on the center of mass rotation [27].

In this study, we used the asynchronous (through YouTube) and synchronous (through Zoom) learning environments to teach the electric circuit to vocational students. We investigated the students' anxiety, in both learning environments, to compare the effect of students' conceptual understanding of the electric circuit. The study's research questions were as follows:

1. What is the effect on students' conceptual understanding in the electric circuit by using asynchronous (YouTube) versus synchronous (Zoom) learning?
2. How does asynchronous learning (YouTube) impact students' anxiety in online learning, compared with synchronous learning (Zoom)?
3. How does students' anxiety in online learning (psychological, physiological, and online dimensions) impact conceptual understanding (post-test) in asynchronous (YouTube) versus synchronous (Zoom) learning?

4. Vocational System in Thailand

In the vocational system in Thailand, the certificate in ducal vocational education, which is also a three-year curriculum, is another option for students who graduated from middle school. After, the students can choose to enter the high certificate for a two-year program (VET) [28]. Tarat and Sindecharak conducted a comparative study of the vocational education systems in Singapore and Thailand, from a sociological perspective [29]. This study provides numerous insights into the vocational students in Thailand. According to Tarat and Sindecharak, vocational education is the academic institution that had an essential role to play in building and generating trained and professional staff for different businesses demands in Thailand [29]. For students with particular interests, vocational education is an alternative for them. However, it was established that the choices of students after completion of high school were more inclined to pursue higher education than vocational training, given the number of vocational students at present. Seeking a bachelor's degree, thus, appeared to be the main factor leading to a decision to not to enroll in vocational courses, which might affect the economic and social development of the country, as reflected in the requirement of job seekers who must have obtained a bachelor's degree to get greater pay. There was, accordingly, a negative public perception integrated into vocational education and students. For instance, as Tarat and Sindecharak exemplified, students with poor academic performance and engagement with gangs were more likely to be vocational students [29]. For such a negative image, students tended to study in high schools, rather than in vocational education. Overall, Thai vocational education was faced with numerous challenges, such as negative public perception, gaps in university education, lack of staff, and budgetary problems, resulting from planning and policy for vocational education management.

Vocational education management is an education that focuses on equipping students with professional competence. Knowledge (head on), skills (hands on), and desirable characteristics (heart on), which are the models of teaching and learning in a distance via electronic system, can develop learners in knowledge (head on); however, skills (hands on) must be trained until proficiency, then they can continue to use and solve problems in real situations. That kind of learning is not suitable for online study.

The Bureau of Vocational and Vocational Standards Office of Vocational Education Commission, The Ministry of Education has prepared a guideline for vocational learning management, in the situation of the coronavirus disease 2019 (COVID-19) epidemic. In theory, teachers need to analyze theoretical content into two groups: know and should know.

The content that "must know" is for teachers to manage remote learning through electronic systems through an online system (online) in the form of teaching live through a quality online learning management platform and content that "should know, the teachers provide suitable teaching materials (on demand) for the learners to study on their own.

Additionally, there is a communication channel through social media between the teacher and the students.

In the practical field, under the circumstances of the coronavirus disease 2019, the Epidemic Administrative Center (CDC) announced the refrain from using the building or premises for organizing activities. If an educational institution has a need for students to practice in the educational establishment, it is necessary to request permission from the provincial Communicable Disease Committee. The instructor must conduct a practical content analysis by considering key competencies. Additionally, it must be in practice in the workplace to design learning, in the form of modules, by focusing on problem solving setting case studies, and teaching and learning are a learning base with continuous practice (block course), where educational institutions and instructors must divide students into small groups for practice.

5. The Research Design

This study was a quantitative research, using survey data collection. The study assessed the students' conceptual understanding in electric circuits, through online learning. The study was conducted with the same group of students, but in two different online learning environments. We relied on two groups: the asynchronous (YouTube channel) (n = 49) and synchronous (Zoom program) (n = 50) learning groups. Both groups were selected randomly from students enrolled in a vocational program, training electricians and electronics specialists in Thailand. The program itself provides online learning to around 1000 students each year (with a total of 983 enrolled at the time of data collection). It offers students a combination of synchronous and asynchronous learning modules, which helps prepare students for the theoretical aspects of their program. To select the participants, a random number generator was used to select approximately a quarter of the first-year enrolled students following the course (n = 250). The students were emailed through their school accounts and invited to participate. On response, students were provided with information about the study. They then completed the survey and submitted it through the online data collection platform used (Google Docs). Initially, a total of 163 students accepted the study. After that, only 112 students submitted the assessment results. Of the 112 respondents, 13 provided incomplete information and were excluded from the study; so, the final response rate was 39.6%.

Figure 1 provides an overview of the research design. A diagnostic test of the electric circuit pre-test was administered before taking online learning, both in asynchronous and synchronous learning; additionally, a post-test was administered after the online learning in both modes. We used the determining and interpreting resistive electric circuit concepts test (DIRECT) to test for conceptual understanding [30]. The study also used an online test anxiety inventory (OTAI) to investigate the students' anxiety in online learning [31]. The OTAI obtained three factors: psychological, physiological, and online dimensions.

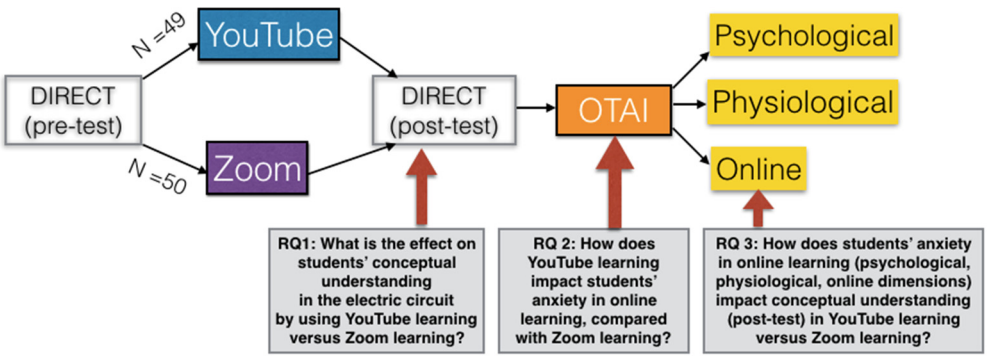
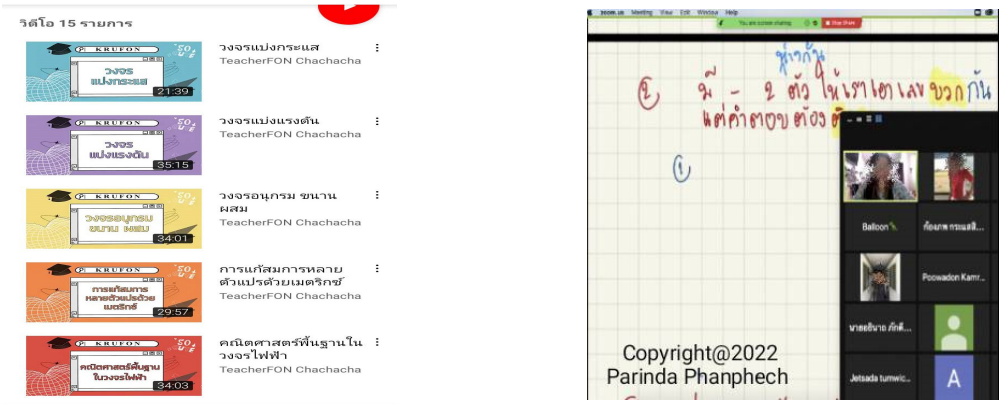


Figure 1. The research design.

5.1. Procedures

The online learning spanned six weeks, from June–July 2021, during the COVID-19 pandemic era. To reduce bias and the effects of compound variables, the researcher is teaching both forms, and there are line application groups to discuss after class. Group study, via Zoom, studied 1 h per week, as shown in Figure 2a. The YouTube classes uploaded once a week, as shown in Figure 2b. Both groups were assigned the same assignments at the end of each week.



(**a**) (**b**)

Figure 2. (**a**) Learning by YouTube channel. (**b**) Learning by Zoom program.

5.2. Participants

Participants are students enrolled in their first year of vocational education in a technical college located in an urban area of Thailand. The students in both groups were 17–19 years old, and they were studying in an electrician department. All students were male because there were no female students enrolled in this program. This study did not take into account differences in gender, age, and learning experience.

6. Materials

6.1. The Diagnostic of the Electric Circuit

This research applies the determining and interpreting resistive electric circuit concepts test (DIRECT), in Thai translation, to assess conceptual understanding of electrical circuits in pre- and post-test, with both synchronous and asynchronous learning groups [30]. The DIRECT is a multiple-choice questionnaire in common concepts of the electric circuits. The reliability and validity of this test have been well-established [32]. The test consists of 29 questions, with four concepts about electric circuits, i.e., the physical aspects of DC electric circuits, energy, current, and potential difference (voltage). The contents of the DIRECT were categorized, followed by an item in Table 1.

Table 1. The contents of DIRECT.

Contents	Definition	Items
Physical aspects of DC electric circuits	Understand the circuit element, explain a short circuit, and identify a complete circuit.	4,5,9,10,13, 14,18,19,22, 23,27
Energy	Apply the concept of power and energy.	2,3,12,21
Current	Explain current flow in the circuit and understand a conservation of current.	1,8,11,17,20
Potential difference (voltage)	Apply the concept of potential difference to a variety of circuits.	6,7,15,16, 24,25,28,29
Current and potential difference	Apply the concept of the voltage and understand the current.	26

6.2. Test Anxiety in Online Learning

The study of Ajmal and Ahmad found that students might have difficulties studying [12], taking tests, or making important life decisions, and the study of Alibak, Talebi, and Neshat-Doost focused on students' anxiety, in relation to test-taking. According to Alibak et al., test-related anxiety is a major concern for numerous students at the college level, with the ever-growing and prevalent development of online education platforms, alongside the rapid increase in the numbers of students involved in both purely online and hybrid programs. Accordingly, this situation has signified the need for a measurement to quantify test anxiety in the online context. Alibak et al., thus, created and validated an online test anxiety inventory (OTAI) for postgraduate students who are involved in online learning programs [31]. The authors incorporated the test anxiety inventory (proposed by Abolghasemi, Moghadam, Najarian, and Shokrkon), test anxiety scales (proposed by Spielberger and Sarason), and numerous interviews with the students with a significant degree of test anxiety [33–35]. To test the validity of OTAI, the authors employed an analysis for the confirmatory factor of the model to the data, in order to obtain the goodness of fit indices, and the consistency value (α) of OTAI was 0.91, which is quite high. Ultimately, an OTAI with 18 multidimensional items (psychological, physiological, and online dimensions), with a four-point Likert scale (almost never = 0, sometimes = 1, most of the time = 2, and almost always = 3), was applied in this research. The explanation of each dimension is shown in Table 2.

Table 2. The dimension of the OTAI.

Psychological Anxiety	Physiological Anxiety	Online Anxiety
Based on the OTAI, proposed by Alibak et al. [22], students who scored high in the psychological dimension were those who high psychological anxiety, and those who: (1) Felt inadequacy, (2) Had a fear of failing, (3) Had irrelevant and negative thoughts, (4) Had low concentration, (5) Had low self-efficacy, (6) Had poor performance, (7) Thought about the consequences of failing. Students who scored low in the psychological dimension were those who, during critical tests: (1) Had no negative and irrelevant thoughts, and (2) Were not bothered by the results of the tests or the excellent performance.	Based on the same OTAI, students experienced high physiological anxiety and scored high in physiological dimension were those who: (1) Had drying mouth, (2) Had a fast heartbeat, (3) Had muscle spasms, (4) Experienced a shift in body temperature, (5) Had sleep disorders, (6) Had trembling hands, (7) Had poor performance. Students who scored low in the physiological dimension were those who: (1) Had got good sleep, (2) Had normal body temperature, (3) Had a normal heartbeat tempo, and (4) Were relaxed.	Finally, also based on the same OTAI, students who experienced high online anxiety and scored high in the online dimension were those who: (1) Lacked enough computer-related knowledge, (2) Did not like to deal with technology, (3) Thought that having social interaction with other students is significant, (4) Thought that having communication with instructors and faculties is significant. Students who scored low in the online dimension were those who: (1) Had enough computer-related knowledge, (2) Had enough skills to work with computers, and (3) Enjoyed working with technology, (4) Not completely depended or relied on other students for their studies.

6.3. Data Analysis

Data collected through online assessments, via google docs, were statistically analyzed using descriptive statistics and paired-sample testing for comparative measurements on pre- and post-test scores between groups. The results of this test reveal differences in students' understanding of concepts before and after learning. An independent t-test was used to compare student anxiety in online learning in different conditions, i.e., psychological, physiological, and online dimensions, during asynchronous (via YouTube) and synchronous (via Zoom) learning. In addition, multiple linear regression analyses were used to analyze

the relationship of students' anxiety in online learning, during asynchronous (via YouTube) and synchronous (through Zoom) learning, for conceptual understanding after learning.

7. Results

7.1. Factor Analysis

The OTAI model presupposes a three-factor structure, including the psychological, physiological, and online dimensions of test anxiety [31]. In order to test whether the data collected from the sample was consistent with the OTAI's proposed model, principal components analysis (PCA) was used to test the factor structure of the data. The assumptions of PCA include that: (1) the data were measured using continuous variables; (2) there are linear relationships between all variables; (3) there is sampling adequacy; (4) data are suitable for data reduction; and (5) there are no significant outliers. Assumption 1 was assured through the data collection design, while assumptions 2 and 5 were investigated using linear and box plots. No significant outliers were identified. For assumption 3, the Kaiser-Meyer-Olkin (KMO) test of sampling adequacy was used. The test outcome indicated that the sample was adequate for factor analysis (KMO = 0.905). To investigate assumption 4, the Bartlett's test of sphericity was used [36]. The results indicate that the data variables are independent if the significance is considered at the 99% confidence level (x^2 (153) = 1791.060, $p < 0.001$). Therefore, the data were considered suitable for PCA.

PCA was conducted using varimax rotation, with component selection determined automatically, using the eigenvalue >1 criterion. This process resulted in the extraction of a three-component matrix. As the total variance explained shows (Table 3), the combination of these factors explained 77.876% of the variance within the model. In comparison, a one-factor model explained 57.383% of variance; a two-factor model explained 69.746% of variance; and a four-factor model explained 81.953% of variance. While the four-factor model did explain about 4% more variance in the model, the distribution of factors variables into the components was inconsistent with the theoretical model, with the fourth factor having only two significant unrelated variables. Therefore, the three-factor model was used.

Table 3. Variance explained in the factor analysis.

Component	Initial Eigenvalues			Extraction Sum of Squared Loadings			Rotation Sum of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.329	57.383	57.383	10.329	57.383	57.383	5.559	31.108	31.108
2	2.225	12.363	69.746	2.225	12.363	69.746	4.436	24.656	55.754
3	1.463	8.130	7.876	1.463	8.130	77.876	3.982	22.123	77.876

The rotated component matrix (Table 4) was used to investigate the factor structure used. Here, component 1 represents the online component of the OTAI, while component 2 is the physical component, and 3 is the psychological component. All variables were loaded onto at least one factor. Most variables only loaded the theoretical components or effect on the theoretical component, as it had a higher load factor than the other components. One exception was the variable Psy1, which was loaded on component 1, with a higher load factor than component 3 (the expected theoretical component).

To address this inconsistency, the internal correlations of Psy1 with the other Psy variables and online variables was investigated. Data analysis revealed that Phy1 was significantly correlated to the variables in the Psy scale (r = 0.300 to 0.712), but this was also true for the online variables (r = 0.417 to 0.628). Given that there was not strong evidence in either direction, the final decision was to keep Psy1 within its theoretical component, rather than moving it to another scale.

Table 4. Rotated component matrix of the factor analysis.

	Component		
	1 (Online)	**2 (Physical)**	**3 (Psychological)**
Online1	0.836	0.325	
Online2	0.861		
Online3	0.807	0.370	
Online4	0.567	0.409	0.380
Online5	0.562	0.511	0.401
Online6	0.818	0.381	
Online7	0.829	0.342	
Phy1	0.511	0.659	
Phy2	0.376	0.790	
Phy3		0.815	0.375
Phy4		0.867	
Phy5		0.833	
Psy1	0.613		0.580
Psy2			0.814
Psy3			0.851
Psy4	0.446	0.320	0.629
Psy5			0.805
Psy6	0.423		0.721

Note: only significant factors ($p < 0.05$) indicated.

Overall, the results of the factor analysis confirmed the factor structure of the OTAI model, with the exception of Psy1. Scale reliability was assessed using Cronbach's alpha (Table 5), in order to assess the effects of the placement of Psy1 and overall internal consistency of the scales. All scales were above the minimum value of 0.800 for an explanatory model. The online scale was marginally above 0.950, which can indicate item redundancy, according to Brace [37]. Inter-item correlations were investigated to determine whether there were any items that were duplicating each other (r > 0.900). However, no such items were identified for removal. Therefore, the scales were used as extracted from the PCA process.

Table 5. Scale reliability statistics.

Scale	Cronbach's Alpha	Number of Items
Psychological	6	0.893
Physiological	5	0.938
Online	7	0.952

7.2. Descriptive Statistics and Correlations

Table 6 summarizes the results of descriptive analysis for the dependent and independent variables used in this research. The most important aspect of this is the normal distribution of the variables, which is an assumption of linear regression [38]. The skewness and kurtosis were used to investigate significance among the variables. While none of the variables are perfectly normally distributed, all are within the range of −2 to 2, which indicates an adequate level of normal distribution [39]. Table 7 summarizes the correlation

analysis, which were used to ensure that the variables were independent. This shows that, while there are some significant relationships among the variables, none of them are replicating each other. Therefore, this is adequate.

Table 6. Descriptive statistics.

	Mean (n = 99)	Standard Deviation	Skewness		Kurtosis	
			Statistic	S.E.	Statistic	S.E.
Total_Pre	10.24	3.441	0.425	0.243	1.010	0.481
Total_Post	17.73	4.560	0.091	0.243	−0.304	0.481
Total_Psy	13.30	4.182	0.364	0.244	0.211	0.483
Total_Phy	8.70	4.209	1.154	0.243	0.447	0.481
Total_Online	14.73	6.417	0.563	0.243	−0.901	0.481

Table 7. Correlations.

	1	2	3	4	5
1 Total_Pre	1	0.692 (<0.001)	−0.118 (0.247)	−0.085 (0.402)	−0.131 (0.198)
2 Total_Post		1	−0.150 (0.141)	−0.094 (0.354)	−0.115 (0.259)
3 Total_Psy			1	0.557 (<0.001)	0.596 (<0.001)
4 Total_Phy				1	0.732 (<0.001)
5 Total_Online					1

7.3. Comparison of Asynchronous and Synchronous Learning

This section is the result of the comparison of asynchronous and synchronous learning, which was the answer to the research questions, as follows:

7.3.1. What Is the Effect on Students' Conceptual Understanding in the Electric Circuit by Using Asynchronous Learning (YouTube) versus Synchronous Learning (Zoom)?

Figure 3 compares the pre- and post-test results of the YouTube group (n = 49), applied via the DIRECT test. The results of the pre-test showed that the highest percentage of conceptual understanding (54.3%) was in the current part, and the lowest (39.8%) was in the energy part. The post-test showed the percentage of conceptual understanding, and the highest (60.8%) was in the current part, with the lowest (51.9%) in the energy part. The overall results of the pre- and post-tests were 45.2% and 55.7%. The post-test was higher than the post-test by 10.5.

Figure 4 compares the pre- and post-test results in the Zoom group (n = 50), applied via the DIRECT test. The results of the pre-test showed that the highest percentage of conceptual understanding (47.6%) was in the current part, with the lowest (39.8%) in the energy part. The post-test showed the percentage of conceptual understanding, and the highest (71.5%) was in the voltage part, with the lowest (55.4%) in the energy part. The overall results of the pre- and post-tests were 40.7% and 62.9%. The post-test was higher than the post-test by 22.2%.

Post-test results show that, for both groups, there was an increase of conceptual understanding. The highest scores for YouTube group were in the voltage part (42.6% to 59.5%), with a difference of 16.9%. The highest scores for Zoom group were in the voltage part (40.5% to 71.5%), with a +31% difference. The lowest scores for the YouTube group were in the current part (54.3% pre-test, 60.8% post-test, and a +6.5% difference). The lowest scores for the Zoom group were in the physical DC part (42.1% pre-test, 56.9% post-test, and a +14.8% difference)

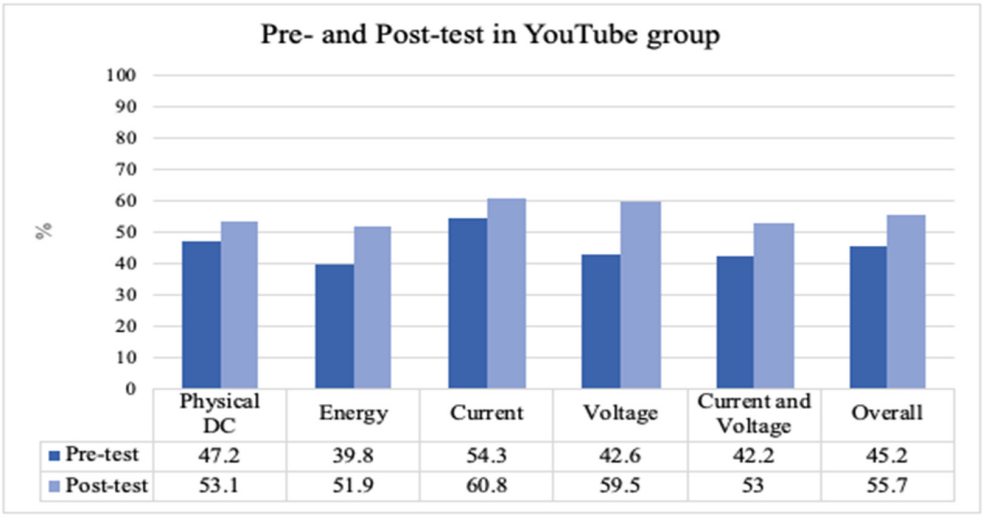


Figure 3. Pre- and post-test of students' conceptual understanding in the electric circuit on YouTube learning.

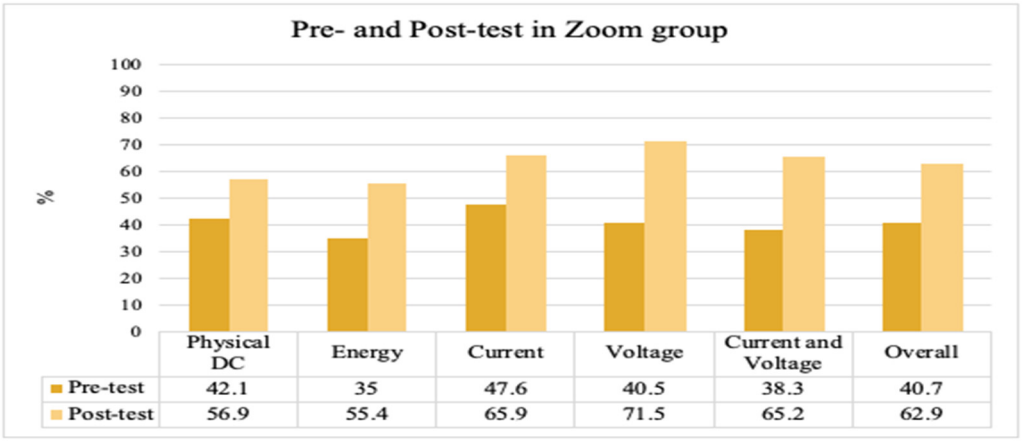


Figure 4. Pre- and post-test of students' conceptual understanding of the electric circuit on Zoom learning.

In Table 8, a paired-samples t-test was conducted to compare students' conceptual understanding in pre- and post-tests for both groups. There was a significant difference in the scores of the pre-test for the YouTube group (M = 9.96, SD = 4.108), as well as the post-test (M = 15.39, SD = 4.041), as the p value was 0.001, which was less than p at a significance level of 0.05. In addition, there was a significant difference in the scores of the pre-test for the Zoom group (M = 10.52, SD = 2.644), as well as the post-test (M = 20.02, SD = 3.841), as the p value was 0.000, which was less than p at a significance level of 0.05. Results indicated that either YouTube or Zoom learning showed a significant improvement in students' conceptual understanding between the pre- and post-tests ($p < 0.05$).

Table 8. Paired sample t-test of significance for both groups.

	N	$\bar{X}$		SD		t	p
		Pre	Post	Pre	Post		
YouTube	49	9.96	15.39	4.108	4.041	−15.100	0.001 *
Zoom	50	10.52	20.02	2.644	3.841	−24.975	0.000 *

* $p < 0.05$.

7.3.2. How Does Asynchronous Learning (YouTube) Impact Students' Anxiety in Online Learning, Compared to Synchronous Learning (Zoom)?

In Table 9, the independent sample t-test was conducted to compare students' anxiety in online learning for certain conditions, i.e., the psychological, physiological, and online dimensions, for the YouTube and Zoom groups. For the psychological dimension, there was a significant difference in the scores of the YouTube group (M = 3.11, SD = 0.69; and M = 2.43, SD = 0.66), with condition p values of 0.000, which was less than p at a significance level of 0.05. For the online dimensions, there was a significant difference in the scores the YouTube group (M = 3.67, SD = 0.34; and M = 2.79, SD = 0.84), with p values at 0.000, which was less than p at a significance level of 0.05. On the other hand, there was no significant difference in physiological condition, with p values at 0.110, which was greater than p at a significance level of 0.05. Results indicated that the psychological and online dimensions had an effect on students' anxiety in online learning via the YouTube learning group.

Table 9. The impact of the students' anxiety in online learning.

Group	n	Mean	SD	df	t-Test
		Psychological			
YouTube	49	3.11	0.69	97	0.000 **
Zoom	50	2.43	0.66		
		Physiological			
YouTube	49	2.83	0.56	97	0.110
Zoom	50	3.07	0.86		
		Online dimensions			
YouTube	49	3.67	0.34	97	0.000 **
Zoom	50	2.79	0.84		

** $p < 0.05$.

7.4. Role of Anxiety in Online Learning on Post-Test Conceptual Understanding

How Does Students' Anxiety in Online Learning (Psychological, Physiological, and Online Dimensions) Impact Conceptual Understanding (Post-Test) in Asynchronous (YouTube) Versus Synchronous Learning (Zoom)?

In Table 10, regression was used to determine if various forms of students' conceptual understanding with learning through YouTube learning can influence students' anxiety level in online learning. The students' anxiety in online learning can be predicted by the three factors, namely the psychological, physiological, and online dimensions. A multiple linear regression was used to test this result. The result shows that 19.3% of the variance in the students' anxiety in online learning can be accounted for by three predictors collectively ($F(3,45) = 4.831$, $p < 0.01$). Considering the unique individual contributions of the predictors, the result showed that online dimensions ($\beta = -0.461$, $t = -3.056$, $p = 0.004$) positively predicted the students' anxiety in online learning. The prediction power in the students' anxiety in online learning scores were equal to 0.186 (psychological), −0.461 (online dimensions), and −0.432 (physiological). The online dimensions factor in student's anxiety was a significant predictor of students' conceptual understanding in YouTube learning. Additionally, the psychological and physiological dimensions were not significant predictors of students' conceptual understanding in YouTube learning.

Table 10. The relationship of the students' anxiety in online learning, in the YouTube group, to conceptual understanding (post-test).

Variable	b	SE	Beta	t	*p*(t)
Psychological	0.186	0.175	0.141	1.064	0.293
Physiological	−0.432	0.302	−0.194	−1.427	0.160
Online dimensions	−0.461	0.151	−0.407	−3.056	0.004
R^2 = 0.193, SEE = 0.6850, F = 4.831, $n = 49$					

In Table 11, a multiple linear regression in the Zoom group was calculated to predict weight, based on their psychological, physiological, and online dimensions. The result shows that 4.7% of the variance in the students' anxiety in online learning can be accounted for by three predictors collectively (F (3,45) = 1.802, $p < 0.05$). Considering the unique individual contributions of the predictors, the result shows that physiological (β = −0.244, $t = -2.308$, $p = 0.026$) positively predict the students' anxiety in online learning. The prediction power of the students' anxiety in the online learning scores were equal to 0.103 (psychological), −0.244 (physiological), and +0.093 (online dimensions). The physiological factor in student's anxiety was a significant predictor of students' conceptual understanding in Zoom learning. Additionally, the psychological and online dimensions were not significant predictors of students' conceptual understanding in YouTube learning.

Table 11. The relationship of the students' anxiety in online learning, in the Zoom group, to conceptual understanding (post-test).

Variable	b	SE	Beta	t	*p*(t)
Psychological	0.103	0.130	0.119	0.791	0.433
Physiological	−0.244	0.106	−0.398	−2.308	0.026
Online dimensions	0.093	0.105	0.144	0.887	0.380
R^2 = 0.047, SEE = 0.5277, F = 1.802, $n = 50$					

8. Discussion

8.1. Discussion of Results

This study was conducted to investigate the impact of students' anxiety on the conceptual understanding in online learning on physical, synchronous, and asynchronous learning. It sought to explore the: (1) comparative effects of using YouTube and Zoom learning on students' conceptual understanding in the electric circuit course; (2) comparative impact of YouTube and Zoom learning on students' anxiety in online learning; and (3) comparative impact of students' psychological, physiological, and online anxiety in online learning on their conceptual understanding (post-test) in YouTube and Zoom learning. In the following, a discussion of the results of this study is presented.

8.2. Comparative Effects of Using YouTube and Zoom Learning on Students' Conceptual Understanding in Electric Circuit

Initially, this study sought to explore the effects on students' conceptual understanding of the electric circuit by using YouTube versus Zoom learning. In the asynchronous learning environment, with the use of YouTube as a learning tool, results revealed that the percentage of conceptual understanding of the students increased by 10.5%, as shown in the comparison of the students' overall percentage of conceptual understanding of pre- and post-tests. In this learning environment, students' highest scores were revealed in the voltage content, with an increased conceptual understanding of 16.9% in post-test, and the lowest scores were revealed in the current content, with an increased conceptual understanding of 6.5% in post-test. In synchronous learning, with the use of Zoom as a learning

tool, however, results revealed that the percentage of conceptual understanding of the students increased by 22.2%, as shown in the comparison of the students' overall percentage of conceptual understanding of pre- and post-tests. In YouTube learning, post-test results showed that, for both groups, there was an increase in conceptual understanding. In this learning environment, students' highest scores were also revealed in the voltage content, with an increased conceptual understanding of 31% in post-test, and the lowest gains were revealed in the physical DC content, with an increased conceptual understanding of 14.8% in post-test.

In both learning environments, the results suggested that both YouTube and Zoom, as distinctive learning tools of each learning environment, contributed to a significant improvement ($p < 0.05$) in students' conceptual understanding between the pre- and post-test. Notably, in the synchronous learning environment, the percentage of conceptual understanding of the students significantly increased ($p < 0.000$) with the use of Zoom as a learning tool. This finding was consistent with the findings of Yeh and She, which revealed that, through obtaining online synchronous argumentation in a scientific learning program, students were facilitated for conceptual change and argumentation ability [40]. Synchronous learning allows for students' engagement in discussion and argumentation, which were revealed, in previous studies, to help improve their scientific conceptual understanding and change in both secondary school and university students [41–43]. This study adds new evidence that students' conceptual understanding is also significantly facilitated by the synchronous learning environment. However, in a study conducted by Dahlstrom-Hakki, Alstad, and Banerjee, among disabled students, the student's performance on the test of conceptual understanding were better facilitated in the asynchronous learning environment [44].

8.3. Comparative Impact of YouTube and Zoom Learning on Students' Anxiety in Online Learning

This study sought to explore the manner in which YouTube learning affected students' anxiety in online learning, as compared to Zoom learning. A previous study, by Alibak et al., proposed and validated an online test anxiety inventory (OTAI), with 18 multidimensional items (psychological, physiological, and online dimensions) for postgraduate students who were involved in online learning programs. This study adopted the dimensions of students' anxiety, proposed by Alibak et al., to frame the dimensions of students' anxiety in engaging in YouTube and Zoom learning.

Results showed that, in the asynchronous learning environment, with the use of YouTube as a learning tool, students' psychological anxiety and online anxiety were significantly higher ($p < 0.001$) than in synchronous learning, with the use of Zoom as a learning tool. It was shown that in the asynchronous learning environment, students expressed higher psychological and online anxiety. This can be explained by the fact that students might feel inadequacy, a fear of failing, irrelevant and negative thoughts, low concentration, low self-efficacy, and poor performance. They might think about the consequences of failing, lack of enough computer-related knowledge, preferring to not deal with technology, and thinking that having social interaction with other students and communication with instructors and faculties are significant. Nonetheless, students' physiological anxiety in asynchronous learning, with the use of YouTube, was less than in synchronous learning than with the use of Zoom. Accordingly, in the asynchronous learning environment, students might experience better sleep, normal body temperature, normal heartbeats, and feelings of being more relaxed [31].

This study conforms with previous studies, which revealed that the perceived difference between online and face-to-face learning, as well as their associated environmental factors affecting students, could lead to anxiety and add new evidence that students experience anxiety in the online learning environment, to a certain degree, depending on the tool used to facilitate their online learning [15].

8.4. Comparative Impact of Students' Anxiety in Online Learning on Conceptual Understanding (Post-Test)

This study also sought to explore the manner in which students' anxiety (psychological, physiological, and online dimensions) in online learning affected their conceptual understanding (post-test), with YouTube and Zoom as learning tools. Based on the relationship of the students' anxiety in the asynchronous learning environment, with YouTube as a learning tool, which was obtained using a multiple linear regression from the determination of whether students' conceptual understanding with YouTube learning could influence to respond with their anxiety in online learning, the results showed that 19.3% of the variance in the students' anxiety in online learning, using YouTube, could be accounted collectively for by three predictors ($p < 0.01$), with online anxiety (online dimension) positively predicting the students' anxiety in online learning ($p = 0.004$). In this way, online anxiety was revealed to be a significant predictor for students' conceptual understanding, with YouTube as a learning tool. Meanwhile, psychological and physiological anxieties were not significant predictors of students' conceptual understanding in this learning environment. In the synchronous learning environment, with the use of Zoom as a learning tool, a multiple linear regression was also calculated to predict weight, based on the students' psychological, physiological, and online anxiety (dimension). With Zoom learning, result showed that 4.7% of the variance in the students' anxiety in online learning could be accounted for by three predictors collectively ($p < 0.05$), with physiological anxiety positively predicting their anxiety in online learning ($p = 0.026$). In this way, physiological anxiety, as a factor in student's anxiety, was a significant predictor for their conceptual understanding in Zoom learning. Meanwhile, the psychological and online anxieties (dimensions) were not significant predictors of students' conceptual understanding in Zoom learning.

In the synchronous learning environment, the percentage of the conceptual understanding of the students significantly increased ($p < 0.000$) with the use of Zoom as a learning tool; the results were higher than that in the asynchronous learning environment with the use of YouTube. Based on this finding, results on the comparative impact of students' anxiety in online learning on conceptual understanding (post-test) revealed that, in the asynchronous learning environment, with the use of YouTube as a learning tool, students' anxiety affected their conceptual understanding to a greater extent than in the synchronous learning environment with the use of Zoom as a learning tool. Students' concerns about lack of adequate computer knowledge, as well as the need for social interaction and communication with professors and faculty (online dimension) of online learning, has a great influence on their understanding of concepts. The findings add new insights into academic knowledge about student anxiety in different types of online learning environments.

9. Conclusions

Learner's anxiety in the classroom is undoubtedly a factor in the success of the classroom. If the students are suffering from anxiety, they are likely to underperform academically. While some students are capable of lessening the anxiety by themselves, it is also up to the teachers to design their lesson in a way that is not anxiety-inducing. In this research, the investigated aspect of classroom anxiety was the anxiety that comes with being forced to study online. Interestingly, aside from the mentioned causes, there are numerous other potential factors that can increase learner's anxiety, namely the lack of computer knowledge, low affinity with technology, or not having communication with peers and instructors. Therefore, aside from the usual causes, the teachers, who have to teach in an online environment, should take these factors into account, in addition to the usual causes of anxiety.

While the causes of classroom anxieties almost exclusively come from the learners, it is not to say that there is nothing the teacher can do to aid the students in their academic pursuit. The understanding of the causes and consequences of anxiety in the classroom will undoubtedly be helpful for the learners. Furthermore, as mentioned in the current

situations, most classrooms have been moved to an online space; with this comes a new set of anxiety for the students to overcome. Therefore, it is more important than ever for teachers to understand the causes and impacts of classroom anxiety, in order for them to be able to correctly handle this particular challenge. Furthermore, at least in the context of Thailand, anxiety, despite being an important factor in the classroom, it is still overlooked by some teachers. In the field of vocational school, there is only a limited selection of past research on the subject. Therefore, this research will hopefully provide clarity on the anxiety that vocational students are experiencing in the online classroom.

There are some limitations to this study. The biggest limitation is that the study was conducted on a relatively small sample of students, who had undertaken the same course of study over several years. Therefore, the results may not be generalizable to a wider audience, which would need to be investigated further. The sampling strategy, also meant the study, had limited opportunities to investigate other effects, for example, the effects of gender or age differences on test anxiety or learning outcomes. These limitations do not detract from the usefulness of the study, but they do mean that the findings may not apply to other samples. In particular, the difference in vocational learning and university learning may mean that the findings may not apply to undergraduate samples. Furthermore, it may not apply to other kinds of teaching and learning (for example, humanities and social sciences), due to the differences in learning and assessment strategies used in different learning disciplines. Additionally, this study did not focus on how long students in the asynchronous group spent looking at the material on YouTube, and the results did not provide implications on this matter.

At the same time, the study does have its strengths, and it has made significant contributions to the literature. Its comparison of modes of distance learning between synchronous and asynchronous learning extends existing studies, which have mainly focused only on one mode of learning (typically asynchronous learning). It also investigates a population of vocational students, who are often overlooked in the literature, particularly in distance learning. The negative public perception of vocational students, as well as factors such as poorer academic performance, learning needs, and processes of vocational students are often not considered, even though they are a vital part of Thai society [29]. As a result, they often lack resources and support to achieve academically and learn effectively; there is not adequate information about the vocational learning process in Thailand. This study has made significant strides in understanding test anxiety, particularly for students who may not have dealt with online learning previously, as vocational education is typically structured as 'hands-on' learning [28]. Since vocational students may have had neither previous experience with online and distance learning nor the academic preparation that university students receive, it is likely that they have been particularly affected by the disruption of learning and rapid transition to online learning. Thus, this contribution to knowledge may be especially practically important, in order to ensure that vocational students are well-prepared, and resources can be provided to fully support their needs.

In general, if teaching is intended to provide the subject matter representing basic principles, teachers should choose an asynchronous format, which, for both teachers and learners, is very convenient. Teachers and students do not need to be logged in at the same time. In a systematic way, there is no problem of transmitting a large amount of video and audio signals simultaneously. The quality of the picture and sound that the learner receives is usually better.

The synchronous learning section is suitable for content that is difficult to understand, which requires continuous discussion, such as conducting a case conference or an event that requires improving communication skills, teamwork, etc. In synchronous teaching, especially in teaching that requires discussion or comment, teachers should use a closed room system (do not open independent rooms for anyone to enter) with pre-registration. Only those who register for the class can enter the room. Instructors should require all students to display their screen name with their real first and last name and have students turn on their screen camera at all times.

In asynchronous teaching, teachers can enable active learning by inserting activities or questions during the lesson; for example, in one session, the teacher divides the content into short clips, 10 min each. At the end of a clip, the teacher presents a multiple choices question and inserts it. After the students answer the question, they will open the clip for another 10 min. Then, there will be an open-ended question for the student to type the answer in the given box and proceed to the clip.

The lesson arrangement should combine both synchronous and asynchronous together. There are different advantages and disadvantages. If teachers design lessons appropriately, by which knowledge content is provided to learners asynchronously and appointments are made to attend classes synchronously at certain times to develop skills in applying knowledge, it will be a lesson that maximizes the advantages of both formats.

Promoting discipline in asynchronous learning by scheduling students to attend classes and submit assignments at regular intervals is essential, although asynchronous teaching requires flexibility to allow learners to study at a convenient time. However, teachers should also set a timeline for attending lessons. For example, if a lesson has ten sessions and each lesson has 3 h of teaching time, the teacher may determine that, after publishing the video on YouTube, the learner must go to study the video within 72 h. Setting restrictions for students in this manner encourages them to have discipline. Otherwise, they may gradually study the lessons and watch all the clips one night before the exam, which will lead to poor learning.

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