AN ONLINE LEARNING EFFECTIVENESS GUIDELINE BASED ON ANALYTIC HIERARCHY PROCESS
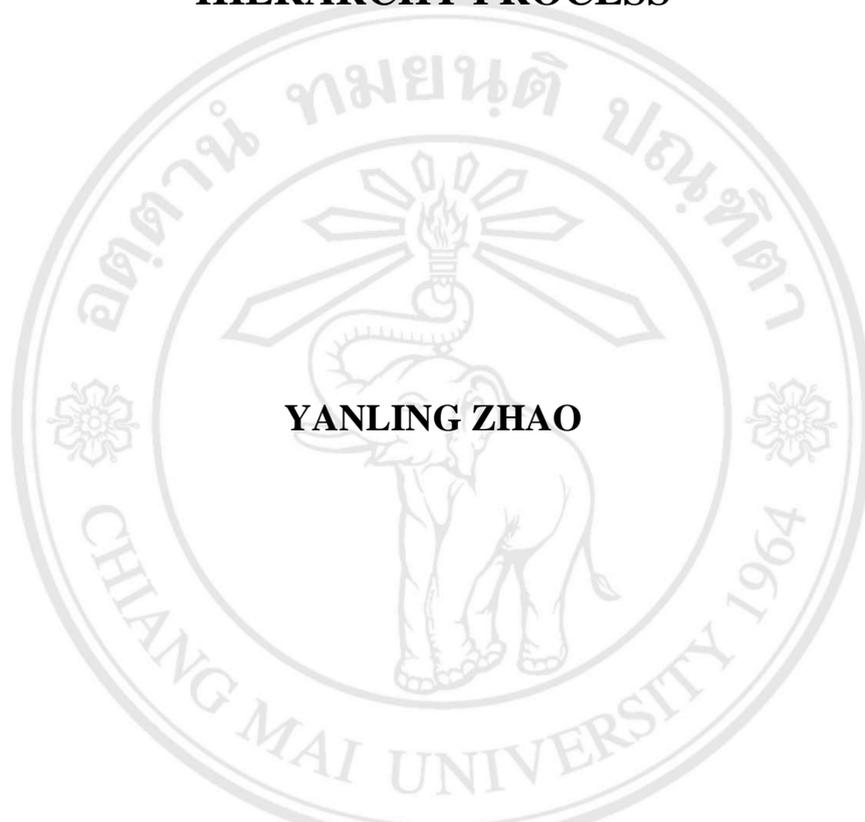
YANLING ZHAO

MASTER OF SCIENCE
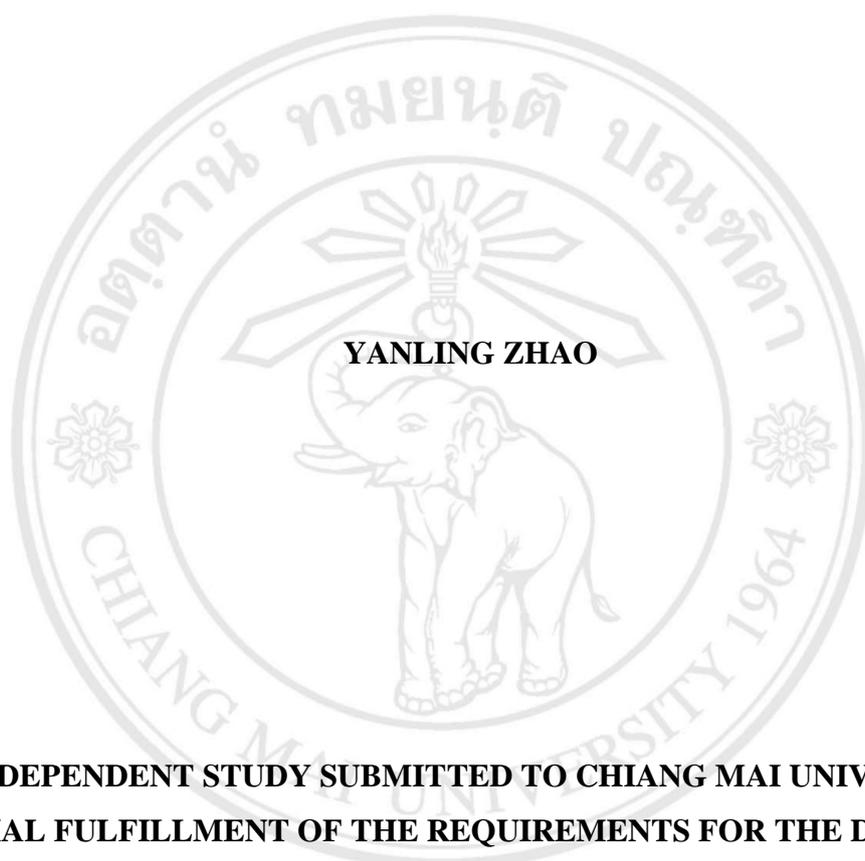**IN KNOWLEDGE AND INNOVATION MANAGEMENT**

CHIANG MAI UNIVERSITY
OCTOBER 2023

AN ONLINE LEARNING EFFECTIVENESS GUIDELINE
BASED ON ANALYTIC HIERARCHY PROCESS

YANLING ZHAO

AN INDEPENDENT STUDY SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE
IN KNOWLEDGE AND INNOVATION MANAGEMENT

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27 October 2023

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b

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Yanling Zhao

c

หัวข้อการค้นคว้าอิสระ	แนวทางการเรียนรู้ออนไลน์ให้เกิดประสิทธิภาพด้วยกระบวนการวิเคราะห์เชิงลำดับชั้น
ผู้เขียน	นางสาว หยานหลิง จ้าว
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บทคัดย่อ

สถานการณ์การแพร่ระบาดของไวรัส COVID-19 ได้ส่งผลกระทบต่อวิถีชีวิตบุคคลทั่วโลกอย่างมีนัยสำคัญ โดยเฉพาะทางการศึกษาที่ผู้เรียนต้องเปลี่ยนรูปแบบจากการเรียนแบบดั้งเดิมในห้องเรียนไปเป็นรูปแบบการเรียนออนไลน์ ส่งผลให้รูปแบบ และวิธีการเรียนการสอนเกิดความท้าทายต่อวิธีการสอนของผู้สอน และรูปแบบการเรียนของผู้เรียนด้วยเช่นกัน ดังนั้นผู้วิจัยจึงมีความสนใจศึกษาปัจจัยที่ส่งผลต่อประสิทธิภาพในการเรียนรู้ออนไลน์ของผู้เรียน และนำเสนอแนวทางการเรียนออนไลน์อย่างมีประสิทธิภาพ

กระบวนการเก็บข้อมูล ปัจจัย สถานการณ์การเรียนรู้ผู้เรียนดำเนินการผ่านการสำรวจจากแบบสอบถามและการสืบค้นจากวารสารและงานวิจัยที่เกี่ยวข้อง หลังจากนั้นใช้กระบวนการ Delphi จากผู้เชี่ยวชาญเพื่อระบุปัจจัยที่สำคัญต่อการเรียนรู้อย่างประสิทธิภาพ และปัจจัยเหล่านี้ถูกนำมาวิเคราะห์เชิงลำดับชั้น (Analytic Hierarchy Process: AHP) เพื่อทราบถึงลำดับน้ำหนักความสำคัญแต่ละปัจจัย เสนอแนะแนวทางผ่านวิธีการ CommonKADS และจัดทำแนวทางเพิ่มประสิทธิภาพของการเรียนรู้ออนไลน์

ทั้งนี้ ผลลัพธ์การวิเคราะห์เชิงลำดับชั้นของงานวิจัย ประกอบระดับปัจจัยหลักและปัจจัยรองเพื่อสร้างแนวทางการเรียนการสอนแก่ผู้เกี่ยวข้องในกระบวนการการเรียนรู้ออนไลน์ตามปัจจัยที่ระบุส่งเสริมประสิทธิภาพของการเรียนรู้ออนไลน์เพื่อเสนอแนะต่อผู้เรียน ผู้สอนต่อไป

Independent Study Title   An Online Learning Effectiveness Guideline Based on Analytic Hierarchy Process

Author   Miss Yanling Zhao

Degree   Master of Science
(Knowledge and Innovation Management)

Advisor   Asst.Prof.Dr.Napaporn Reeveerakul

ABSTRACT

The global outbreak of COVID-19 has significantly impacted the lifestyles of individuals globally, with students being severely influenced due to a critical shift from traditional offline to the new norm of online learning. This relatively uncharted territory in learning-teaching methodology has resulted in challenges concerning adaptation both from a student's perspective as well as the teacher's. The primary objective of this research endeavour is to elucidate the factors influencing the efficacy of online learning for students and propose methodologies to enhance this efficacy.

Pertinent data concerning the contemporary status of student learning was collected through comprehensive questionnaire surveys. Subsequently, the Delphi method was employed to identify factors contributing to the effectiveness of student learning online. These factors underwent evaluation by leveraging the Analytic Hierarchy Process (AHP) method. A strategic approach via CommonKADS was used to formulate practical guidelines, aiming at the augmentation of online learning effectiveness.

This study's outcomes delineate two distinct levels of influencing factors, which include three primary (level 1) factors, along with ten secondary (level 2) factors. Both levels are accompanied by implications concerning their levels of importance. The research outputs, in turn, contribute to the compilation of recommendations and directives for stakeholders involved in the online learning process, concerning the identified factors.

The insights derived from this study serve a dual purpose. They promote the effectiveness of online learning for students and also shed light on improvised teaching methods for teachers, institutions, and societal engagements during analogous occurrences in the future.

f

CONTENTS

LIST OF TABLES

Page

j

LIST OF FIGURES

Page

k

CHAPTER 1

Introduction

The COVID-19 pandemic is widely believed to have started in Wuhan, China, in late 2019. The first cases were reported in December 2019 and were linked to a wet market in Wuhan where live and dead animals were traded for consumption. The virus quickly spread from Wuhan to various parts of China and then to countries worldwide.

On March 11, 2020, the World Health Organization (WHO) officially declared COVID-19 a pandemic as it rapidly spread globally. The pandemic has had a profound impact on nearly every aspect of daily life, including public health, the economy, education, and social interactions.

From a public health perspective, COVID-19 has led to widespread illness and death, putting immense pressure on healthcare systems in many countries. The pandemic has also highlighted existing disparities in health and healthcare access, particularly among marginalized communities.

The economy has been significantly affected, with many businesses closing and millions of people losing their jobs. The pandemic has triggered a recession, posing substantial economic challenges for numerous countries.

In terms of social interactions, COVID-19 has brought about extensive changes in daily life. This includes the adoption of remote work, virtual events, and restricted travel.

Moreover, the pandemic has made many people feel more alone, worried, and stressed as they try to adapt to the "new normal".

Education has been widely disrupted around the world, causing problems for both students and teachers. They've had to deal with things like online learning, not enough teachers, and unequal access to technology and the internet. COVID-19 has completely changed how students learn, with lots of schools and universities moving to online classes to stop the virus from spreading. Online learning means using digital tools to get educational stuff and talk to teachers and classmates from far away. It's good because it's flexible and handy, but it also brings new problems like not everyone having the right technology, missing face-to-face chats, and finding it hard to stay motivated and interested. Even with these difficulties, online learning has become really important in education during the pandemic. It lets students keep studying in a safe and familiar place.

1.1 Research Background

Due to the COVID-19 pandemic, many schools in Thailand have switched to online learning to keep students and teachers safe from the virus. This means using technology like laptops, tablets, or smartphones to attend virtual classes, join video calls, and access educational materials.

1.1.1 Online Learning in Thailand

The Ministry of Education in Thailand has started the "Distance Learning Project" to provide online educational resources to students. This includes video lessons, educational websites, and interactive tools. The government is working with private organizations and tech companies to give devices and internet access to students who don't have what they need for online learning.

Even though online learning has helped education during the pandemic, it has also brought challenges. Some students don't have the right technology or internet, and it's hard to keep them engaged in a virtual class. But the Thai government and schools are actively working to fix these issues and support students during these tough times.

As the COVID-19 situation gets better in Thailand, many schools and universities are going back to in-person classes. They're also using online resources along with traditional teaching methods. This mix of in-person and online learning is making education better.

For example, some schools still use online platforms for self-paced learning. They have recorded lectures and interactive assignments for students to do when they can. At the same time, in-person classes let students talk directly to teachers, do group activities, and have hands-on learning experiences.

But the impact of the pandemic is still there. Schools are keeping health and safety rules, like wearing masks and staying apart, to lower the risk of the virus spreading.

1.1.2 Students' Effectiveness of Online Learning in Thailand

People in Thailand have been talking a lot about how well online learning is working for students during COVID-19. Even though online learning has kept education going, there are challenges in making sure students get a good education this way.

The Ministry of Education in Thailand did a study. They found that while most students could use online resources and join virtual classes, there were big differences in how good these experiences were. This was mostly because of things like money and access to technology and the internet. For students who didn't have the right tools, the study showed it was affecting how well they were learning.

1.1.3 CAMT Faculty, Chiangmai University

During the COVID-19 pandemic, students at Chiang Mai University, like those in many other Thai universities, have had to adjust to a new way of learning. The impact of the pandemic on regular classes and traditional teaching methods has led to a widespread shift to online education.

At Chiang Mai University, students are involved in a hybrid learning model that combines both in-person and online classes. In-person classes follow strict health and safety rules, like wearing masks, keeping a safe distance, and regularly cleaning facilities. Meanwhile, online classes use platforms like Zoom, Google Meet, or Blackboard, allowing students to actively take part in live lectures and discussions from their homes.

The Major in Knowledge and Innovation Management at Chiang Mai University focuses on how organizations can effectively create, handle, and use knowledge and

innovation to reach their goals. This program gives students a strong foundation in the theories and practices of knowledge and innovation management, while also developing the necessary skills to apply these practices in real-world organizational settings.

Due to the COVID-19 pandemic, students, including those in the Knowledge Management program at Chiang Mai University, have had to switch to remote learning. While online classes have been a good option for students who can't be physically present in Thailand, there are concerns about how effective online learning is compared to traditional in-person classes.

To address these concerns, a survey was done among Knowledge Management students at Chiang Mai University to find out what they think about online learning during the COVID-19 pandemic. The survey showed that 56% of the students felt less motivated to learn when using online methods instead of traditional face-to-face classes. These results highlight how the way classes are delivered can affect students' interest and motivation to learn. It's clear that more research is needed to better understand the challenges of online learning and find ways to overcome them, making sure students have a good educational experience during this time.

1.2 Research Problems

This study highlights the significant challenges of online learning, leading to lower effectiveness for students compared to traditional face-to-face teaching methods. Students face issues like lack of attention, limited interaction with teachers, and unfamiliar teaching styles, creating significant hurdles. Teachers, on the other hand, struggle with delivering hands-on experiential learning in online courses. The remote nature of online learning also brings difficulties in school administration and teacher-student management, causing stress for parents.

The challenges are further compounded by the need for extra instructional materials to improve students' learning effectiveness. To address the problem of low effectiveness, everyone involved—students, schools, teachers, and parents—needs to work together. It's

crucial for each party to take proactive measures to enhance the overall effectiveness of online education.

1.3 Research Objectives

The main research objective of this study is to obtain guidance on enhancing students' effectiveness in online learning. The following are the two sub-objectives:

(1) To explore influencing factors of online learning effectiveness

(2) To evaluate the success factors of online learning effectiveness using the AHP technique.

1.4 Definition of Crucial Items

In alignment with the paper's title, this section introduces two primary defining terms: online learning and learning effectiveness. The purpose is to provide clarity and precision regarding these terms within the context of the study.

1.4.1 Online Learning

Online learning, also known as e-learning or distance learning, is an educational approach that uses the Internet and digital technologies to make learning easier. With online learning, students can access course materials, interact with teachers and classmates, and complete assignments and tests through an online platform. It brings more flexibility and accessibility to education, allowing students to join classes and finish coursework from any place with an internet connection. The popularity of online learning has grown, especially because of the urgent need for remote learning during the global impact of the COVID-19 pandemic.

The development of online learning has been a gradual and flexible process, meeting the changing needs of students and educators. It has historical roots in correspondence courses from the 19th century, where students could study from a distance. The introduction of computers and the Internet in the latter half of the 20th century was a crucial moment in the history of online learning, making it a practical and influential way to deliver education.

In the beginning, online learning mainly used text-based materials, and students had to send assignments and assessments through regular mail. However, as technology progressed, online learning transformed significantly. It now includes various multimedia content, interactive simulations, and virtual classrooms, creating a more engaging and dynamic learning environment.

The widespread availability of high-speed Internet and mobile devices has driven the growth of online learning. This allows students to access course materials and participate in virtual classrooms from almost anywhere. The COVID-19 pandemic has accelerated this trend, with many educational institutions adopting remote learning solutions to continue education during the global crisis.

This research focuses on how online learning is used in the context of the COVID-19 pandemic. Specifically, it explores how live broadcasting by educators, through online education platforms, serves as a method of online instruction. Students can join these online courses by accessing live broadcasts on their mobile devices or computers. Unlike some institutions that use prerecorded content in Massive Open Online Courses (MOOCs), this study narrows its focus to Chiang Mai University students, concentrating on live lectures. This approach aims to provide a more accurate understanding of the current educational situation faced by students in traditional classrooms, offering valuable insights into the effectiveness of this specific approach to online learning.

1.4.2 Learning Effectiveness

Learning effectiveness refers to how well educational experiences and practices lead to desired outcomes, such as gaining knowledge, skills, and competencies. In the education field, there's a lot of research exploring the factors that influence learning effectiveness and strategies to improve it.

In academic settings, we often measure learning effectiveness using tools like standardized tests, grades, and performance-based assessments. Additionally, a more qualitative evaluation involves gathering perspectives from both students and instructors about the learning experience and assessing critical competencies and skill development.

6

Effective learning is a complex concept with many factors at play. These include the quality of instruction, how engaged students are, the use of technology, and the availability of suitable resources and support. The study of learning effectiveness is multidisciplinary, drawing on various academic areas such as education, psychology, sociology, and technology.

Research on learning effectiveness aims to understand the processes and factors that make learning successful. This understanding helps shape policies, programs, and practices to improve learning outcomes for all students.

This research specifically looks at how well online education worked for students during the COVID-19 pandemic. To deal with the complexity of assessing learning effectiveness, the study takes a subjective approach, relying on the opinions of both students and educators. This method provides valuable insights into how learners and instructors experienced online learning during the unique circumstances of the pandemic. It significantly adds to our understanding of the challenges and opportunities in online learning during this period.

While subjective evaluations have limitations, this approach gives a unique perspective on how effective online learning was during the pandemic. It helps highlight the key factors that contributed to successful learning in this specific context.

1.5 Research Structure

Chapter One: Introduction

The first chapter introduces the research background, research objectives, research problems, the definition of crucial items, and the research structure.

Chapter Two: Literature Review

The second chapter elaborates on the foundational theories and relevant literature central to this research. It encompasses two primary aspects: firstly, the domain of online learning, and secondly, the concept of learning effectiveness. This chapter is intended to offer a comprehensive exposition of the theoretical framework and the existing scholarly body of work that informs this research.

Chapter Three: Methodology

The third chapter provides a detailed exposition of the research methodology, comprising three essential components. The first segment introduces the conceptual framework that underpins the research, elucidating the theoretical foundations. The second segment delineates the research sample, offering a comprehensive description of the participants or subjects involved. The third segment elucidates the progression of the research, detailing the various stages and methodologies employed throughout the study.

Chapter Four: Analysis, Discussion, and Results

The fourth chapter provides a comprehensive exposition of the investigation outlined in the preceding chapter. It places particular emphasis on the current state of students' online learning, as well as the determinants that influence its efficacy. Additionally, this chapter offers conclusive guidance and recommendations aimed at enhancing the effectiveness of students' online learning.

Chapter Five: Conclusion

The fifth chapter offers a comprehensive presentation of the results derived from the execution of this study. Furthermore, it delves into the study's limitations and provides insight into potential avenues for future research.

1.6 The Research Significance

This study explores the factors influencing the effectiveness of students' online learning, and it holds profound significance, spanning three distinct dimensions: students, teachers, and society.

1.6.1 To Students Who Study Online

For students, it's crucial to understand the things that affect how well they learn and perform in an online setting. These include having the right technology, a good internet connection, staying motivated and engaged, and using effective time management strategies. If students grasp these factors well, they can figure out where they need to improve and make plans to overcome any challenges they might face.

8

1.6.2 To Teachers Who Teach Online

Understanding the teacher's perspective is essential to grasp the factors influencing their ability to provide effective online instruction. This includes how lessons are designed, the smart use of technology, and the implementation of strong evaluation methods. By understanding these factors, teachers can create high-quality online learning experiences that engage students and support their success. Through research on the elements affecting teaching effectiveness, educators can improve their instructional methods and be better equipped to help students achieve their academic goals.

1.6.3 To Society and the Education System in the Future

Looking at it from a society-wide view, how well online learning works is super important for the future of education and jobs. As more and more students use online learning to move forward in their education, it's really important to understand what makes them succeed in this setup.
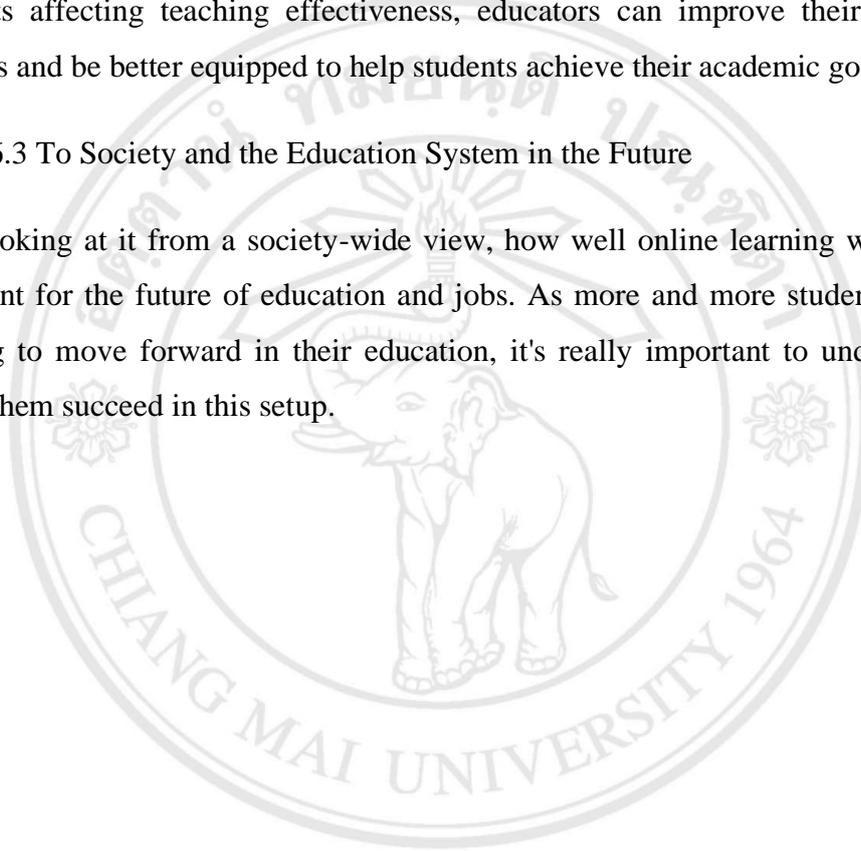
CHAPTER 2

Literature Review

This article is mainly here to help students make their online learning experience better. Even though the COVID-19 pandemic is over, it looks like online education is here to stay. During the pandemic, many scholars did research on online learning. I found around 5,000 research papers on online learning when I searched with keywords like "online learning." The next part gives a short summary of what these papers say.
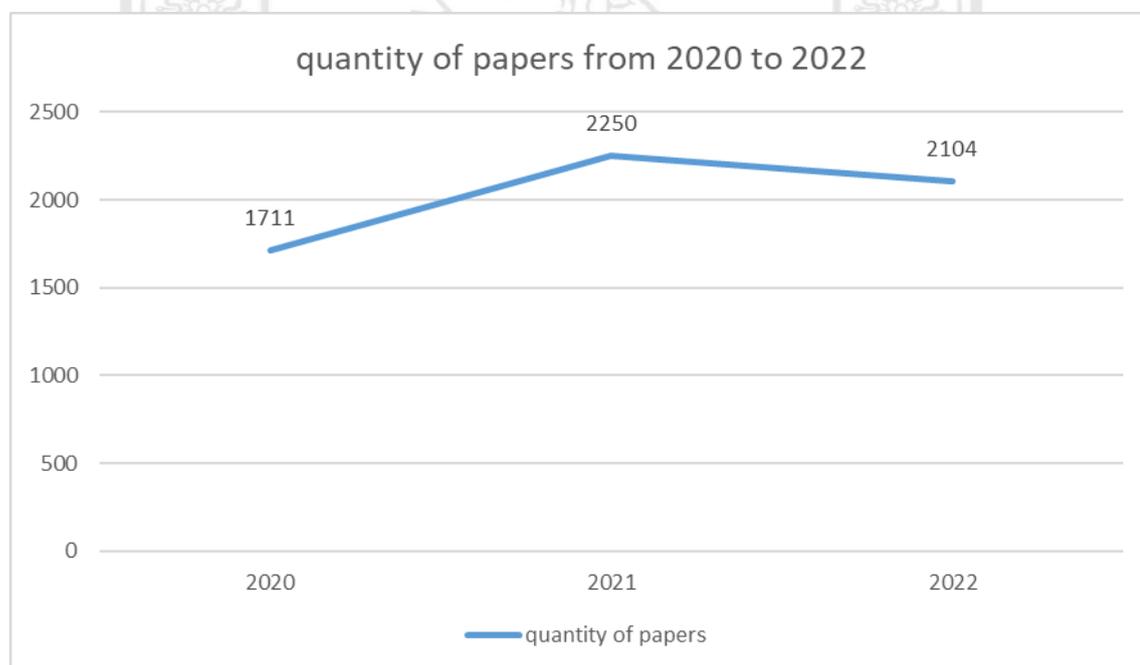
Figure 2. 1 Quantity of Papers from 2020 to 2022 about Online Learning

Over the three years following the start of the COVID-19 pandemic, many researchers have focused on online learning. In 2020, there were 1,711 articles published about it. In 2021, the most research activity happened, with 2,250 articles all about online learning. However, in 2022, as the COVID-19 pandemic became less of a concern, the number of studies on online learning went down a bit to 2,104. This change in research output shows how education is changing after the pandemic.
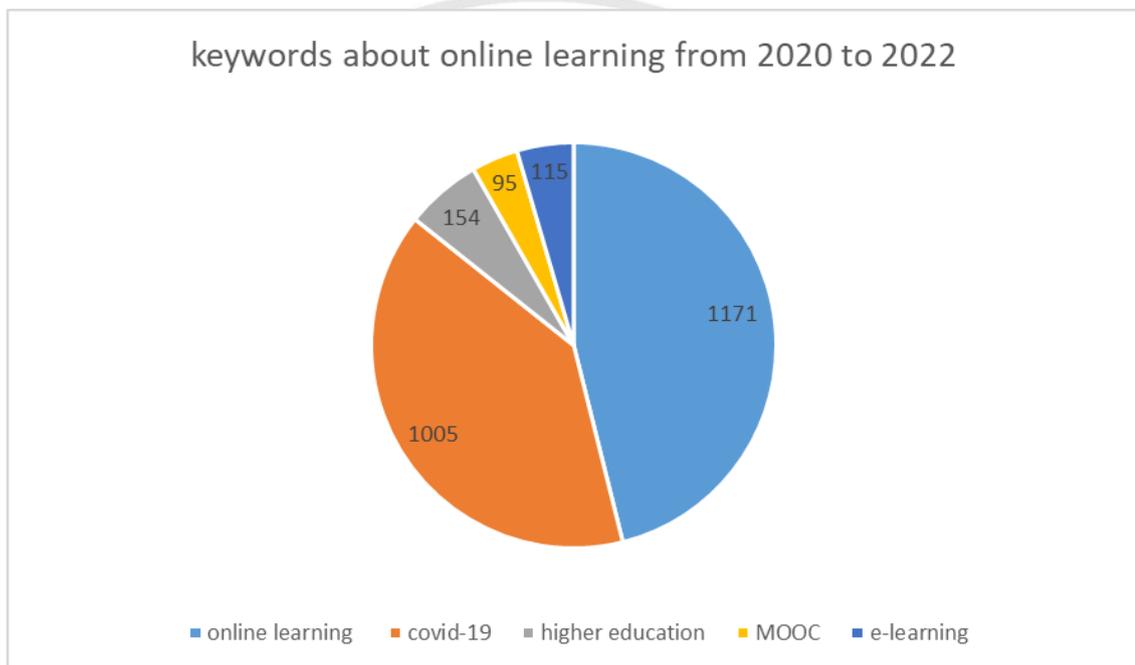
Figure 2. 2 Keywords about Online Learning from 2020 to 2022

During our search for articles about online learning, we noticed that most of them, about 46.1%, were mainly about discussions on online learning. Additionally, 1,005 articles, making up 39.57% of the total, specifically mentioned COVID-19. The remaining articles covered topics like higher education (6.06%), e-learning (4.53%), and MOOC (3.74%). These percentages show the different themes present in the articles we analyzed concerning online learning. In the following sections, we'll delve into specific analyses drawn from these articles, relevant to our study.

2.1 Online Learning

In recent years, online learning has grown significantly and become a popular choice for education across different age groups. Ongoing research in this field is dynamic,

adapting to technological advancements and the increasing availability of data. The next section outlines key aspects of the current research landscape in online learning:

According to Shea et al. (2005), previous research emphasizes the crucial role of community in promoting effective learning, with teaching presence—defined as the central role of the online instructor—emerging as a promising way to cultivate an online learning community. Expanding on this idea, Shea et al. (2005) conducted a study involving 2,036 students from thirty-two different colleges. Their research not only supports this claim but also explores the complex relationship between the online learning community and teaching presence.

Abdous (2019) explores various factors related to the online learning experience, such as students' demographics, prior online learning exposure, satisfaction levels, and their sense of preparedness after online learning orientation. This study examines how these factors contribute to students' anxiety in online learning. Participants completed a 45-item Likert survey, and two open-ended questions were used to investigate critical factors affecting their online teaching and learning experiences (Tanis, 2020). In the same study, Kornilov et al. (2020) identify primary approaches to developing online learning in higher education.

The COVID-19 pandemic has brought significant changes to how education is delivered, prompting research to explore these changes and their consequences. Simamora (2020) analyzes student essays that express perspectives and responses, focusing on challenges faced during online learning amid the COVID-19 pandemic. Additionally, Bryson and Andres (2020) examine the experiences of transitioning three modules from in-person to online delivery between March and May 2020. Lastly, Jena (2020) emphasizes the advantages of online learning during crises, such as work absences or pandemics.

In the field of online learning, a common research approach is to focus on students as the main subjects, exploring their learning status and experiences. Chen and Cui (2020) conducted a comprehensive study to evaluate the quality of online learning for college students. They used questionnaires covering four critical dimensions: the learning environment, resources, activities, and outcomes. Analyzing data from 3,510 students,

the study gained insights into various aspects of students' engagement, initiative, recognition, self-evaluation, summarization, reflection, and challenges during online learning. The findings showed that 23.85% of students reported an excellent overall online learning experience, 31.91% found it good, and 36.52% deemed it average.

In a related study, Tana wongsuwan (2020) researched at NIDA College in Thailand, surveying 898 students to explore their perceptions of offline and online learning experiences at the end of a semester. The survey covered class interaction, activities, laboratory training, and teaching resource availability. Results revealed lower ratings for various aspects of online learning, including laboratory training, student engagement, interaction, writing, and classroom activities. Notably, laboratory training suffered the most due to challenges in developing practical skills through virtual means.

In addition to exploring students' views on online learning, some researchers have investigated its impact on students' mental health. For instance, Irawan et al. (2020) conducted telephone interviews with 30 university students from Mulawaiman University in Indonesia. Their findings revealed that, after two weeks of engaging in online learning from home, students frequently reported feelings of boredom and heightened anxiety, which were linked to the substantial workload.

Moreover, Gwang-Chol Chang and Satoko Yano have examined the provision of psychological support to students globally. Their article notes that, in response to the COVID-19 pandemic, several countries, including China, Japan, Spain, and the United States, have implemented measures such as providing free 24-hour telephone counseling services to students in need of psychological support.

Moving beyond a primary focus on students, various studies have also explored the current state of online teaching, school administration, and parental expectations. Wang et al. (2020) conducted an online survey with 33,240 participants, including education administrators, school administrators, teachers, students, and parents. The survey results indicated that, out of 777 school administrators, 68.92% believed that online teaching could effectively maintain the quality of instruction during the pandemic. In contrast, 68.72% believed that online teaching could adequately address students' fundamental educational needs but expressed concerns about teachers' preparedness.

13

Furthermore, the survey found that 31.5% of school administrators had concerns about teachers' technical skills in online teaching. Among the 2,401 teachers surveyed, over 50% believed that online teaching effectively meets students' educational needs, and 31.9% showed willingness to continue using online teaching after the pandemic. However, teachers also experienced anxiety related to online teaching, particularly in terms of student interaction (62.6%), equipment operation (58.6%), and instructional organization (52.1%).

In a survey of 12,130 parents, it became evident that they had high expectations regarding the measures taken by schools to address online teaching challenges. Approximately 49.2% of parents expressed the desire for a variety of online teaching formats, including live classes, video recordings, assessments, and feedback. Notably, parents from urban schools and those with primary school students showed a stronger interest in diversifying online teaching methods.

The academic discussion about online learning platforms often focuses on evaluating them. In 2020, Cejun Cao and colleagues evaluated various platforms, looking at their stability, instructional quality, usability, resource availability, and interactive features (Cao et al., 2020). They emphasized that network stability is crucial in assessing these platforms. Additionally, the use of online learning platforms varies between countries. In China, Wu Daguang and Li Wen's survey revealed that 97 universities used 66 platforms, with 83% having a market-oriented focus (Wu & Li, 2020). On average, each university used 6.9 platforms, with Chaoxing, QQ, China University MOOC, Dingding, WeChat, and Tencent conferences being the most popular. The survey found that teachers used 2.16 platforms on average, while students used 2.99 platforms. In Thailand, AU University uses Microsoft Teams for communication and collaboration. Although Zoom is used for live teaching, it is criticized for limited interactivity and classroom features. These findings highlight that not all platforms meet the diverse needs of students and teachers, leading educators to use multiple platforms for effective teaching.

While online education has become a practical solution for maintaining school attendance during pandemics, it does have its drawbacks. Yang (2020) surveyed 150 college students to uncover the challenges of online learning. The results showed various difficulties, such as issues with online platforms, limitations in doing laboratory exercises,

increased workload, unrealistic performance evaluation criteria, reduced teaching effectiveness, and a less engaging classroom atmosphere. Prolonged online engagement can lead to physical and mental exhaustion. Technical challenges, like limited internet coverage in some areas, make it tough for students to access online educational resources. Moreover, Pragya Nuankaew (Nuankaew et al., 2021) pointed out the gap between technological advancements and accessibility, especially in rural areas. This often requires additional expenses for learning tools and materials, further complicated by limited network coverage.

(Yuhua & Jin, 2020) explored how well online learning adapts, suggesting its suitability depends on the course type. They emphasize the crucial role of hands-on experimentation in learning, especially in fields like medicine, science, and engineering. Therefore, online learning should ensure students get enough chances for hands-on exploration. In language studies, the classroom environment and student emotional engagement are crucial for learning outcomes.

On the flip side, online learning can engage students differently. In physical education, hands-on experience in sports is vital for acquiring technical skills. However, online learning can provide unique forms of guidance compared to in-person teaching. So, the suitability of online learning depends on the specific course characteristics.

Several challenges are associated with studying online learning, including:

Data Quality and Availability: The quality of data in online learning may vary, leading to issues like incomplete or biased data.

There are challenges in how research is designed and conducted in online learning environments. This includes dealing with the complexities of controlling extraneous variables and ensuring the validity of research outcomes.

Online learning populations might not represent a diverse range of learners, limiting the generalizability of research findings due to sample bias.

15

When conducting research with online learners, ethical considerations become important. This involves obtaining informed consent and protecting the privacy and confidentiality of participants.

These challenges highlight the need for well-planned and skillfully executed research studies in online learning environments to better understand this rapidly evolving field.

2.2 Learning Effectiveness

Studies show that various factors impact learning, including teaching methods, teacher quality, student motivation, and the learning environment. Recently, there's been more attention on how technology supports and improves student learning, especially in online and hybrid learning. Additionally, there's a growing focus on assessing and measuring learning outcomes, also finding effective strategies for more meaningful learning methods and experiences.

(Hu & Hui, 2012) suggested a structural model to explain students' learning effectiveness and satisfaction. They tested the model and associated hypotheses in an experiment with 212 students in university. (Kuo et al., 2015) used the Mayer's cognitive theory of multimedia learning (CTML) to deliver multimedia instructional materials to students using both auditory and visual methods. Recently, many engineering educators have been trying various educational techniques. This paper aims to analyze and assess the impact of different methods in a flipped classroom on student learning effectiveness (Tseng et al., 2015). Also, (Tsai et al., 2017) used a quasi-experimental design to explore the influence and predictive power of learner motivation for achievement, employing a mobile game-based English learning approach. (Chitre & Srinivasan, 2018) outlined their findings and recommendations on using student feedback scores to create an unbiased minimum variance estimate of teaching effectiveness. (Geng et al., 2019) investigated the effects of self-directed learning, technology readiness, and learning motivation on the three presences. Those are social, teaching and cognitive perspectives. To comprehensively assess the multi-stage learning effectiveness of students in MOOCs, (Xiao et al., 2020) introduced MOLEAS, a multi-stage online learning effectiveness assessment scheme. (Ahmad, 2021) aimed to analyze the impact of the learning

16

environment and learning motivation on student learning effectiveness at As-Syafiiyah Islamic University.

Research on students' learning effectiveness in online and hybrid learning, has significantly grown recently due to the increasing use of technology in education. Many studies have explored various factors influencing learning effectiveness online, including student engagement, motivation, and self-regulated learning. Additionally, researchers have investigated the impact of instructional design, technology, and teacher support.

Studies have shown that student engagement is a crucial predictor of learning outcomes in online environments. Using strategies as an interactive multimedia and collaborative learning can enhance engagement and offer valuable support for student learning.

Moreover, studies have emphasized the importance of self-regulated learning for students in online learning environments. Students who use self-regulated learning strategies generally achieve more positive learning outcomes.

Furthermore, research has been proved that effective instructional design, included with 1: clearly defined learning objectives, 2: intensively crafted assessments, and 3: constructive feedback. Those plays a vital role to support student learning and accomplishments in online environments.

The study focuses on using technology to support learning in online environments. This involves with an investigation on the effectiveness of virtual and augmented reality, gamification, and personalized learning to improve the educational experience.

Over the last ten years, extensive research has explored how well online learning works for students. However, it's essential to recognize some limitations in this research. These limitations include:

1) Limited investigation into long-term outcomes: The majority of studies examining the effectiveness of online learning have primarily concentrated on short-term outcomes, such as examination scores or course completion rates, as opposed to more

protracted and comprehensive outcomes, such as employment prospects and lifelong learning achievements.

2) Variability in online learning environments poses a significant challenge to comparing studies and drawing generalized conclusions. Factors such as course design, technology platforms, and instructor experience all wield influence over the effectiveness of online learning.

3) Absence of control groups: Numerous studies assessing the effectiveness of online learning lack the inclusion of control groups, rendering it challenging to discern whether any disparities in outcomes are attributable to the online learning environment or other variables.

4) Self-selection bias: Online learners frequently engage in a process of self-selection when enrolling in courses, a phenomenon that can introduce bias into research studies. For instance, individuals opting for online courses may exhibit higher levels of motivation or possess distinct learning styles compared to their counterparts who opt for in-person instruction.

5) Scarcity of research on particular student demographics: There has been a notable dearth of research investigating the efficacy of online learning for specific student cohorts, including but not limited to low-income individuals, underprepared students, and those with disabilities.

Although research on the effectiveness of online learning for students has made considerable advancements in the past decade, there remains ample room for further exploration and enhancement.

2.3 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), developed by Thomas Saaty in the 1970s, is a structured decision-making method designed to assist individuals or groups in prioritizing and reaching decisions based on multiple criteria.

The AHP process involves the systematic breakdown of a complex decision problem into a hierarchical structure with three distinct levels:

18

Goal: This top-level element represents the overarching objective or purpose of the decision-making process.

Criteria: These are the key factors deemed essential in achieving the established goal. Criteria can be further subdivided into sub-criteria when necessary to provide a more granular analysis.

Alternatives: This level encompasses the various options or choices being considered as potential solutions to the decision problem.

The AHP methodology helps evaluate the importance or preference of both criteria and alternatives. This assessment is done on a scale from 1 to 9, with 1 indicating equal importance and 9 indicating very high importance.

After completing all the pairwise comparisons, the AHP method uses a mathematical formula to figure out the priorities or weights for each criterion and alternative. These calculated weights are then used to calculate a final score or ranking for each alternative, which helps in the decision-making process.

AHP can be applied in the field of online learning to assist in decision-making on various matters such as course design, technology selection, and strategies to improve student engagement. Here are some examples of how AHP can be effectively used in the context of online learning:

Course design: AHP can assist online educators in the prioritization and decision-making process related to the inclusion of specific content and activities within a course. This application may entail the comparison of the relative significance of various course components, such as lectures, readings, discussions, and assignments. Additionally, AHP can be employed to evaluate and compare different pedagogical methods, such as synchronous versus asynchronous instruction.

Technology selection: AHP serves as a valuable tool for online educators to assess and prioritize various technologies and tools for their courses. This includes the ability to compare the relative importance of different learning management systems, video conferencing software, or collaborative tools. Furthermore, AHP can be employed to

gauge the effectiveness of technology-based interventions, such as gamification or adaptive learning strategies. For instance, in a study conducted by Xu (2018), AHP was applied to investigate the online teaching performance of higher vocational colleges.

Student engagement: AHP provides online educators with a valuable framework to assess and prioritize diverse strategies aimed at enhancing student engagement within their courses. This process entails comparing the relative importance of various engagement strategies, including interactive activities, peer-to-peer feedback mechanisms, and personalized learning experiences. AHP can also be employed to evaluate the effectiveness of these engagement strategies, encompassing measurements of student participation rates, satisfaction levels, and their impact on learning outcomes.

After examining existing literature, it is clear that previous research has mostly focused on comparing and evaluating different online education platforms. As a result, the more intricate aspects of online teaching have been challenging to explore. Additionally, most of these studies have used qualitative analysis methods, with only a few employing techniques like the Analytic Hierarchy Process (AHP) to assess factors influencing the effectiveness of students' online learning experiences. This underscores a significant gap in the literature, emphasizing the need for more comprehensive and quantitative approaches to evaluate the effectiveness of online learning.

This study aims to explore the effectiveness of online learning and its impact on students using the Analytic Hierarchy Process (AHP). The goal is to fill the existing gap in the literature by taking a quantitative approach to comprehensively assess the various factors influencing the effectiveness of online learning. By employing AHP, this research aims to provide a strong evaluation of different aspects of online learning and their respective importance in achieving the best learning outcomes.

20

CHAPTER 3

Methodology

This chapter is composed of three essential sections: the conceptual framework, research sample, and experiment design. The conceptual framework offers a comprehensive overview of the dissertation's implementation, encompassing three core components: the problem, the solution, and the results. The sample section introduces the research subjects and the experts invited to participate. The primary focus of the research is on students at CAMT College of Chiang Mai University who received online classes during the pandemic. The seven invited experts are categorized into three groups based on their diverse experimental objectives.

The section on research design and implementation details how the conceptual framework is put into action. This includes identifying and addressing the research problem, obtaining results, and describing the research methods used. The main goal of this chapter is to introduce how knowledge management tools can be used to improve the effectiveness of online learning.

3.1 Conceptual Framework

Figure 3.1 highlights three areas in the paper, namely the problem, the solution, and the outcome.
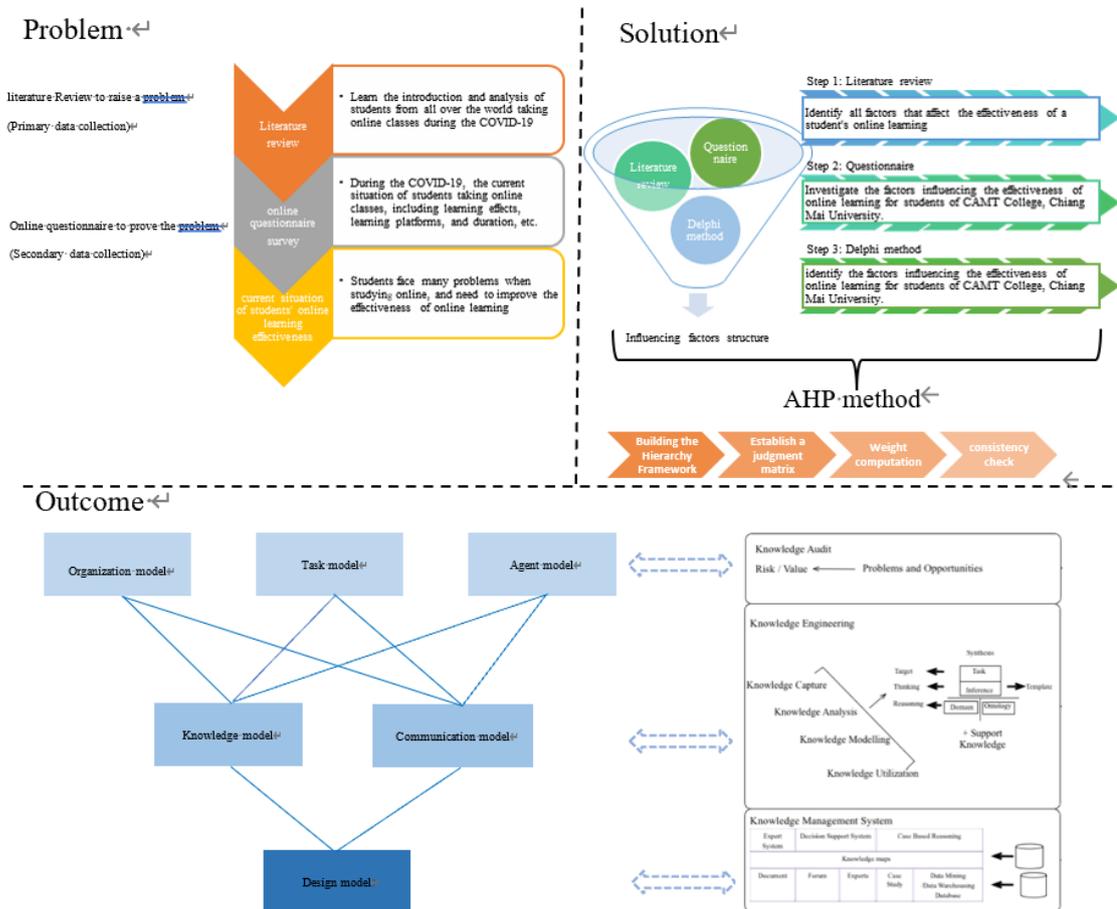
Figure 3. 1 Conceptual Framework

During the problem analysis phase, this study explores the current situation of students who have transitioned to online learning due to the COVID-19 pandemic. This is done by thoroughly examining existing literature and creating a questionnaire to understand the online learning experiences of participants. Analyzing and synthesizing the collected data result in a clear understanding of the challenges students encounter in online classes and the various factors influencing their learning.

The solution phase of this study aims to understand the key factors influencing the success of online learning for students. Initially, a thorough review of literature, a survey using a questionnaire, and the Delphi method are used to identify the variables that impact

the effectiveness of online learning for CAMT college students at Chiang Mai University. Then, the Analytic Hierarchy Process is employed to assess the importance of each of these factors in relation to learning effectiveness.

In the outcomes section, this study uses a knowledge management tool, CommonKADS, to create a knowledge model to tackle the identified issues and improve the effectiveness of online learning for students. Implementing this model provides an effective solution to the identified problems and leads to enhanced student learning outcomes.

The expected result is a guideline that can help students improve the effectiveness of online learning.

3.2 Research Samples

Students: 83 students from CAMT faculty at Chiang Mai University were selected for this study. Among these students, 24 of them were male and 59 were female. These students were divided into undergraduate, graduate, and doctoral groups. Specifically, there were two first-year students, six second-year students, five third-year students, and 14 fourth-year students in the undergraduate group. The graduate group had 17 first-year students, 27 second-year students, and seven third-year students. The smallest group was the doctoral students, with five students, including four first-year students and one third-year student.

Experts: This study involved a total of 7 experts, who were classified into three types based on the research purpose and methods. The first type included three experts who used the Delphi method to identify the factors influencing the effectiveness of online learning for students. The second type consisted of three experts who evaluated the importance of these factors using the Analytic Hierarchy Process. The final type of expert was the guidance provider who used CommonKADS.

3.2.1 Research Organization

Chiang Mai University (CMU), a main government university in northern Thailand, has 25,394 students and 1,714 academic staff (2004). The Thai government has proposed

23

CMU as the aviation hub for Greater Mekong Sub-region (GMS) nations, including Laos, Burma, China, Cambodia, and Vietnam. It recently declared Chiang Mai one of three ICT (Information and Communication Technology) Cities.

The government activities cover the development of e-tourism, e-business for the handicraft industry, e-commerce, e-government, e-learning, alternative media, games, animation, mobile, and e-business for SMEs and larger organizations. The city provides modern infrastructure for international business investment because its economy mainly depends on tourism handicraft and software businesses.

CMU has just established a new faculty called the faculty of Arts, Media, and Technology (CAMT). CAMT focuses on human resource development and innovation in ICT for tourism, handicraft, and software industries in Northern Thailand. The CAMT faculty intends to provide bachelor's programs in software engineering, animation, e-tourism, and handicraft design. At a postgraduate level, CAMT grants degrees for both Master's and Doctoral studies for experienced knowledge workers. Research groups are set up in the college to support industrial research.

On March 23, 2020, Chiang Mai University announced the temporary closure of the campus due to COVID-19. It mentioned that classroom teaching will be canceled, and some departments will be closed. All courses will be taught online. If exams are involved, other examination forms will be adopted. In place of classroom-focused exams or postponed exams as appropriate. Students of CAMT faculty are also forced to take classes online through the online platform ZOOM. This learning pattern continued for more than a year.

3.2.2 Sample Selection

When selecting research samples, the scope is narrowed down to the CAMT faculty of Chiang Mai University. The research samples must be related to online classes during the COVID-19 pandemic. It can be divided into students who have taken online classes and teachers who have taught KIM online classes. Due to the limited number of teacher samples, teachers outside CAMT College were recruited for the survey.

24
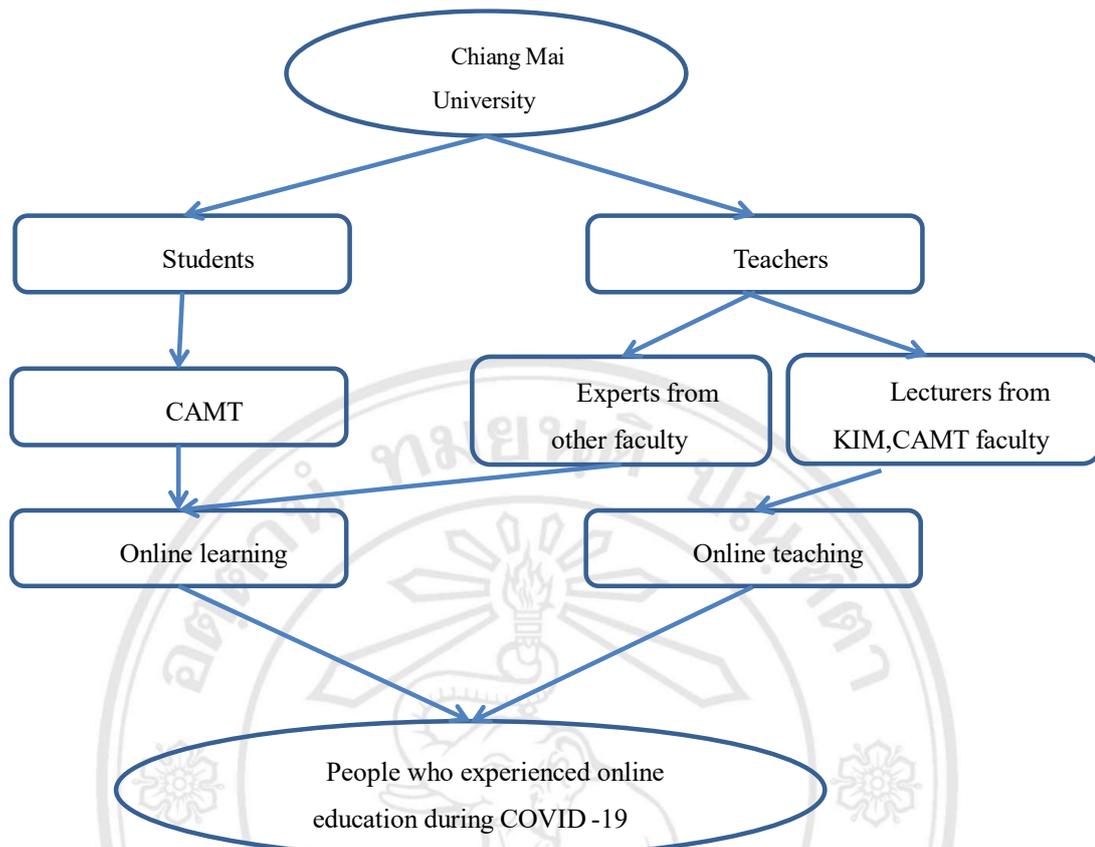
Figure 3. 2 Samples of Research

3.2.3 Sample Groups

The students are categorized into three groups based on their academic levels: undergraduates, postgraduates, and doctoral students. Among the participants, there were 27 undergraduates aged 18 to 23, 51 postgraduates aged 22 to 27, and five doctoral students aged 25 to 32 included in the study. The duration of online learning varied; specifically, ten students had been engaged in online learning for over two years, 14 students for less than six months, and 30 and 29 students for six months to one year and one to two years, respectively.

A questionnaire survey has been utilized to explore various facets of online learning. This survey encompasses topics such as the duration of online courses, disparities in learning materials, and the factors that influence the efficacy of online learning for students. The primary objective of this research is to pinpoint and comprehend the factors that contribute to successful online learning experiences and offer practical guidance for both students and educators.

Furthermore, a panel of experts is incorporated in the study, classified into three subgroups according to their research methodologies and objectives. The initial subgroup utilizes the Delphi method and consists of three educators from Chiang Mai University who possess experience in online teaching during the pandemic. Their objective is to pinpoint the factors that notably influence the efficacy of online learning.

The second group employed the AHP to evaluate how important the factors, identified through the Delphi method, are in influencing learning outcomes. This team comprises three experts and four lecturers.

The third group consists of one instructor who uses the CommonKADS methodology to create a guidebook aimed at improving the effectiveness of online learning for students.

The study aims to provide a comprehensive understanding of various factors affecting the effectiveness of online learning. The goal is to offer practical guidance to both students and educators to enhance the quality of online learning experiences.

Table 3. 1 Sample Groups of Research

Sample group	Roles	Process	Output	Outcome
Students (83 students)	Undergraduate (27 students)	Online questionnaire	The current situation of online learning	The duration of online learning, problems encountered, learning experience, and suggestions for online learning
	Graduate (51 students)			
	Doctoral (5 students)			

Table 3. 1 Sample Groups of Research (Continued)

Sample group	Roles	Process	Output	Outcome
Experts (7 experts)	Expert group 1 (3 experts)	Delphi method	Factors affecting student effectiveness in online learning	The Hierarchy of the effectiveness of online learning
	Expert group 2 (3 experts)	AHP method	The data analysis result of AHP	Importance ranking of factors
	Expert group 3 (1 expert)	CommonKADS	The knowledge model	The guidelines about how to improve students' online learning effectiveness

3.2.4 The Profiles of Experts

There are 3 groups participated in this research:

Expert group 1: Asst.Prof.Jirawit Yanchinda, Ph.D, Asst.Prof.Manissaward Jintapitak, Ph.D and Pattaraporn Khuwuthyakorn (cmu.ac.th)

Expert group 2 (AHP): 4 lecturers from KIM Department

Expert group 3 (guideline knowledge): Asst.Prof Uraiwan Harnwong, PhD

Following are profiles of experts:

Jirawit Yanchinda: Assistant Professor Dr. Jirawit Yanchinda, hailing from the College of Arts, Media, and Technology, possesses a wealth of teaching experience and

enjoys high popularity among students. Throughout the COVID-19 epidemic, he served as a lecturer at Chiang Mai University, imparting knowledge engineering to students through a diverse array of online courses.

Manissaward Jintapitak: The College of Arts, Media, and Technology proudly extends its congratulations to Assistant Professor Dr. Manissaward Jintapitak, a dedicated Lecturer in Animation and Visual Effects. The College has been honored with the prestigious Distinguished Educator Award, recognizing Dr. Jintapitak's exemplary achievements in fostering teaching and learning practices that align with 21st-century skills at Chiang Mai University, thereby promoting a conducive learning environment.

Tang Dongmei: Tang Dongmei, Doctor of Philosophy, has presided over 1 provincial and ministerial-level scientific research project, 1 sub-project of humanities and Social Science key research base project of the Ministry of Education, and 1 provincial department-level project. He has published 4 articles in CSSCI journals and several other journal papers. Research direction: Modern Christian thought and literary criticism theory Overseas experience: I led the Chengdu excellent middle school students to visit the United States, and visited the Chinese University of Hong Kong.

Uraiwan Harnwong: Assistant Professor Dr. Uraiwan Hanwong, who serves as the Deputy Dean of the Faculty of Education and holds the position of Lecturer in the Primary Education Department within the Department of Curriculum Teaching and Learning, has been honored with the esteemed "Golden Elephant" award for the year 2022 from Chiang Mai University. Dr. Hanwong received this accolade in the category of Teacher Award for Outstanding Achievement in Morality Development and Ethics for students, specifically in the field of Humanities and Social Sciences.

3.3 Research Design and Implementation

This section focuses on outlining the methodology for creating an experimental framework. Built on the foundation of the knowledge management process, the article carefully develops and implements research plans to achieve the overall experimental objectives.

Table 3. 2 Experimental Design

Objectives	Knowledge management process	Research tools	Output	Outcome
Obj.1. To explore influencing factors of students' online learning effectiveness	Knowledge acquisition	Literature review	The learning platform, duration, satisfaction of teachers and students, challenges of online learning.	Improvement of online learning effectiveness in CAMT faculty, Chiangmai University
		Online questionnaire survey	Learning basic situations, satisfaction, problems, and suggestions	
Obj.2. To evaluate the success factors of online learning effectiveness by using AHP technique	Knowledge creation	Literature review	Hierarchy of factors	
		Delphi method		
		AHP method	Ranking of importance of factors affecting student effectiveness	
	Knowledge storage	CommonKADS	Guideline for improving online learning effectiveness	

Objective 1 aims to explore the factors that impact online learning. This involves two phases. First, a thorough literature review will delve into the landscape of online learning during the COVID-19 pandemic. It will cover aspects like the platforms students use, study durations, satisfaction with educators and peers, and challenges faced during online learning. Second, empirical data will be collected from CAMT faculty students at Chiang Mai University who have experienced online learning. This data aims to gather information about their satisfaction levels, encountered difficulties, and suggestions for improving the online learning experience. This process aligns with knowledge acquisition in the knowledge management framework, starting with understanding the research's importance by examining the current state of student learning and identifying areas for

29

improvement. Survey results indicate that online learning has significant potential for enhancement compared to traditional face-to-face instruction.

Objective 2 involves the use of Analytical Hierarchy Process (AHP) techniques to assess success factors that contribute to the effectiveness of online learning. First, this study determined the influencing factors through a combination of literature review, questionnaire survey and Delphi method. The AHP approach is then used to prioritize these factors based on their impact on students. By comparing the questionnaire results of experts and lecturers, the relative importance of these factors to students' online learning effectiveness can be determined.

In the final stage of knowledge storage, the utilization of CommonKADS involves expert interviews to gather guidelines for enhancing students' online learning effectiveness.

3.3.1 Knowledge Acquisition

This section outlines the process of identifying and substantiating the presence of a research problem. By using both literature review and questionnaire survey methods, this study aims to evaluate the current state of online learning and the challenges students, especially those in the CAMT faculty at Chiang Mai University, are facing during the COVID-19 pandemic. This effort is focused on highlighting the essential importance of the research.
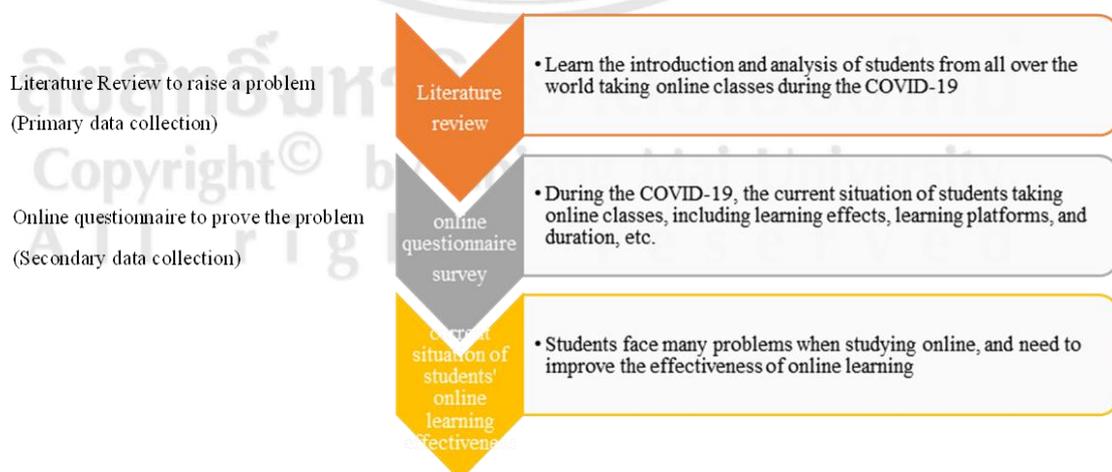
Figure 3. 3 Methodology of Knowledge Acquisition

To identify the online learning situation

To understand the real situation of online learning and the challenges students in the CAMT faculty at Chiang Mai University are encountering during the COVID-19 pandemic, a study was raised. The literature review and questionnaire survey methods was used for analysis.

Step 1: Literature review

To explore the challenge students face in online learning, the researchers conducted a thorough literature review to gather pertinent information. They used specific keywords for their searches on Google Scholar and CNKI databases. Initially, the aim was to examine students' online learning experiences across different countries in order to identify commonalities in areas such as online learning platforms, learning materials, learning schedules, course arrangements, and other pertinent factors. However, due to significant variations in education systems across countries, the research scope was subsequently narrowed down to Thai universities.

Through the literature review approach, the researchers were able to gain valuable insights into the online learning experiences of students from various countries. Additionally, they were able to pinpoint key factors that influence the effectiveness of online learning.

Step 2: A questionnaire survey

The primary aim of the questionnaire was to investigate students' experiences at the CAMT faculty of Chiang Mai University during the COVID-19 pandemic outbreak. In contrast to traditional modes of learning, online education entails distinct learning methods, materials, and demands a certain level of adaptability from students. By creating and distributing questionnaires and subsequently analyzing the responses received, the researcher generated reports on the learning experiences of 83 students at the CAMT faculty of Chiang Mai University.

31

Step 3: Questionnaire design

By thoroughly examining questionnaires used by other researchers, a new questionnaire was created to collect information about students' experiences in online learning. The questionnaire comprises three sections: Table 3.3, which focuses on basic demographic information of students, such as gender and grade level; Table 3.4, which inquires about the conditions of online learning, including time allocated to online learning, the platforms employed, and the equipment utilized; and Table 3.5, which assesses students' experiences with online learning, encompassing their adaptability to the virtual learning environment, their learning status (i.e., attention, motivation, and interaction), and their overall satisfaction with online learning.

Step 4: Distribution of the questionnaire

Due to geographical constraints, the current study utilizes an online questionnaire platform, specifically Questionnaire Star which is a Chinese website, to facilitate the development and administration of the survey instrument. The survey will be distributed through two WeChat groups to eligible participants. Before distributing the questionnaire, it is emphasized that respondents need to meet specific inclusion criteria, which stipulate that they must be students enrolled at CAMT and have experienced online coursework during the COVID-19 pandemic. This criterion is essential to ensure the validity and reliability of the data collected for this study.

Step 5: Questionnaire data analysis

The survey was distributed to two WeChat groups, and the participants completed the questionnaire within a two-day period. A total of eighty-three valid questionnaires were collected, comprising 27 undergraduates, 51 postgraduates, and five doctoral students. Utilizing Questionnaire Star proved to be particularly advantageous for this research due to its automatic analysis and sorting capabilities.

As an online survey tool, Questionnaire Star offers a wide array of data analysis functions. For instance, it facilitates basic statistical analysis of survey data, allowing for the computation of means, standard deviations, and percentages. This feature enhances the understanding and comparability of the collected data by generating corresponding

32

reports and charts. Furthermore, Questionnaire Star supports cross-tabulation analysis of various survey questions, enabling users to compare and scrutinize data from multiple questions, thereby exploring correlations and differences among them.

By analyzing the data, we have gained insights into key aspects of students' online learning experiences during the COVID-19 pandemic. This includes their personal information, conditions in online classes, challenges faced, overall experiences, and levels of satisfaction.

3.3.2 Knowledge Creation

This section focuses on the realm of knowledge creation, which involves generating fresh knowledge, ideas, and insights through various activities like research, experimentation, collaboration, and innovation. It entails turning information and data into new knowledge that can be used to solve problems or improve understanding in a particular subject or field.

The previous step, concerning knowledge acquisition, has provided valuable insights into how students at the CAMT faculty of Chiang Mai University experienced online learning during the COVID-19 pandemic. It has specifically revealed the challenges these students faced and their desire to enhance their learning conditions. To further explore the factors influencing the effectiveness of online learning for these students, this section employs three research techniques: a literature review and the Delphi method.

Step 1: Literature review

A literature review is a way of researching a topic by gathering and assessing existing knowledge about it. When exploring the things that affect how well students learn online, a literature review helps find the important factors that impact their learning.

The process starts with the researcher finding the main question or problem they want to explore. In this case, it's "What things affect how well students learn online?" Then, they find useful sources like academic articles, books, and conference papers. These sources can be found in online databases such as Google Scholar, Web of Science, and Scopus.

33

Afterwards, the researcher reviews the existing literature and identifies the main themes or factors that come up. These themes may include technical aspects like how the online learning platform is designed and if there's enough technical support. There are also educational factors, such as the quality of teaching materials and how much interaction there is between students and instructors. Other things that affect how well students learn online are their prior knowledge, motivation, and learning styles.

Doing a literature review is an effective way to figure out what factors impact how well students learn online. By thoroughly looking at existing research, the researcher can systematically identify and organize the factors that influence the effectiveness of online learning.

After reviewing 27 articles, it's clear that different authors use various criteria to classify factors affecting students' online learning. Some categorize them as primary or secondary based on their impact, while others distinguish them as internal or external depending on their connection to the learners. Also, these factors vary in how they're ranked. While some researchers discuss the teacher factor, others look at the teacher's behavior and teaching style. So, how these factors are grouped depends on the researcher's judgment. Following a thorough literature analysis, these factors have been organized into two levels. The first level includes seven main factors, each with several sub-factors.

Given the variability in students' learning environments and the diverse factors emphasized in each paper, the selection process focused on the most frequently cited factors for analysis. Subsequently, an examination of the actual learning experiences of students within the CAMT faculty，Chiang Mai University during the COVID-19 pandemic was carried out. Following a thorough evaluation of the real-world learning context, factors that did not align with the study sample were excluded. This process led to the derivation of a framework encompassing factors that impact students' learning effectiveness.

Step 2: Delphi method

The Delphi method is a systematic approach for collecting unbiased information, expert opinions, and insights. It involves multiple rounds of independent and subjective

judgments from a panel of experts who usually don't know each other. A facilitator oversees the process to ensure structured communication throughout.

In the initial round, experts are provided with a questionnaire or survey that includes open-ended questions related to the topic under investigation. The responses are subsequently collated and synthesized by the facilitator, who then distributes the consolidated feedback to the experts in the subsequent round. During this second round, experts are presented with the feedback and are asked to reassess their initial responses in light of the insights and opinions shared by their peers. This iterative process continues through multiple rounds until a consensus opinion is achieved.

After sorting and analyzing identified factors, a two-level framework was developed, encompassing Levels 1 and 2. Level 1 incorporated elements such as students, teachers, learning conditions, and interactions. Level 2 expanded on this with fourteen sub-factors, refining the framework further. Establishing a conclusive hierarchy of factors affecting online learning effectiveness involved the use of a straightforward Delphi method. This method engaged three experts from Chiang Mai University, chosen for their extensive experience in delivering online instruction during the COVID-19 pandemic, making them highly suitable participants for the survey.

1) Design the questionnaire

This study conducted a single round of opinion consultation with three experts from Chiang Mai University, employing a questionnaire format to investigate the significance of various factors in enhancing students' online learning effectiveness. Before implementing the Delphi method, factors not relevant to Chiang Mai University students, such as the role of teaching assistants, were excluded. Subsequently, a meticulously crafted questionnaire was prepared and disseminated to the three experts. The responses gathered were summarized and organized in each round. The refined materials were then sent back to the experts for additional analysis and evaluation. After this initial assessment, the outcomes came together. The importance of factors was categorized into five levels: strongly important (5), important (4), moderately important (3), not important (2), and strongly not important (1).

2) Analyze the result

Following the preparation of the questionnaire, it was dispatched to three experts through the online questionnaire website Golden Data. Upon receipt of the questionnaire results, the opinions of each expert were meticulously analyzed and organized. Subsequently, the importance of each factor was calculated by averaging the assessments of the three experts to determine the most appropriate importance level.

Step 3: AHP method

The Analytic Hierarchy Process (AHP) introduced by Saaty in 1971 is a widely recognized approach for addressing decision-making involving multiple criteria. AHP provides a systematic method for organizing intricate decision-making problems into a hierarchical structure. By using quantitative techniques, AHP assesses various alternatives to help decision-makers choose the most suitable solution. This method breaks down complex problems into layers of targets, criteria, and schemes. It calculates combined weights by evaluating the weights of indicators for decision elements in the upper layers. With these weights, the optimal online teaching platform can be determined from multiple options. AHP is known for its systematic, adaptable, and user-friendly nature, making it well-suited for managing large-scale and complex systems. It is particularly beneficial when dealing with expansive, intricately structured systems with diverse attributes and objectives. In such cases where numerous element indicators have primarily qualitative relationships, AHP proves highly effective for evaluation and decision-making.

The basic principle is to break down complex problems into a hierarchy with dominant relationships. Each level consists of interconnected and interdependent elements. The importance of each element in the hierarchy is measured using pairwise comparison methods, resulting in a final ranking of their relative significance.

36
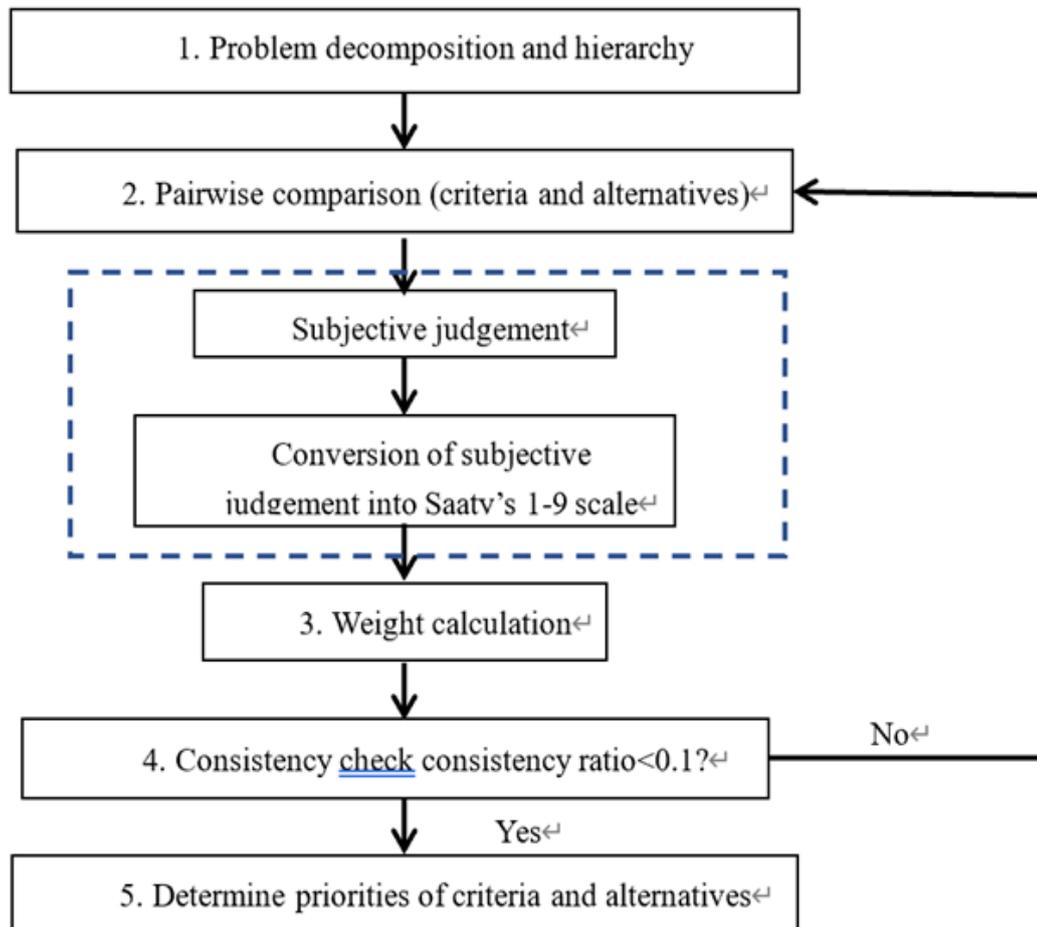
Figure 3. 4 The Process of AHP

Process of AHP

This study presents a four-step process for applying the Analytic Hierarchy Process (AHP) to enhance online learning effectiveness for students. Initially, the Delphi method results are used to create a hierarchical structural model. This involves identifying key factors influencing online learning effectiveness and their interrelationships, forming the basis for a multi-level structural model. In the second stage, a judgment matrix is developed. The third stage involves calculating the influence of element weights within each layer on the weights of upper-layer elements. The final stage includes a consistency test to ensure expert opinions are coherent and to identify any logical inconsistencies.

For this stage, the study chose two groups of research samples. The first group comprises education experts from Chiang Mai University, while the second group consists of lecturers from the Knowledge and Innovation (KIM) project at the CAMT

faculty, who have experience in online teaching during the COVID-19 epidemic. By comparing the evaluation results of experts and lecturers regarding factors affecting online learning effectiveness, the study aims to determine the impact proportion of these factors on students' online learning effectiveness.

This study employs SPSS PRO for conducting the AHP analysis. Unlike traditional client-based statistical software such as SPSS and SAS, SPSS PRO is a cutting-edge online data analysis platform. Utilizing fundamental capabilities such as data processing and analysis algorithms, SPSS PRO offers accessible web-based data analysis services for educators, students, market researchers, and scientific researchers. This versatile platform is widely used in scientific research, business analytics, data mining, and survey research. AHP provides two calculation methods, the sum-product method and the square root method, with SPSS PRO employing the square root method.

1) Building the Hierarchy Framework

Based on the dominance relationship, the evaluation index system is structured into three hierarchical layers, progressing from the uppermost to the lower levels:

(1) The highest level, also referred to as the goal level or target level, represents the objective or outcome that the system aims to attain, which is enhancing the effectiveness of online learning for students.

(2) Criterion Layer: This level encompasses the criteria and sub-criteria devised to achieve the objectives set at the target layer.

Based on the preceding analysis, we have developed a hierarchical structure for the research problem, as presented in Table. The primary objective is to assess the relative weights of the influencing factors (Level 1, denoted as A0). Beneath this overarching goal, the second level (B) encompasses the criteria that impact the effectiveness of students' online learning, including "students," "teachers," and "learning conditions." Numerous sub-criteria linked to each criterion at the second level are further associated with the third level (C).

Table 3. 3 Hierarchical Structure of Online Learning Effectiveness Evaluation

Level 1: Goal	Level 2: Criteria	Level 3: Sub-criteria
Online learning effectiveness (A0)	Students (B1)	Personal characteristics (C1)
		Learning ability (C2)
		Commitment to learning (C3)
	Teachers (B2)	Teaching ability (C1)
		Feedback and assessment to students(C2)
		Attitude（C3）
		Managing ability （C4）
	Learning conditions (B3)	Technology （C1）
		Learning environment （C2）
		Learning resource（C3）
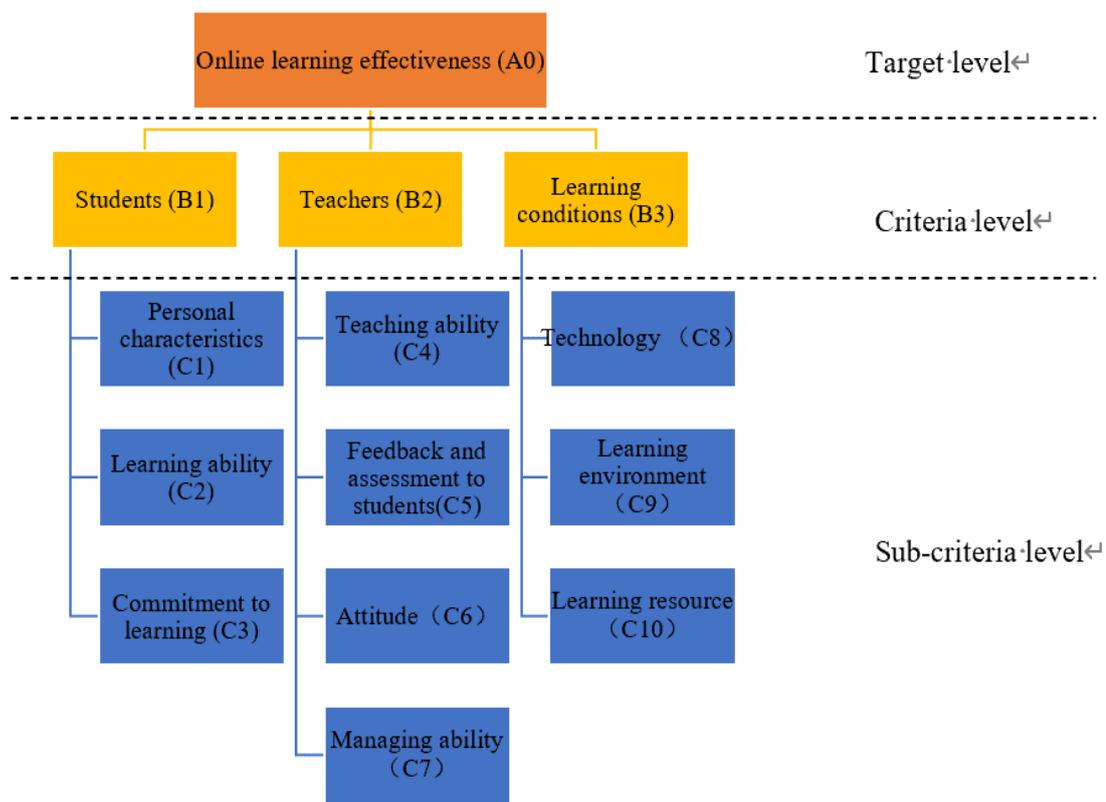
Figure 3. 5 Hierarchical Structure Diagram of Online Learning Effectiveness

2) Judgment Matrix

The relative significance of the indicators at the higher level is conveyed using a specific scale, which is represented in the format of a judgment matrix. The table below illustrates the integer and inverse scale between 1 and 9, initially introduced by Saaty when he developed the Analytic Hierarchy Process (AHP).

Table 3. 4 Definition of the Scale of Judgment Matrix

Scale	Definition
1	Two factors are compared if the two factors are of equal importance
3	Two factors are compared if one factor is slightly more important than another
5	Two factors are compared; if one factor is more obviously more important than another

Table 3. 4 Definition of the Scale of Judgment Matrix (Continued)

Scale	Definition
7	Two factors are compared if one factor is significantly more important than another
9	Two factors are compared; one factor is more important than another
2,4,6,8	The median of the above two adjacent judgments
reciprocal	The ratio of the importance of factor i to factor j is aij, then the importance of factor j to factor i is aji=1/aij

This step primarily involves comparing the elements within the same level and with those at the preceding level to construct a judgment matrix. It simply requires inputting all the outcomes of the teacher questionnaires into the SPSS PRO software. Upon processing and analyzing the questionnaire data, a series of judgment matrices can be established to determine the relative importance among criteria.

3) Weight Computation

1. Use the square root method to calculate the approximate value of the eigenvector of the judgment matrix.

2. Normalize the feature vector to get the weight vector W=(W1, W2, W3,…Wn)T

Utilizing SPSS PRO, it becomes convenient to obtain the eigenvectors and proportions for each factor. The significance of each factor in enhancing students' online learning effectiveness can be synthesized by analyzing the proportion results. Given that this study gathered input from three experts, the AHP methodology was applied with SPSS PRO to incorporate the judgment results provided by each expert. Ultimately, after deriving the importance assigned to each factor by the three experts, their averages are calculated. The resulting average proportions can effectively represent the ranking of factor importance at each hierarchical level.

$$W_i = \frac{(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}}{\sum_{i=1}^{n}(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}}, ij = 12kn$$

4) **Consistency Check**

The potential for subjectivity among experts can introduce variations in results, necessitating a consistency test. Specifically, the judgment matrix should exhibit a consistency ratio of less than 0.1 to affirm the validity of the assigned weights for the indicators. When the consistency ratio exceeds 0.1, adjustments to the judgment matrix are required to ensure a successful consistency test. The calculation formula for the consistency check is provided below. Additionally, the value of the random consistency index (RI) is a known constant, as illustrated in the following table. Ultimately, the consistency ratio can be determined using the following formula:

$$CR=CI/RI$$

The Consistency Index (CI) can be calculated as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Table 3. 5 Random Consistency Index

Order	1	2	3	4	5	6	7	8	9	10	11	12	13
RI	0	0	0.52	0.89	1.12	1.36	1.41	1.46	1.49	1.52	1.52	1.54	1.56

The consistency ratio, denoted as CR, is computed as CR = CI/RI. Generally, a CR value of 0.1 or lower is deemed acceptable, signifying an informed judgment that can be attributed to the expertise of the analyst.

The SPSS PRO software was used to input assessments from three experts and four lecturers into a matrix. This not only helped determine the proportion of each factor but also facilitated the computation of the consistency ratio. When the random consistency ratio (CR) is below 0.1, it indicates that the derived hierarchical ranking weights are

accurate and reasonable. If the consistency test doesn't meet this criterion, it's essential to reevaluate the judgment matrix.

Furthermore, it is essential not only to calculate the consistency ratio for each expert concerning each factor, but also to derive the final average consistency ratio. Ultimately, a comparison was made between the perspectives of the expert group and the lecturer group, allowing for the determination of the proportion of factors influencing the effectiveness of online learning.

3.3.3 Knowledge Storage

This step delineates the process of utilizing the knowledge management tool CommonKADS to acquire guidance with the objective of improving the effectiveness of online learning for students.

CommonKADS

CommonKADS (Common Knowledge Acquisition and Development System) is a knowledge engineering methodology and suite of tools that was developed during the 1980s and 1990s by an international consortium of researchers. The principal aim of CommonKADS is to provide a structured and systematic approach for the development of knowledge-based systems. The CommonKADS methodology comprises four fundamental models: the task model, the knowledge model, the communication model, and the organization model. These models offer a structured framework for capturing and representing the knowledge and expertise required to address specific problems and for the seamless integration of this knowledge into a functional system.

This study specifically focuses on conducting interviews with education experts to construct a knowledge model with the aim of improving the effectiveness of students' online learning, following the approach outlined by Schreiber et al. (2000). The primary objective of this research is to utilize CommonKADS to create a guide that enhances the efficiency of online learning for students.

Build the knowledge model.

The knowledge model serves as a valuable tool for elucidating the structure of information-processing tasks that are rich in knowledge content, as expounded by Schreiber et al. (2000). This model plays a pivotal role within a knowledge-based system, facilitating reasoning and decision-making within a specific domain. It comprises three distinct categories, each of which encapsulates a related set of knowledge structures.

The initial category, task, serves to delineate the objectives of the application and elucidate how these objectives can be achieved through a decomposition into subtasks and inferences. This category also encompasses a portrayal of the dynamic behavior of tasks and their internal control mechanisms. The primary aim of this research is to produce a practical guide aimed at assisting students in enhancing their online learning experience. Therefore, task knowledge plays a crucial role in acquiring the necessary guidance for this endeavor.

The second category is inference knowledge, which outlines the fundamental steps of inference that the system should undertake using the domain knowledge. Inference knowledge involves the analysis and reasoning based on task knowledge, serving as a means to achieve the desired goal. Therefore, prior to establishing inference knowledge, it is essential to review and consolidate the findings of previous research, including the identification and analysis of influencing factors. Subsequently, the task knowledge can be further subdivided into more specific inference knowledge.

The third and last category is domain knowledge, which encompasses the domain-specific information and knowledge types relevant to the application. Task knowledge pays more attention to the reasons and the relationship between domains.

This study will employ the Knowledge Capture Meeting interview method to construct a knowledge model. A Knowledge Capture Meeting is a guided session designed to capture the knowledge and expertise possessed by a group of subject matter experts (SMEs) within a specific domain or area of expertise. The primary objective of a Knowledge Capture Meeting is to gather, document, and structure tacit knowledge and

44

best practices that are frequently held by individuals, rather than being explicitly documented.

The following figure gives a brief overview of the three knowledge categories and some sample knowledge elements in each category.
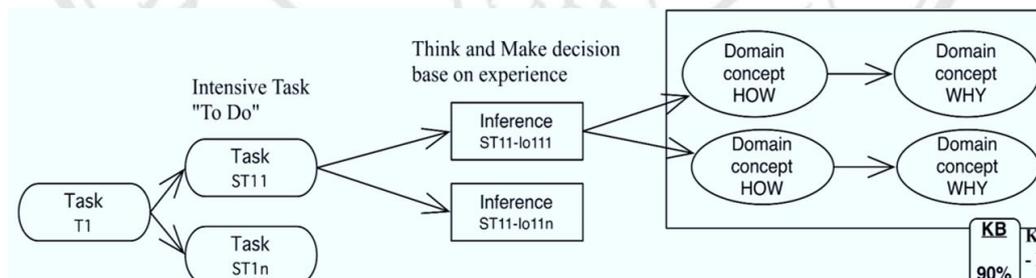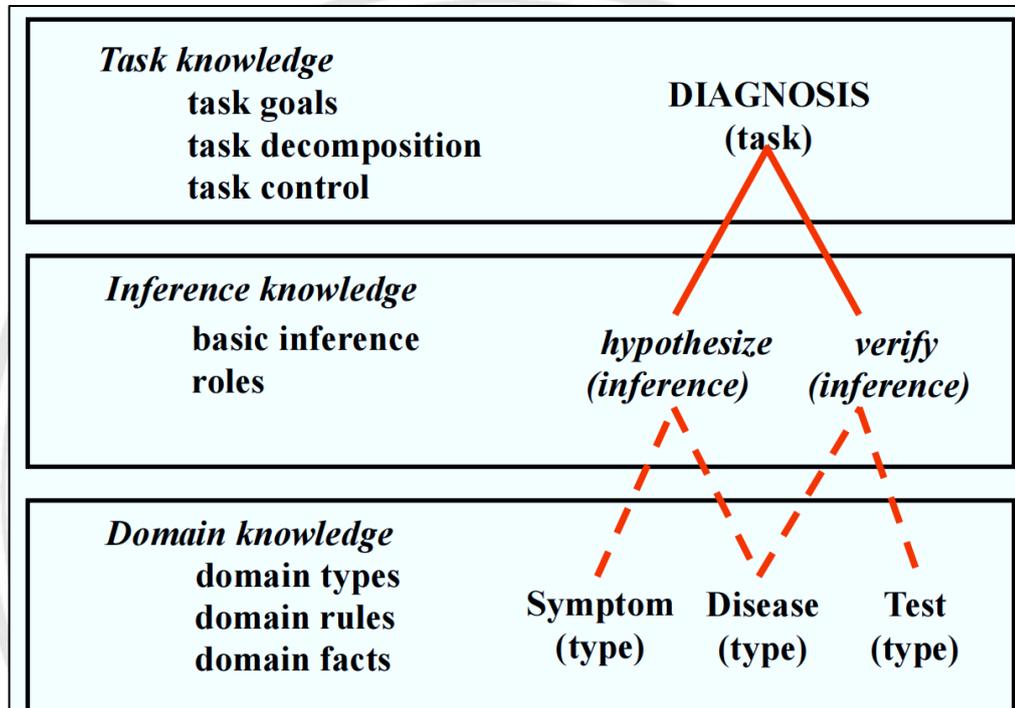

Figure 3. 6 The structure of CommonKADS

Make a guideline for improving students' online learning effectiveness

After constructing the knowledge model based on expert insights, a comprehensive analysis of the task, inference, and domain is undertaken. This analysis subsequently provides the guidance required to enhance the effectiveness of online learning for students.

CHAPTER 4

Analysis, Discussion, and Results

This chapter is dedicated to addressing the thesis objectives and presenting the analysis, discussion, and results. It will elucidate the learning situation of students during the COVID-19 pandemic, examine the influencing factors on the effectiveness of online learning, and assess the significance of each of these factors.

4.1 The Result of the Real Situation of Students' Online Learning

This section focuses on the initial objective, which is to understand students' online learning experiences during the COVID-19 pandemic. This is accomplished through two research methods: a thorough literature review and a structured questionnaire survey. The aim is to identify the challenges and issues that students encounter in online learning. Two different tools have been used to assess the status of students' learning experiences.

4.1.1 The Result from the Literature Review

The literature review served as the principal source of data collection, enabling the exploration of research problems by extracting vital and informative insights from various articles.

The current state of online learning for college students during the COVID-19 pandemic can exhibit significant variations based on factors such as the institution, specific course, and individual student. Nonetheless, certain overarching trends and issues can be identified:

Learning platforms and devices: Learning platforms and devices play a crucial role in today's higher education landscape. Many colleges and universities use online learning platforms like Blackboard, Canvas, or Zoom for virtual classrooms, discussions, and assignments. An Indonesian study specifically explored how different devices impact students' learning experiences. The findings showed that using the website on desktops resulted in higher learnability scores compared to the mobile app version. Conversely, the mobile app was found to be more appealing than the website version (Nurhudatiana et al., 2018).

Learning time: Learning time in online education allows students the flexibility to complete coursework at their own pace, which can be beneficial for some but challenging for others. Effective time management and avoiding procrastination may be a struggle for some students, while others might feel overwhelmed without a structured schedule. Research findings suggest that students who reported higher levels of happiness tended to spend more time studying at home, but this increased study time was also associated with higher stress levels. On the other hand, students with lower happiness levels and higher stress tended to spend more time on phone conversations and exercising at home, which, in turn, was linked to a higher likelihood of experiencing happiness (Monorom & Piantanakulchai, 2020).

Learning style: Online learning can accommodate different learning styles, but it may have limitations for hands-on or experiential learning. People who thrive in independent or self-directed learning environments are more likely to find online learning suitable.

Learning satisfaction: Student satisfaction with online learning can fluctuate based on individual preferences and experiences. While some students may value the flexibility and convenience of online learning, others may yearn for the social interactions and hands-on learning opportunities traditionally associated with physical classrooms.

Learning effect: The effectiveness of online learning, concerning student outcomes and learning gains, remains a topic of ongoing research and debate. Certain studies suggest that online learning could be just as good as traditional classroom learning, but others suggest it might not be as effective for some students.

Challenges and problems faced: Online learning during the pandemic has brought about various challenges for college students, including issues with technology access, limited campus resources, mental health concerns, and problems related to academic integrity. Students who don't have reliable internet or suitable devices may need help to fully participate in virtual classes and complete their coursework. The isolation from online learning can make students feel lonely and disconnected, and there are significant issues with academic integrity, like cheating and plagiarism. Research shows that students often become less engaged with online learning after the first two weeks. Additionally, students from low-income backgrounds may feel anxious about the cost of buying internet data. Too many assignments can also negatively affect students' well-being and are seen as ineffective (Irawan et al., 2020).

Students encountered many of challenges or problems during online courses under the COVID-19 pandemic, with several common issues documented in the academic literature.

(1) Technology and Internet Accessibility: Students who don't have the necessary devices and reliable internet often struggle with joining online classes and finishing assignments. For example, a study in India found that 42% of students had trouble attending online classes because they didn't have good enough internet.

(2) Academic Integrity Concerns: The shift to online learning brought new challenges in maintaining academic honesty. In a study in Saudi Arabia, 62% of students said they cheated during online exams.

(3) Mental Health Issues: Online learning has been influenced on the loneliness feeling to students, disconnected, and leading to increase anxiety. In a study in China, 21.3% of college students reported feeling moderately to severely anxious during the pandemic.

(4) Workload and Time Management: Some students expressed feeling overwhelmed by the increased workload and the absence of structured schedules in online courses. For example, a study in Turkey found that 52.3% of students reported experiencing stress due to the elevated workload during the pandemic.

(5) Limited Access to Campus Resources and Support: Students who depended on campus resources such as libraries, labs, or counseling services needed help when classes moved online. In Australia, a study showed that 20% of students had trouble getting access to academic support services during the pandemic.

Different countries have unique education systems, leading to varied learning situations for students during the COVID-19 pandemic. When studying the challenges students faced in online classes, it became clear that these problems differed from one country and institution to another. However, all the research emphasizes the need for significant improvements in online teaching compared to traditional methods.

4.1.2 The Result of an Online Questionnaire

To examine the experience of students attending online classes at CAMT College, Chiang Mai University, during the COVID-19 pandemic, a total of 83 online questionnaires were distributed. These questionnaires aimed to collect information pertaining to students' online learning preferences, duration of study, utilized learning platforms, overall satisfaction levels, and the encountered challenges. The following section provides a comprehensive breakdown of the students' online learning experiences.

1) Result of Basic Information of Students

Based on the findings of the survey, a total of 83 individuals comprised the sample population. Among the participants, 71.08% were female students, while male students constituted 28.92% of the sample. The largest proportion of students belonged to the second year of study, accounting for 32.53%, followed by senior students, representing 16.87% of the sample.

Amount of male and female
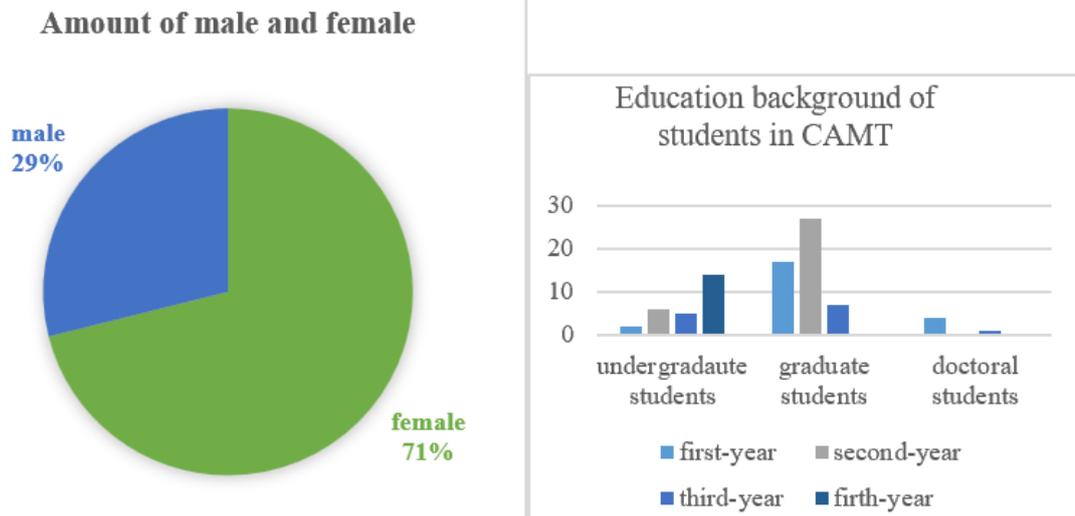

Education background of students in CAMT

Figure 4. 1 Result of Basic Information of Students

2)   The Result of Online Learning Conditions

In this study, around 62% of the participants said they took online classes for more than six months. Out of all the students, 35% mentioned they had been doing online learning for over a year. Regarding the time spent on online classes each day, the majority (40.96%) reported spending 3 to 5 hours. When it comes to devices used, over 80% preferred computers, showing they are the top choice for online learning. Tablets were the second most popular at 14.46%, while only 3.61% used cell phones for online classes.

In the survey pertaining to online learning platforms, Zoom emerged as the overwhelmingly preferred choice, with 96.39% of respondents indicating its use for online classes. Tencent Meeting was the second most popular platform, utilized by 39.76% of the participants, while Nail and StudyTalk were chosen by 18.07% and 9.64% of the respondents, respectively. Tencent Classroom and Rain Classroom registered comparatively lower usage rates at 8.43% and 6.02%, respectively. Several platforms, such as QQ Live, Fishu, CCTalk, Welink, and UMU, recorded usage rates below 3%. Furthermore, 15.66% of respondents selected the "Other" option, as they employed alternative online classroom platforms like Microsoft Teams.
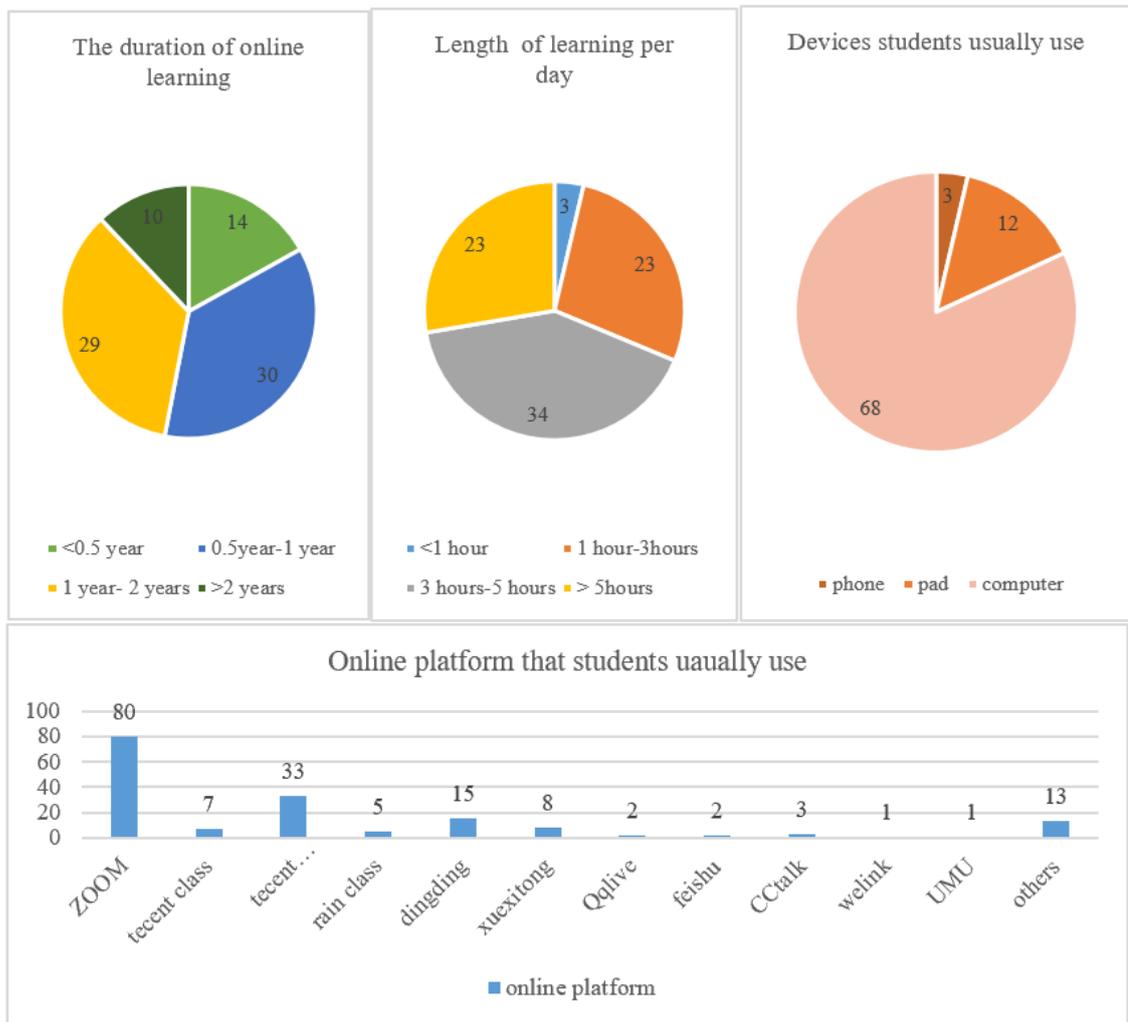
Figure 4. 2 The Result of Online Learning Conditions

3)   The result of the online learning experience

This section presents the results of the survey on the online learning experience. Regarding proficiency in operating the online class platform, more than 50% of respondents reported being highly skilled, 45.78% considered themselves moderately skilled, and only 3.61% indicated that they were not very skilled.

In terms of concentration during online classes, over 90% of respondents claimed they could maintain good focus, with more than 50% expressing the ability to concentrate even more, while 38.55% admitted to occasional lapses in concentration.

51

Concerning learning motivation, over half of the respondents believed that the motivation for online classes was on par with that of traditional teaching, with less than 5% perceiving online classes as more motivating.

Concerning communication with teachers, over 50% of those surveyed believed that the interaction met their learning needs. Additionally, more than 20% felt the interaction was even better than traditional teaching. However, over 20% thought there was room to improve teacher-student interaction, expressing a desire for more communication and engagement.

Approximately 80% of the respondents believed that online class learning was less effective than traditional teaching. When evaluating satisfaction with online class learning, the majority expressed general satisfaction with their online learning experiences, accounting for 72.29%. A relatively small proportion of respondents reported being highly satisfied, making up only 14.46%, while the number of dissatisfied individuals was also relatively low, at 13.25%.
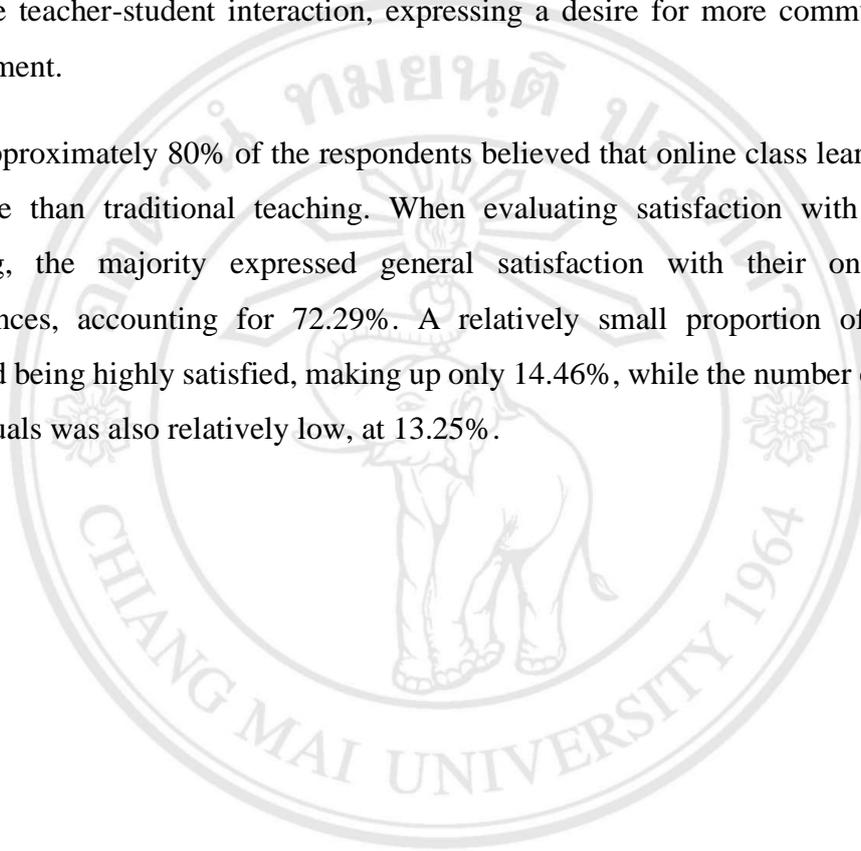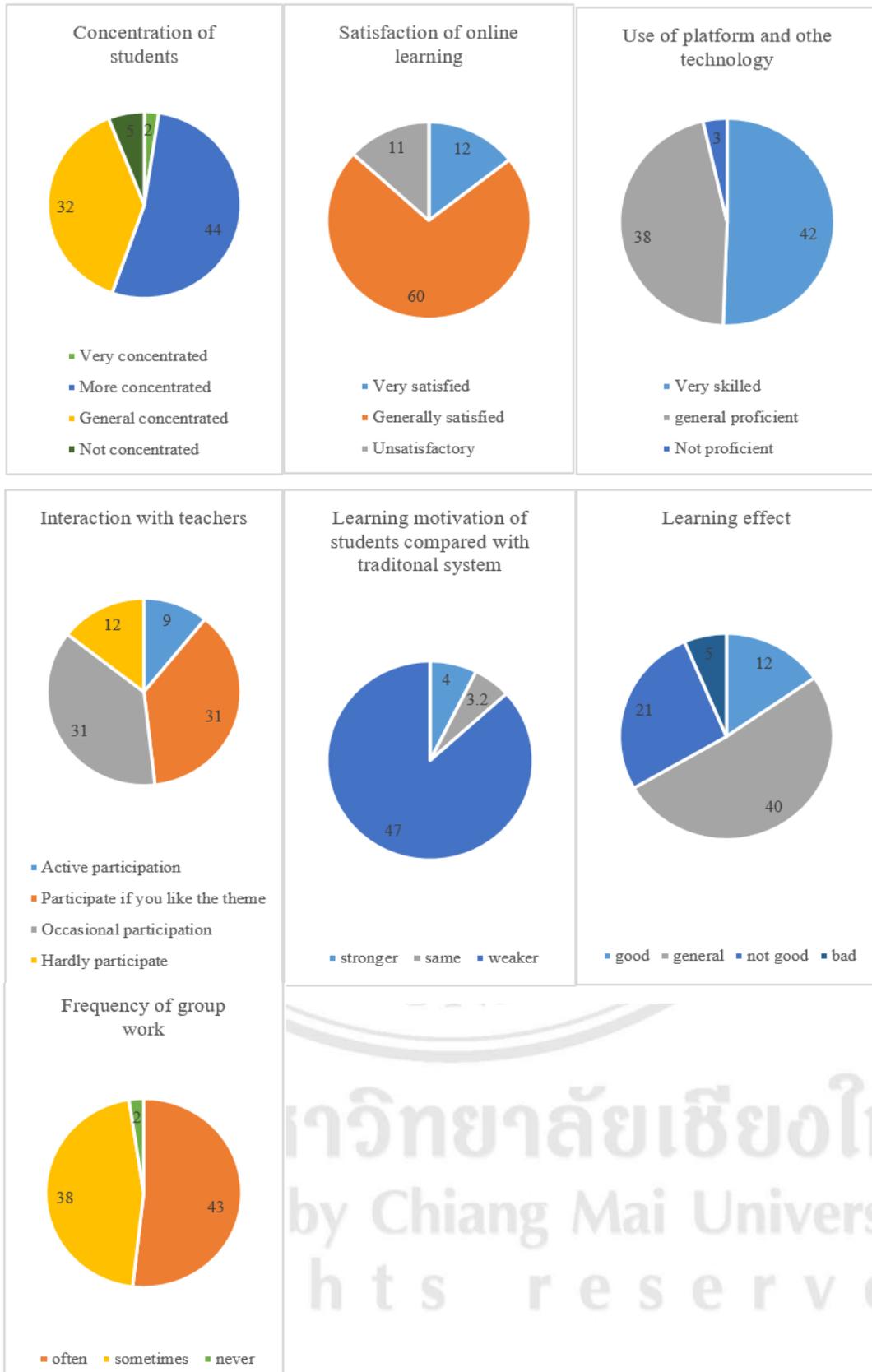
Figure 4. 3 The Result of the Online Learning Experience

4) The Result of the Problems

Students require assistance in accessing online classes, as indicated by the data. The most prevalent challenges identified include the inadequate stability of the online teaching platform (63.86%) and slow internet speed (56.63%), both of which can substantially impede students' learning effectiveness. Additionally, 52.65% of students reported struggling with poor self-control, 49.4% with low engagement, and 46.99% with insufficient communication with classmates and teachers. These factors may contribute to a lack of motivation among students and hinder their comprehensive understanding of course content. Furthermore, 32% of students found experiments challenging to conduct, significantly impacting learning in certain subjects. Finally, while only 14% of students indicated a need for improved teaching resources, addressing this concern remains essential.

According to the results of data analysis, 65.06% of students believe they need to enhance their learning attitude, attention, and methods in online classes. This necessity may stem from the absence of face-to-face communication, requiring students to develop better self-regulation and management skills. Concurrently, 54.22% of students express the need to improve the overall atmosphere of online classes, suggesting a desire for increased engagement and interaction among students to enhance the enjoyment and interactivity of the class. Moreover, 39.76% of students feel the need for improvements in the learning format of online classes, indicating a desire for more innovation and practical applications to enhance their understanding and mastery of the material. Additionally, 31.33% of students believe that the learning conditions for online classes should be enhanced, encompassing the provision of a better network environment and improved equipment conditions. Interestingly, only 15.66% of students feel that the teaching attitude of teachers requires improvement, suggesting overall satisfaction, suggesting overall satisfaction with the teachers' approach and style.

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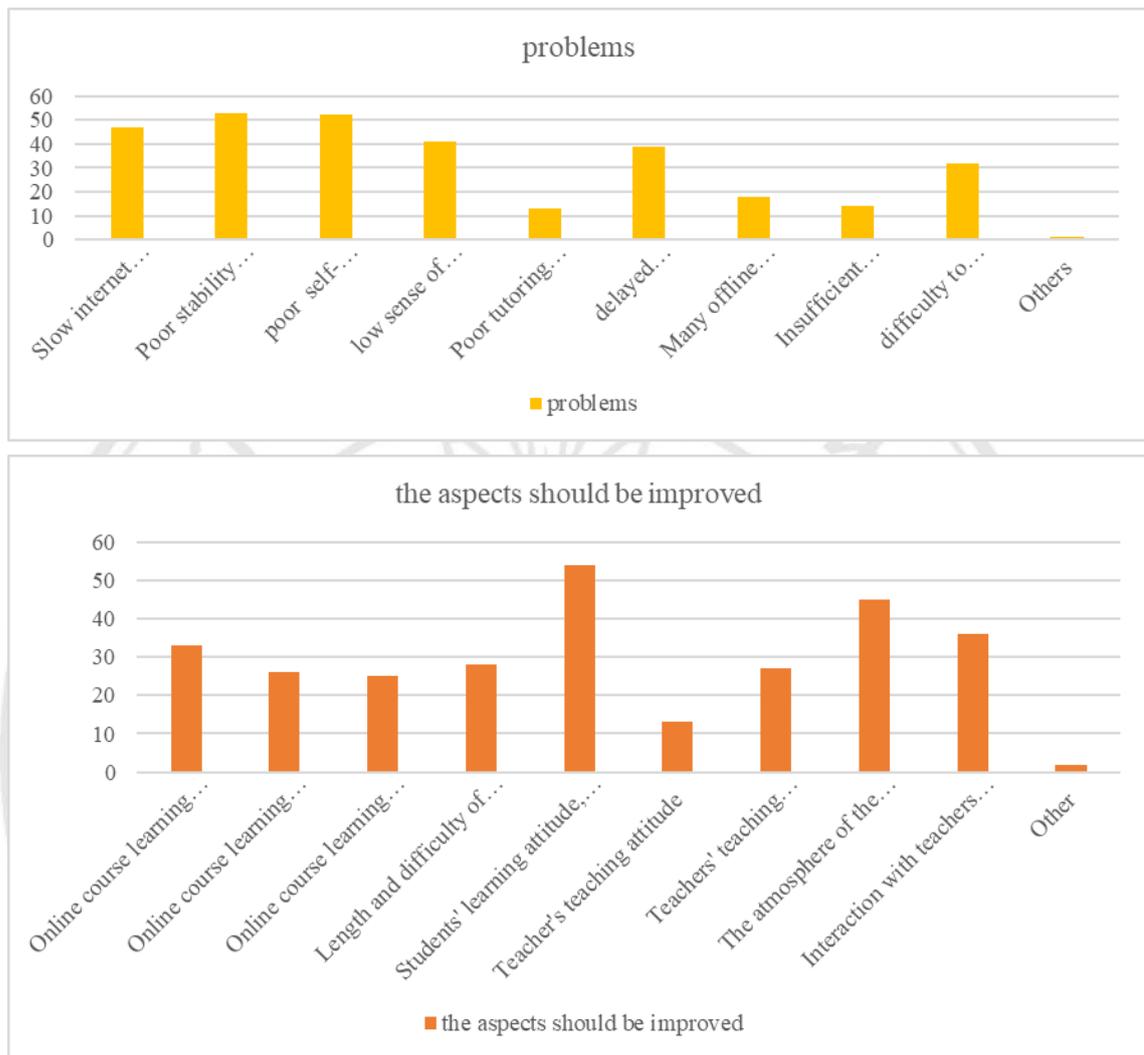
Figure 4. 4 The Result of the Problems

In conclusion, an online questionnaire was employed to gain insights into the current state of online learning and the challenges faced by students during the COVID-19 pandemic and related circumstances.

4.2 The Result of Identifying the Influencing Factors

This section reveals the outcomes obtained from the establishment of a hierarchy of factors impacting students' online learning effectiveness through a combination of the literature review and the Delphi method. These results serve as the foundation for the subsequent phases of the research process.

4.2.1 The Result of Literature Review

Utilizing Google Scholar and CNKI, 27 relevant articles were carefully chosen for analysis by searching keywords related to factors affecting online learning. Given the specific focus of this study on students' learning experiences during the COVID-19 pandemic, the selection of literature also incorporated the contextual backdrop of the COVID-19 pandemic. The publication date of these selected articles ranged from the end of 2019 to the present. These articles collectively encompass a comprehensive overview of the factors influencing the effectiveness of students' online learning. Subsequently, I organized and categorized these factors based on the divisions made by other scholars, eventually arriving at a two-dimensional factor classification.
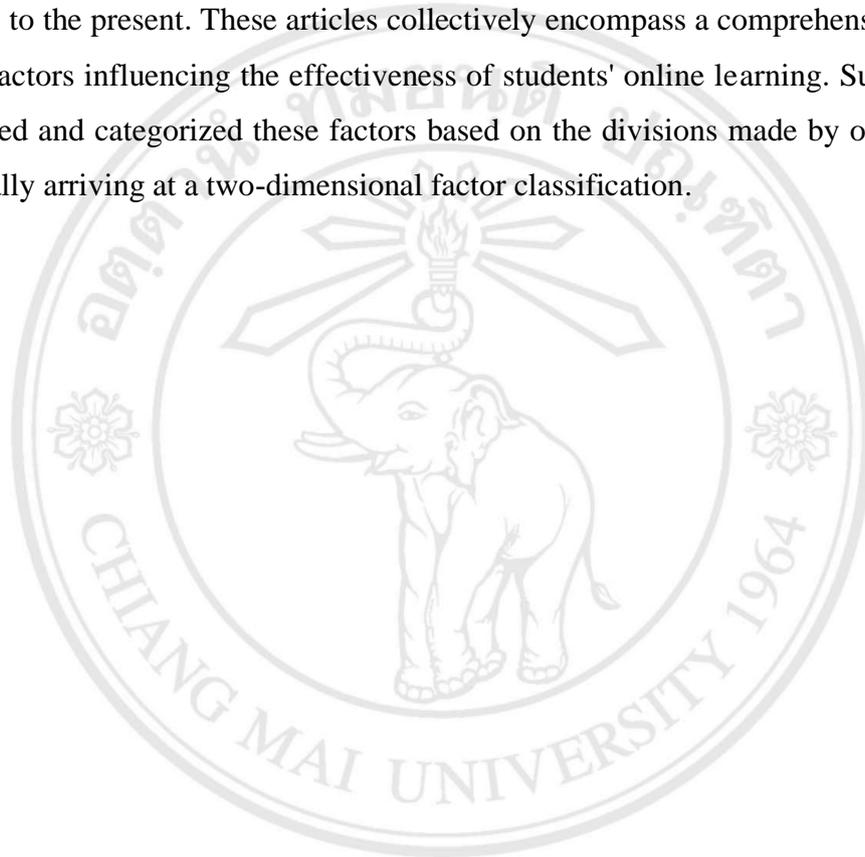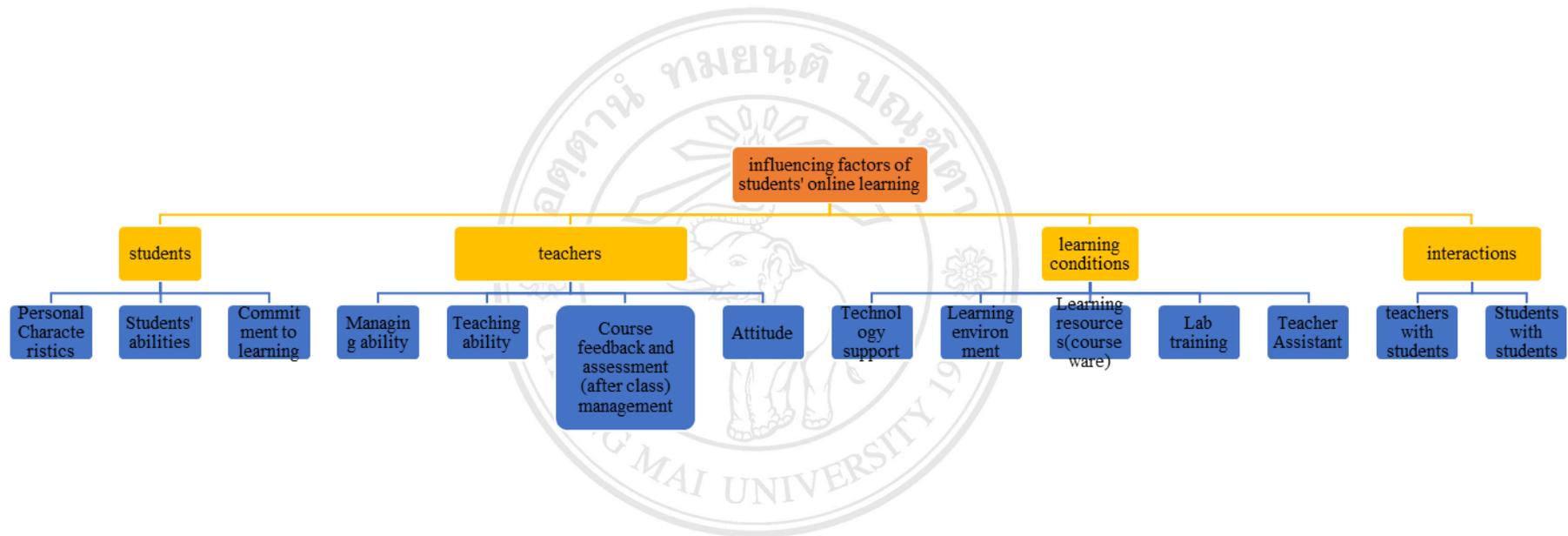
Figure 4. 5 Influencing Factors of Students' Online Learning 1

A total of four primary factors and 14 secondary factors were distilled from the 27 articles. Subsequently, a process of contextual refinement was conducted to eliminate factors not applicable to the specific situation of CAMT faculty students. Within the primary factor 'students,' three secondary factors were identified: personal characteristics, students' learning abilities, and motivation. Similarly, the primary factor 'teacher' encompassed four secondary factors: management skills, feedback and course assessment, teaching attitude, and teaching ability. The third-level factor, 'learning conditions,' included five factors: technical support, learning environment, learning resources, laboratory training, and teaching assistant support. However, an analysis revealed that during the COVID-19 period, students at CAMT faculty of Chiang Mai University did not have access to teaching assistants or laboratory trials, leading to the removal of these two second-level factors. The final first-level element was 'interaction,' focusing primarily on teacher-student and student-student interactions. Here, we present the newly established tiers of factors tailored to the specific needs of CMU CAMT faculty students.
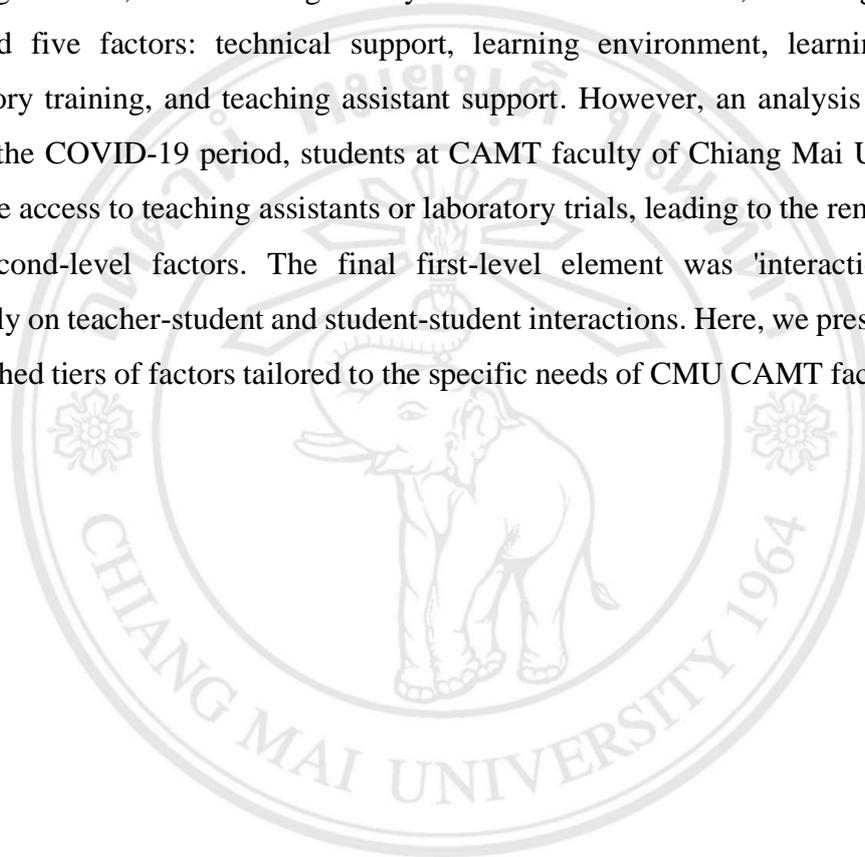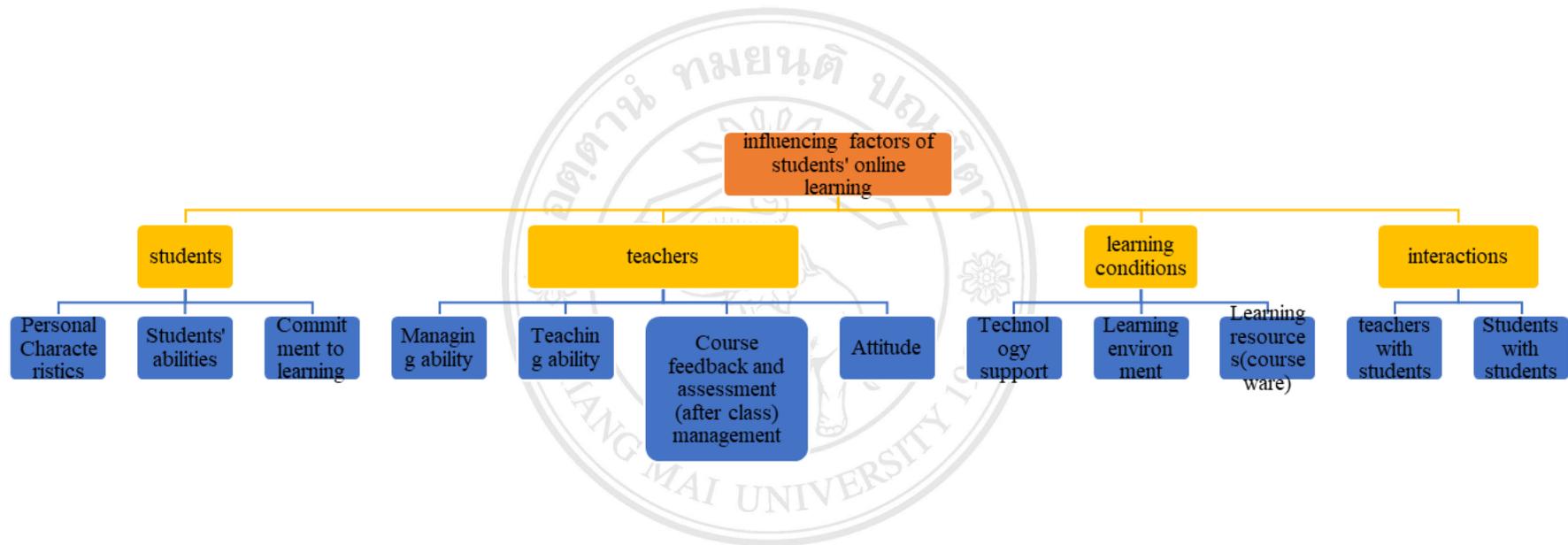
Figure 4. 6 Influencing Factors of Students' Online Learning 2

4.2.2 The Result of Delphi Method

An analysis of the input from three experts at Chiang Mai University suggests that a majority of the factors influencing students' online learning effectiveness hold substantial significance for graduate students studying at Chiang Mai University. This is particularly evident in the case of the teacher-related factors. Notably, teachers' management and instructional competencies, along with the availability of learning resources, emerge as pivotal determinants of students' online learning effectiveness. The following figure provides a comprehensive summary of all these factors:

students	teachers	learning conditions	interaction
• personal characteristics • learning ability • commitment to study	• teaching ability • feedback and assessment to students • attitude • managing ability	• technology • learning enviroment • learning resource	• teacher-student • student-student

Figure 4. 7 Summary of All Factors

Upon scrutinizing the outcomes derived from the inputs of the three experts, drawing from their extensive teaching experience, it becomes evident that factors related to students, teachers, learning conditions, and interactions all assume critical significance. The subsequent section presents the specific findings:
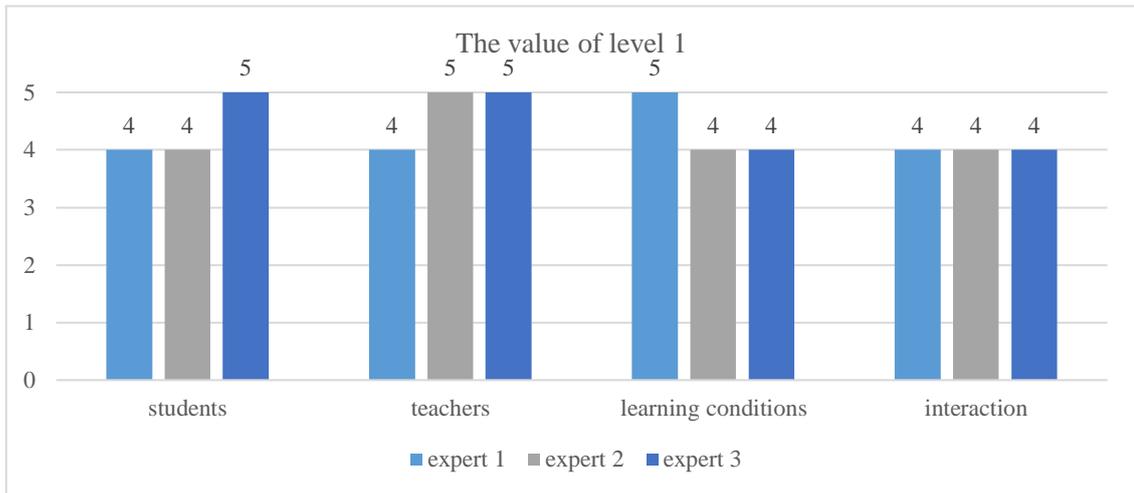
Figure 4. 8 The Value of Level 1

The initial step involved the utilization of the Delphi method to assess the first-level factors. The three experts consistently provided high evaluations for all four first-level factors. By calculating the average importance values, the following results were obtained: students 4.3, Teacher 4.7, Learning Condition 4.3, Interaction 4.
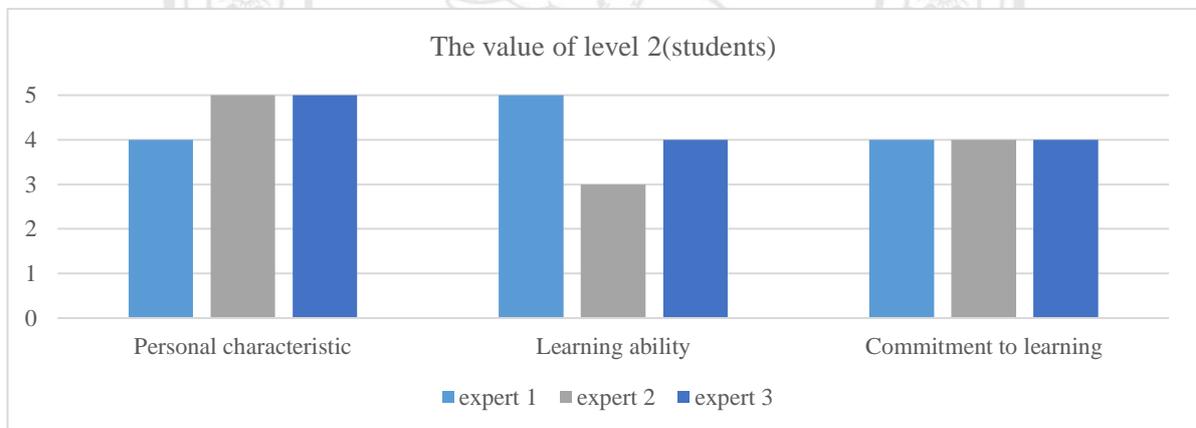
Figure 4. 9 The Value of Level 2 (students)

Within the student factor, three secondary factors were identified, namely personal characteristics, learning ability, and learning commitment. The Delphi method was employed to gauge the importance of these factors, resulting in the following significance levels: personal characteristics scored 4.3, learning ability received a rating of 4, and the level of commitment to learning also attained a significance rating of 4.
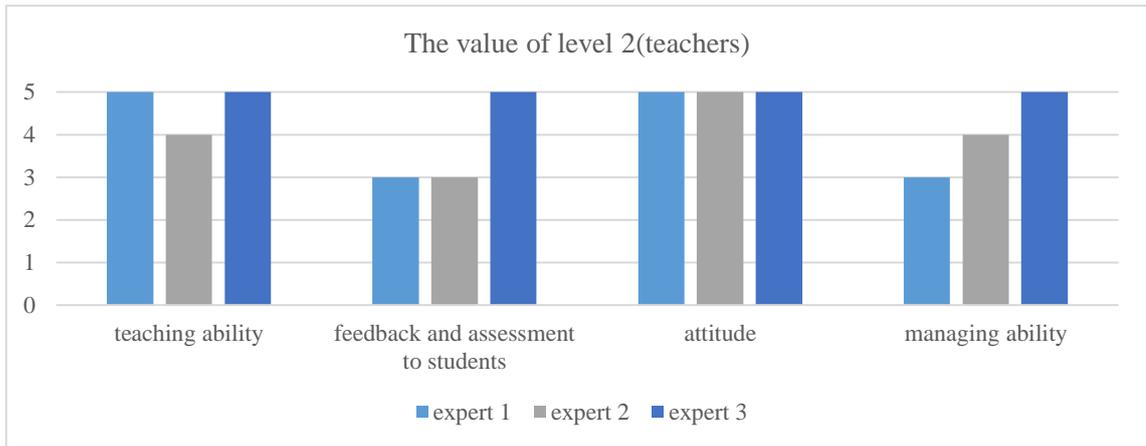
Figure 4. 10 The Value of Level 2 (teachers)

Under the category of teacher factors, four secondary factors were identified: teaching ability, teaching attitude, management ability, and feedback and evaluation of students. The average importance ratings assigned by the three experts for these factors were as follows: teaching ability received a rating of 4.7, teaching attitude was rated at 5, management ability scored 4, and feedback and evaluation of students garnered a rating of 3.7, indicating a level of importance between 'moderate' and 'important'.
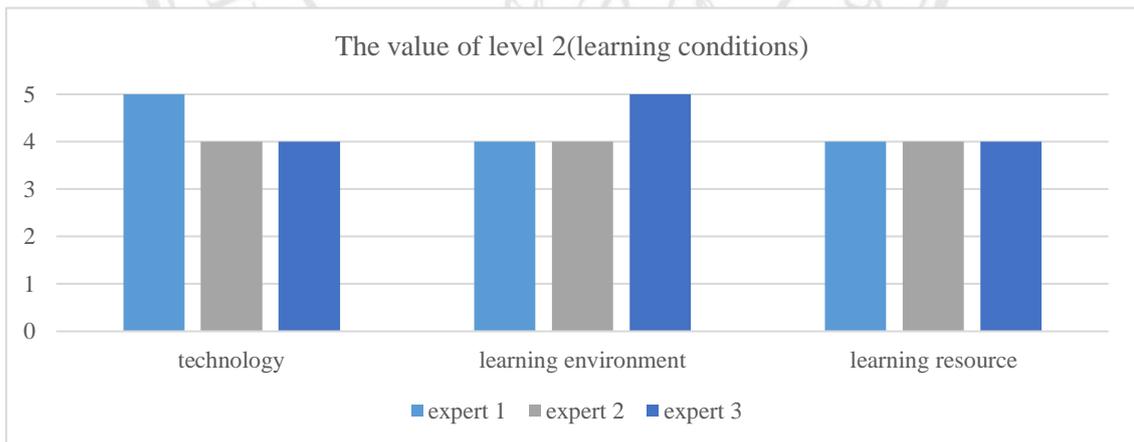
Figure 4. 11 The Value of Level 2 (learning conditions)

Within the domain of learning conditions, there exist three secondary factors: technology, learning environment, and learning resources. Upon analysis, it is noteworthy that both technology and the learning environment were accorded an importance rating of 4.3, while all three experts unanimously assigned a rating of 4 for the significance of learning resources.
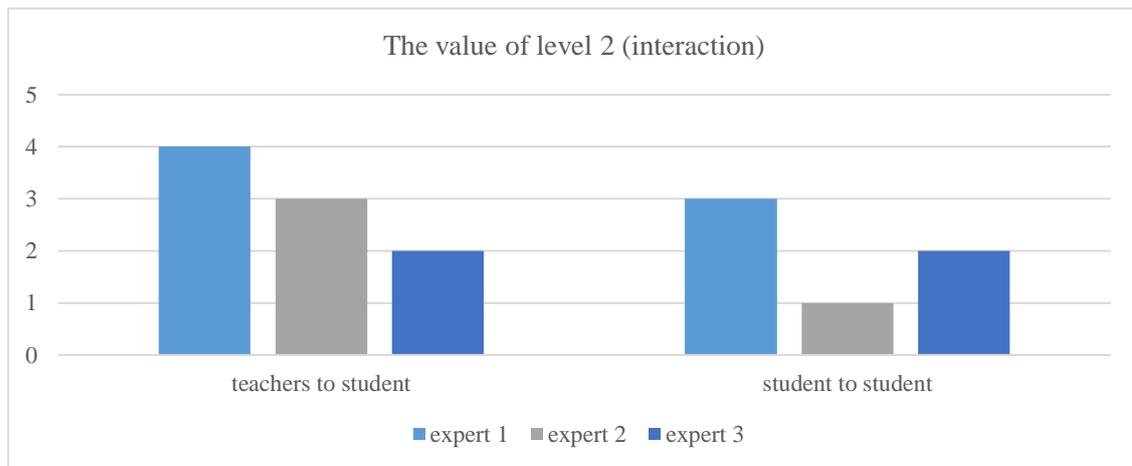
Figure 4. 12 The Value of Level 2 (interaction)

Regarding the concept of interaction, it encompasses two secondary factors: teacher-student and student-student interaction. However, in the Delphi method, all three experts assigned relatively lower evaluations in comparison to other factors. Specifically, the results indicate that the importance of teacher-student interaction was rated at 3, signifying a moderately important factor, while student-student interaction received a rating of 2, suggesting its relatively lower significance.

It is worth noting that interactive factors encompass a rich and intricate web of content and complex relationships, involving not only students but also teachers. As a result, a comprehensive evaluation leads to the decision to exclude the interactive factors from the primary level factors. Nevertheless, it is essential to acknowledge that when introducing the student and teacher factors, some aspects of the interaction factor will naturally come into play, influencing the content and dynamics of the overall educational environment.

To summarize, a hierarchical structure that influences the effectiveness of students' online learning has been constructed through a round of the Delphi method. Below is the finalized structure of the factors of influence:
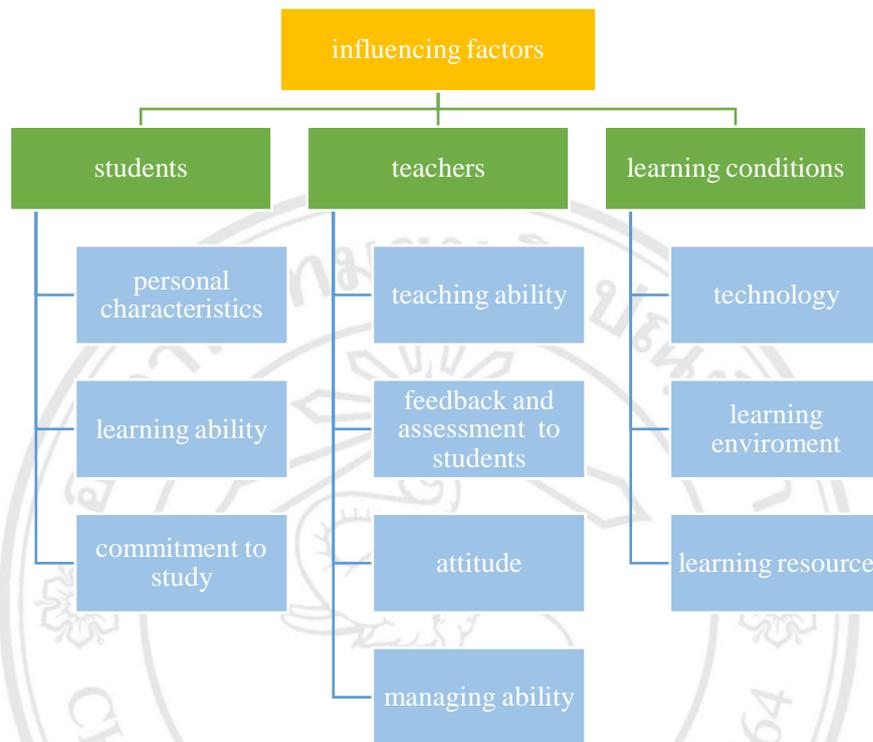
Figure 4. 13 Final Structure of Influencing Factors

There are three main factors in level 1: students, teachers, and learning conditions factor.

Students: Student factors pertain to the individual characteristics, abilities, and the level of commitment that have the potential to impact a student's academic performance and overall success.

Teachers: Teacher factors encompass the influence exerted by the teacher on students' learning effectiveness. This incorporates the teacher's teaching ability, skill in managing attitudes, and other related aspects.

Learning conditions: Learning conditions encompass the educational environment provided by society, schools, and families for students during online classes. This encompasses learning materials and other resources supplied by educational institutions, as well as the learning environment facilitated by families and the broader societal context.

Notably, technology, such as a robust online class platform and high-speed internet connectivity, emerges as a crucial component of these conditions.

There are ten factors in level 2. Student factors can be categorized into three main areas: personal characteristics, learning ability, and Commitment to learning.

Personal characteristics: Personal characteristics encompass the traits and circumstances of students, including their academic background, interests, and other individual qualities that may influence their performance.

Learning ability: Students' learning ability encompasses a spectrum of cognitive, psychological, and emotional factors that shape their aptitude to acquire and retain information, along with their capacity for critical thinking and sustained attention.

Commitment to learning: Commitment to learning pertains to the degree of dedication and effort students invest in their academic pursuits, encompassing their motivation, attitude, and work ethic. These factors can profoundly impact a student's academic achievements.

There are four sub-factors under the teachers' factor: teaching ability, Feedback and assessment to students, attitude, and managing ability.

Teaching ability: The teaching ability of an educator encompasses a wide array of factors, including course design, lecture delivery, feedback mechanisms, and summarization techniques. Moreover, the instructor's proficiency in delivering effective online instruction is integral to their teaching ability.

Feedback and assessment to students: The sub-factor of "Feedback and assessment" concerning students refers to the teacher's proficiency in assessing students' learning progress and offering constructive feedback. A competent teacher should employ fair and appropriate evaluation methods, ensuring timely and accurate feedback for students.

Attitude: The sub-factor of attitude pertains to the teacher's level of dedication and commitment to their teaching responsibilities. A proficient teacher should exhibit diligence and invest substantial effort and time in course preparation and instructional delivery.

65

Managing ability: A teacher's management ability entails the organization and supervision of various learning activities designed to facilitate students' acquisition and mastery of course material. These activities may encompass presentations, group projects, and other collaborative learning opportunities.

There are three sub-factors under the learning conditions factor: technology, learning environment, and learning resources.

Technology: Students have access to a robust learning platform that caters to the class's requirements, and the student network features high-speed connectivity.

Learning environment: The learning environment plays a pivotal role in a student's academic success, and an optimal setting for online courses should be characterized by minimal disruptions, offering a comfortable and quiet ambiance conducive to effective learning.

Learning resource: The availability of sufficient learning resources is crucial to address the diverse learning requirements of students, encompassing a variety of materials, including those found in the school's library, courseware provided by teachers, and other educational materials.

4.3 The Result of the Weight of Factors through AHP

This research involved two groups of teachers as participants. The first group included education experts from Chiang Mai University, while the second group consisted of KIM lecturers experienced in online teaching during the epidemic. Using the Analytic Hierarchy Process (AHP) method, the study aimed to capture the different perspectives of each teacher group regarding the impact on learning effectiveness. By comparing the differences in these two sets of data, the study sought to determine the relative importance of factors influencing the effectiveness of online learning.

4.3.1 The Results from Experts

The hierarchy of factors that influence students' online learning effectiveness, as constructed in this study, is presented in the table below. It comprises three primary factors and ten secondary sub-factors.

According to the table below, students (B1), teachers (B2), and learning conditions (B3) are the three most significant influencing factors in students' online learning effectiveness. Among these, the teacher factor (B2) holds the highest weight at 45%, indicating that teachers play a pivotal role in determining the effectiveness of students' learning and ensuring overall learning quality. Following closely is the learning conditions factor (B3) with a weight of 32%, underscoring the critical role of conducive learning conditions in supporting students' learning effectiveness. The student factor (B1) weighs 23%, signifying its importance, albeit slightly lower than the other two factors.

Within these primary factors, there are ten secondary factors. Under the student factor, there are personal characteristics (C1), learning ability (C2), and commitment to learning (C3). Among these, Commitment to Learning (C3) holds the highest weight at 35%, indicating its dominant influence on students' learning. Learning ability (C2) and personal characteristics (C1) follow closely, with weights of 33% and 32%, respectively, underscoring their significant impact on students' learning effectiveness.

In addition to the student factor, the teacher factor also encompasses four secondary factors: Teaching ability (C4), Feedback and assessment of students (C5), Attitude (C6), and Managing ability (C7). Teaching ability (C4) emerges as the most crucial factor, substantially improving students' learning efficiency, with a weight of 43%. Managing ability (C7) follows with 24%, highlighting the influence of teachers' organizational skills on students' learning effectiveness. Feedback and assessment of students (C5) and Attitude (C6) have comparable weights, at 18% and 16% respectively, signifying their impact on students' online learning, albeit to a lesser degree.

At the last level, the learning conditions factor includes Technology (C8), Learning Environment (C9), and Learning Resources (C10). Technology carries the highest importance at 53%, indicating the prevalent challenges students face regarding technological issues in online learning. Learning Environment follows closely at 35%, emphasizing the necessity of a quiet and comfortable study environment for effective learning. Lastly, Learning Resources accounts for 12%, underscoring its impact on students' learning effectiveness, albeit relatively smaller compared to the other two factors.

In summary, the key determinant of students' online learning effectiveness is the teacher, accounting for 44% of the overall impact. Among the secondary factors, students' Commitment to learning holds significant importance at 35%, followed by teachers' teaching ability at 41%, and technology at 53%.

Table 4. 1 The Result of the Weight of Factors from Experts

Levels	Factors	Weight of factors (%)				
		Expert 1	Expert 2	Expert 3	Average	Rank
Level 1	Students(B1)	49.009	11.111	10.673	23.5976666666667	3
	Teachers(B2)	45.07	11.111	77.579	44.5866666666667	1
	Learning conditions(B3)	5.921	77.778	11.748	31.8156666666667	2
Level 2 (students)	Personal characteristics(C1)	33.333	27.895	33.322	31.5166666666667	3
	Learning ability(C2)	33.333	7.193	59.173	33.233	2
	Commitment to learning(C3)	33.333	64.912	7.506	35.2503333333333	1

Table 4. 1 The Result of the Weight of Factors from Experts (Continued)

Level 2 (teachers)	Teaching ability(C4)	25	66.653	33.735	41.796	1
	Feedback and assessment to students(C5)	25	22.016	7.666	18.2273333333333	3
	Attitude(C6)	25	7.992	15.489	16.1603333333333	4
	Managing ability(C7)	25	3.339	43.109	23.816	2
Level 2 (learning conditions)	Technology(C8)	11.111	77.202	70.494	52.9356666666667	1
	Learning environment(C9)	77.778	17.344	8.414	34.512	2
	Learning resource(C10)	11.111	5.455	21.092	12.5526666666667	3
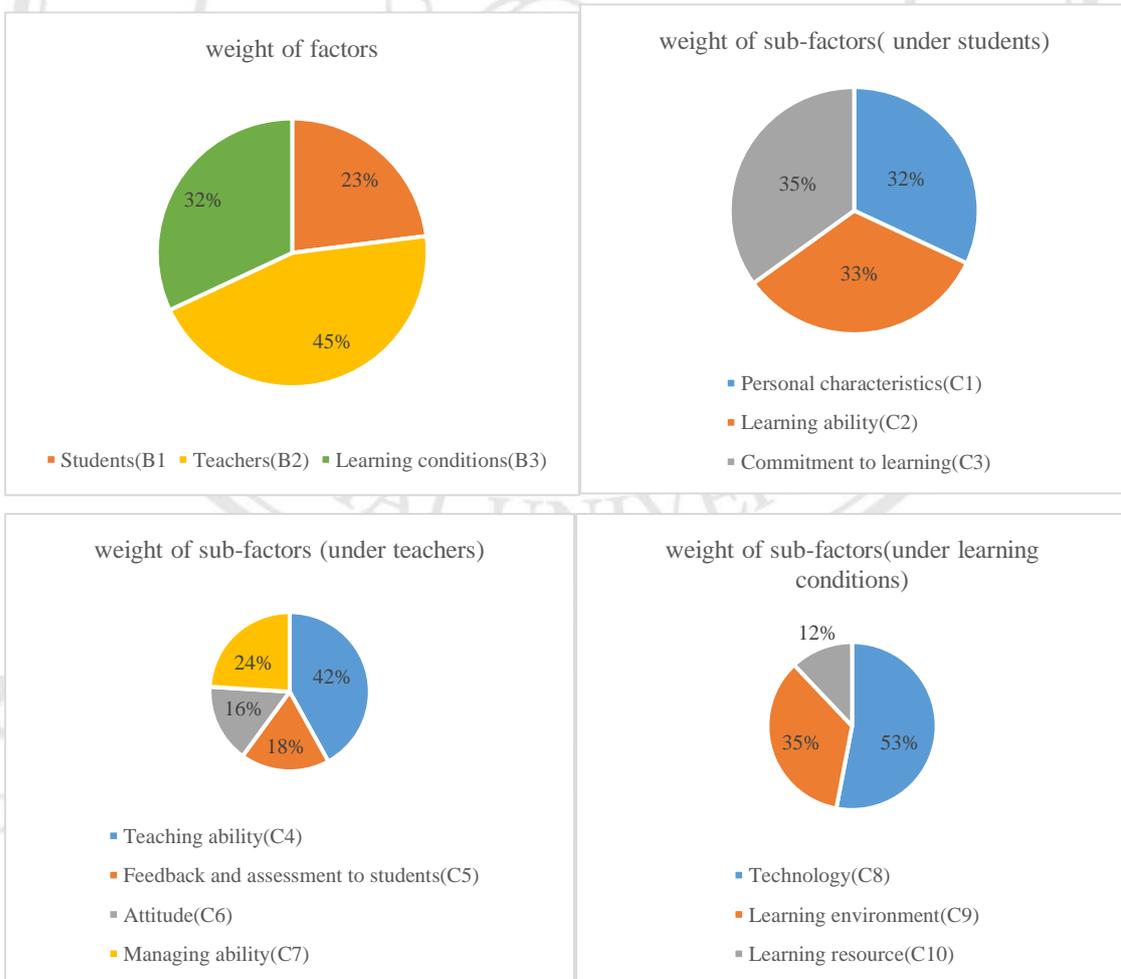
Figure 4. 14 The Result of the Weight of Factors from Experts

69

4.3.2 The Results from Lecturers

Table 4. 2 The Result of the Weight of Factors from Lectures

Levels	Factors	Weight of factors (%)					Rank
		lecture 1	lecture 2	lecture 3	Lecture 4	Average	
Level 1	Students(B1)	33.333	73.064	40.539	48.872	48.952	1
	Teachers(B2)	33.333	18.839	48.064	44.404	36.16	2
	Learning conditions(B3)	33.333	8.096	11.397	6.724	14.8875	3
Level 2 (students)	Personal characteristics(C1)	33.333	16.659	25.828	12.5	22.08	3
	Learning ability(C2)	33.333	73.959	10.473	75	48.19125	1
	Commitment to learning(C3)	33.333	9.381	63.699	12.5	29.72825	2
Level 2 (teachers)	Teaching ability(C4)	25	63.899	24.264	31.579	36.1855	1
	Feedback and assessment to students(C5)	25	18.259	34.315	31.579	27.28825	2
	Attitude(C6)	25	8.469	17.157	31.579	20.55125	3
	Managing ability(C7)	25	9.373	24.264	5.263	15.975	4
Level 2 (learning conditions)	Technology(C8)	33.333	14.286	14.286	7.692	17.39925	3
	Learning environment(C9)	33.333	42.857	71.429	46.154	48.44325	1
	Learning resource(C10)	33.333	42.857	14.286	46.154	34.1575	2

70
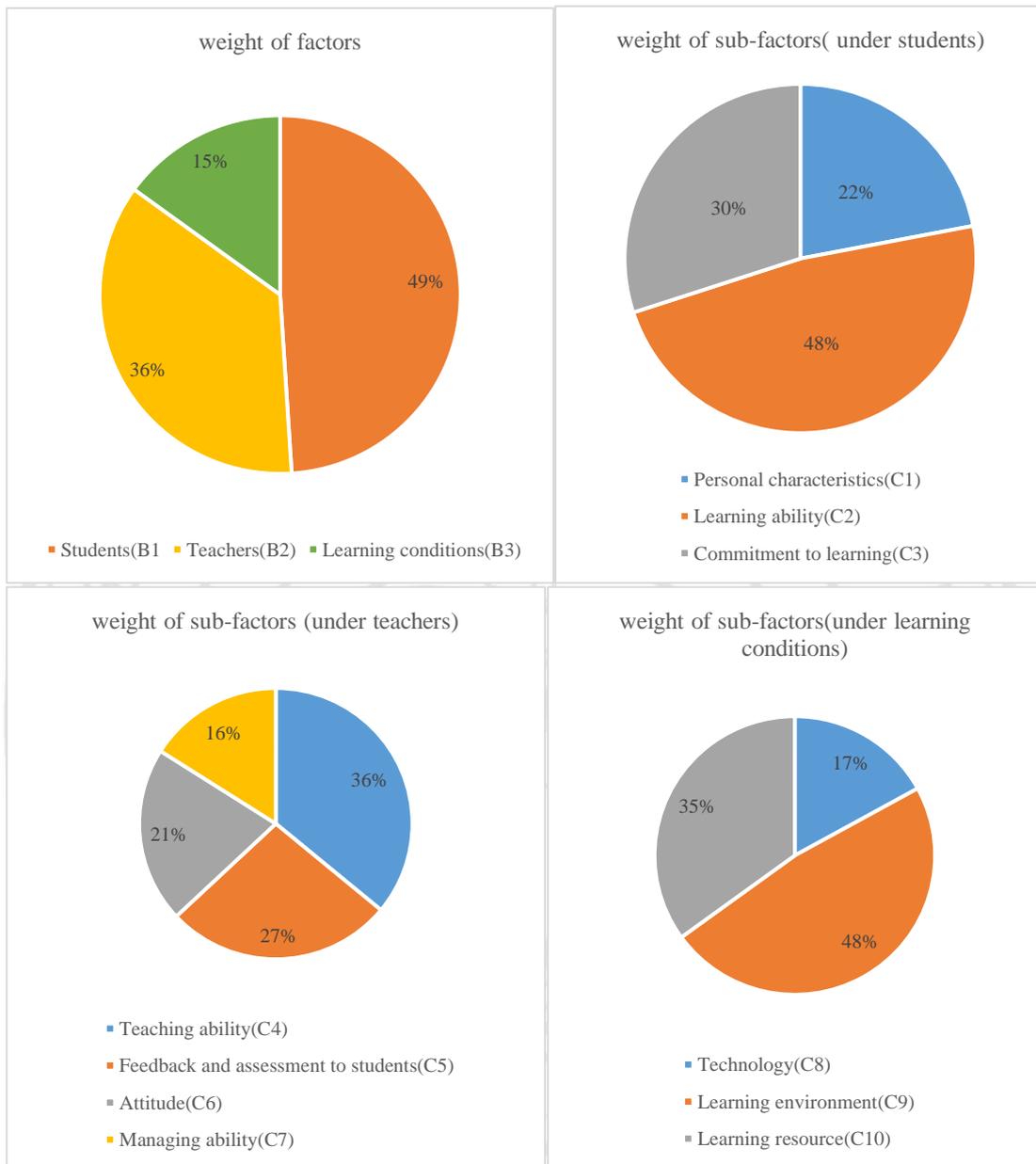
Figure 4. 15 The Result of the Weight of Factors from lectures

By calculating the average values provided by the four lecturers, the researchers can ascertain the proportions and significance of factors influencing the effectiveness of students' online learning. In the primary level of analysis, the lecturers unanimously assert that student factors (B1) exert the most significant impact on the effectiveness of online learning, comprising nearly 50% of the overall influence. Subsequently, teacher factors (B2) are deemed to contribute approximately 36% to this effectiveness, while learning

conditions (B) are perceived as the least influential, representing only about 15% of the total impact.

In the second level, there are a total of ten secondary indicators, with three falling under the category of student factors. These include Personal characteristics (C1), Learning ability (C2), and Commitment to learning (C3). Among these, students' learning ability has the most substantial impact on the effectiveness of online learning, accounting for nearly 50% of the influence. Following this, Commitment to learning contributes approximately 30%, and lastly, students' personal characteristics are deemed the least influential, representing only 22% of the overall impact.

Within the teacher factor, there are four secondary indicators. Notably, the most influential factor for the effectiveness of online learning is the teacher's teaching ability (C4), constituting 36% of the overall impact. Following closely is Feedback and assessment to students (C5), contributing 27%. The two relatively less impactful factors are the teacher's teaching attitude (C6) and management ability (C7), accounting for 21% and 16%, respectively.

The last three factors fall under the category of learning conditions. Notably, the learning environment (C9) exerts the most significant impact on students' online learning, constituting nearly 50% of the overall influence. Following this, learning resources (C10) contribute to the effectiveness, and the least influential factor is technology (C8), representing only 17% of the total impact.

In summary, the four lecturers provided their insights based on their actual teaching experiences. They collectively identified student factors as crucial in influencing students' online learning. Furthermore, within the secondary factors, they emphasized the significant impact of students' learning ability, teacher's teaching ability, and the learning environment on the effectiveness of online learning.

4.3.2 The Results of Importance of Factors Influencing the Effectiveness of Students' Online Learning

Table 4. 3 The Result of the Average Weight of Factors

Levels	Factors	Experts	Lecturers	Average	Rank
Level 1	Students(B1)	23.5976666666667%	48.952%	36.3%	2
	Teachers(B2)	44.5866666666667%	36.16%	40%	1
	Learning conditions(B3)	31.8156666666667%	14.8875%	23.7%	3
Level 2 (students)	Personal characteristics(C1)	31.5166666666667%	22.08%	27%	3
	Learning ability(C2)	33.233%	48.19125%	40.5%	1
	Commitment to learning(C3)	35.2503333333333%	29.72825%	32.5%	2
Level 2 (teachers)	Teaching ability(C4)	41.796%	36.1855%	39%	1
	Feedback and assessment to students(C5)	18.2273333333333%	27.28825%	22.5%	2
	Attitude(C6)	16.1603333333333%	20.55125%	18%	4
	Managing ability(C7)	23.816%	15.975%	20.5%	3
Level 2 (learning conditions)	Technology(C8)	52.9356666666667%	17.39925%	35%	2
	Learning environment(C9)	34.512%	48.44325%	41.5%	1
	Learning resource(C10)	12.5526666666667%	34.1575%	23.5%	3
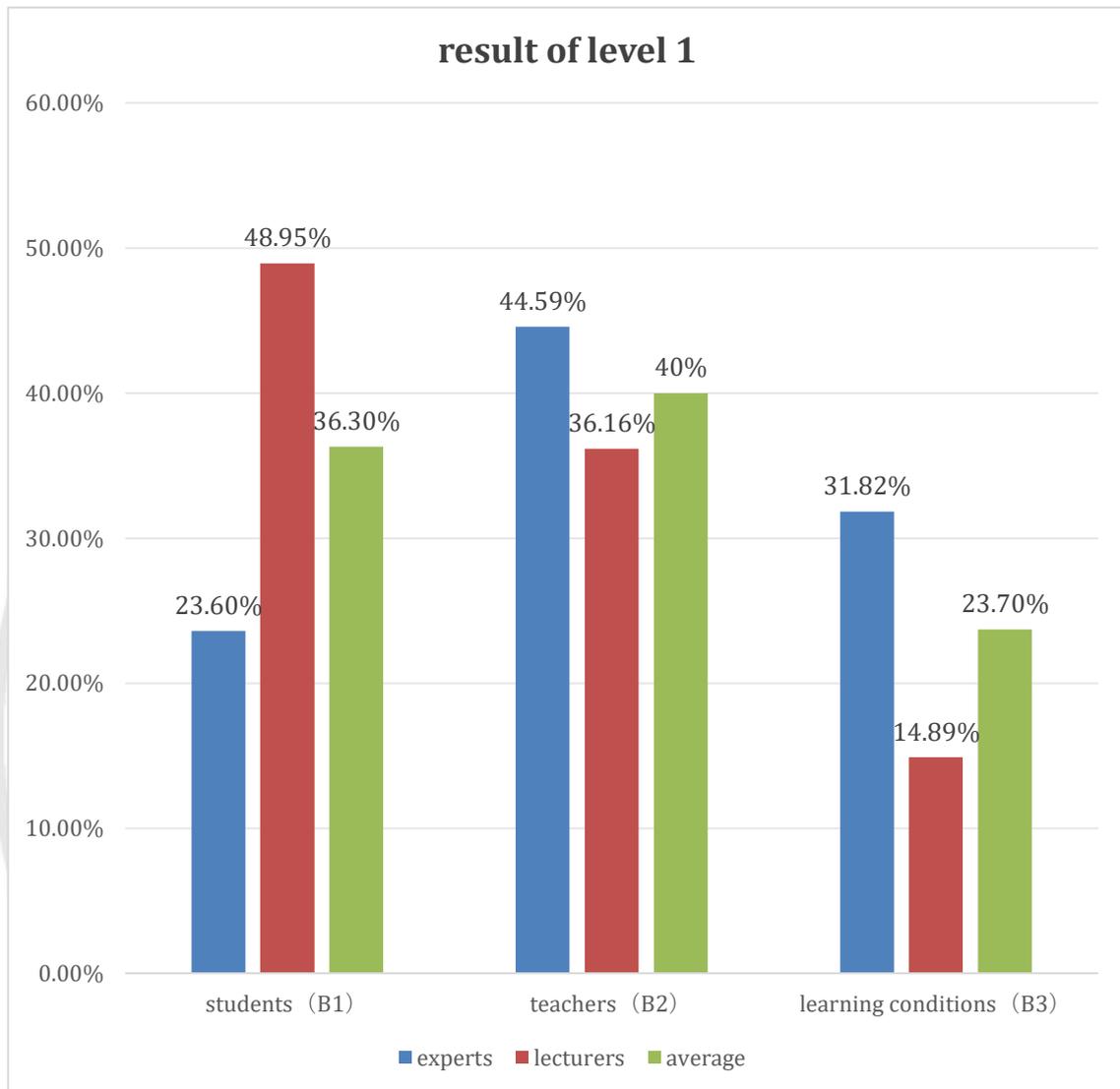
result of level 1

Figure 4. 16 Result of Level 1

In the first level, three experts and four lecturers rated students, teachers and learning conditions respectively. Lecturers believe that student factors have the greatest impact on students' online learning effectiveness, accounting for nearly 50%, followed by teachers and learning conditions, accounting for 36.16% and 14.89% respectively. However, the opinions of experts are different from those of lecturers. Experts believe that teachers' factors have the greatest impact on the effectiveness of students' online learning, accounting for nearly 50%. Student factors have the smallest impact on students' online learning, only 23.60%, and learning conditions are in the middle, accounting for 31.82%.
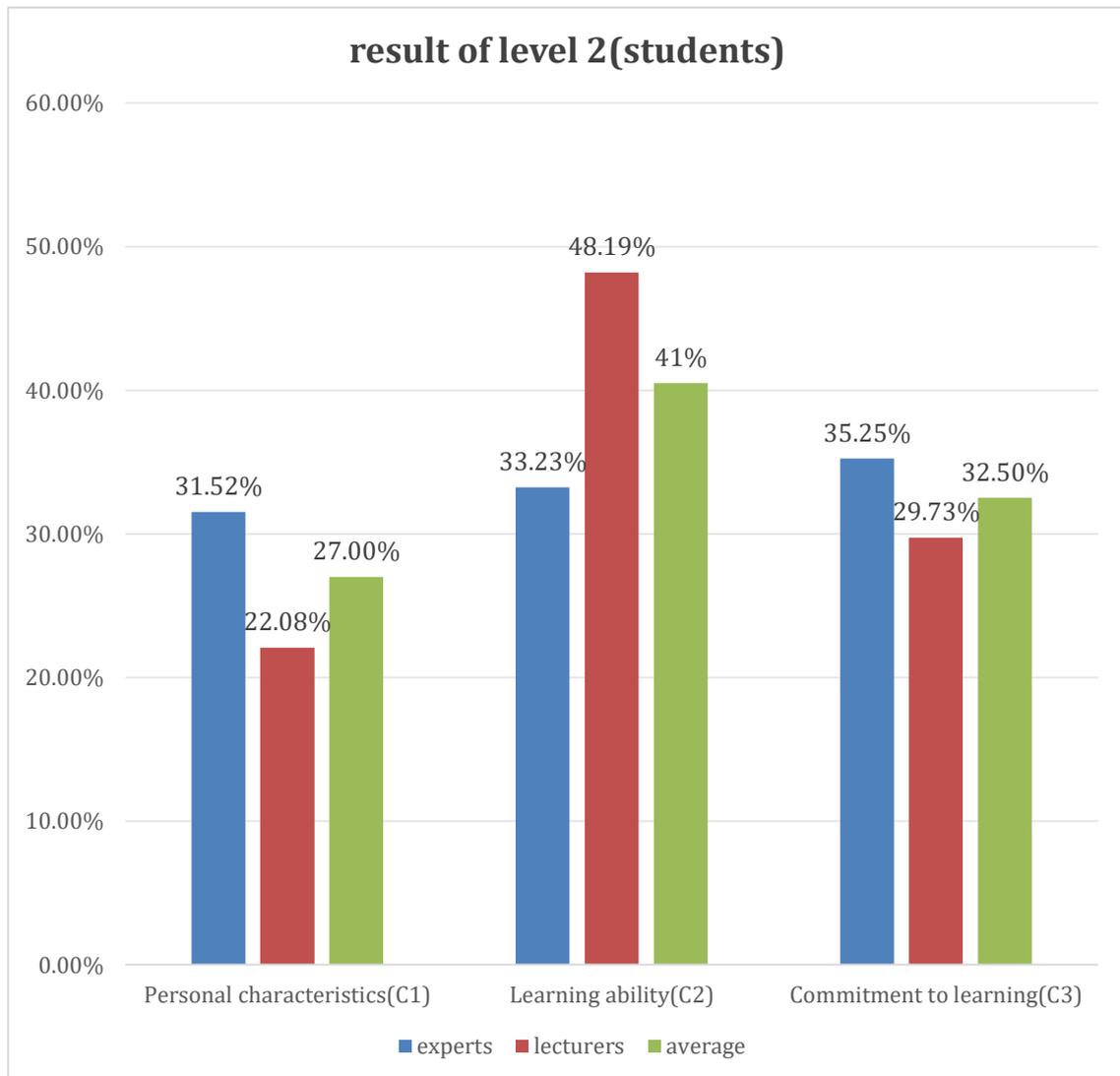
Figure 4. 17 Result of Level 2 (Students)

In the second-level student dimension, experts assign relatively average scores to the three indicators, ranging from 30% to 35%. This suggests their belief in the effectiveness of personal characteristics, learning ability, and commitment to learning for students' online learning, with their impacts being nearly equivalent. Conversely, lecturers present divergent perspectives. They assert that learning ability holds the greatest sway on learning effectiveness, approaching 50%. In contrast, commitment to learning and personal characteristics are perceived to have smaller impacts, accounting for 29.73% and 22.08%, respectively.

result of level 2(teachers)

Figure 4. 18 Result of Level 2 (Teachers)

In the context of the second-level teacher dimension, experts assert that teachers' personal teaching ability holds the most substantial influence on students' online learning, representing 41.8%, followed by management ability at 23.82%. Additionally, experts posit that student feedback and evaluation, as well as teachers' professional attitude, wield relatively minimal impact on students' learning effectiveness, accounting for 18.23% and 16.16%, respectively. This perspective is concurred by lecturers who align with the experts' viewpoints. They contend that teaching ability exerts the greatest impact, comprising 36.19%, followed by student assessment and feedback. Finally, attitude and management ability are considered equally important, completing the hierarchy of influences as perceived by lecturers.

76
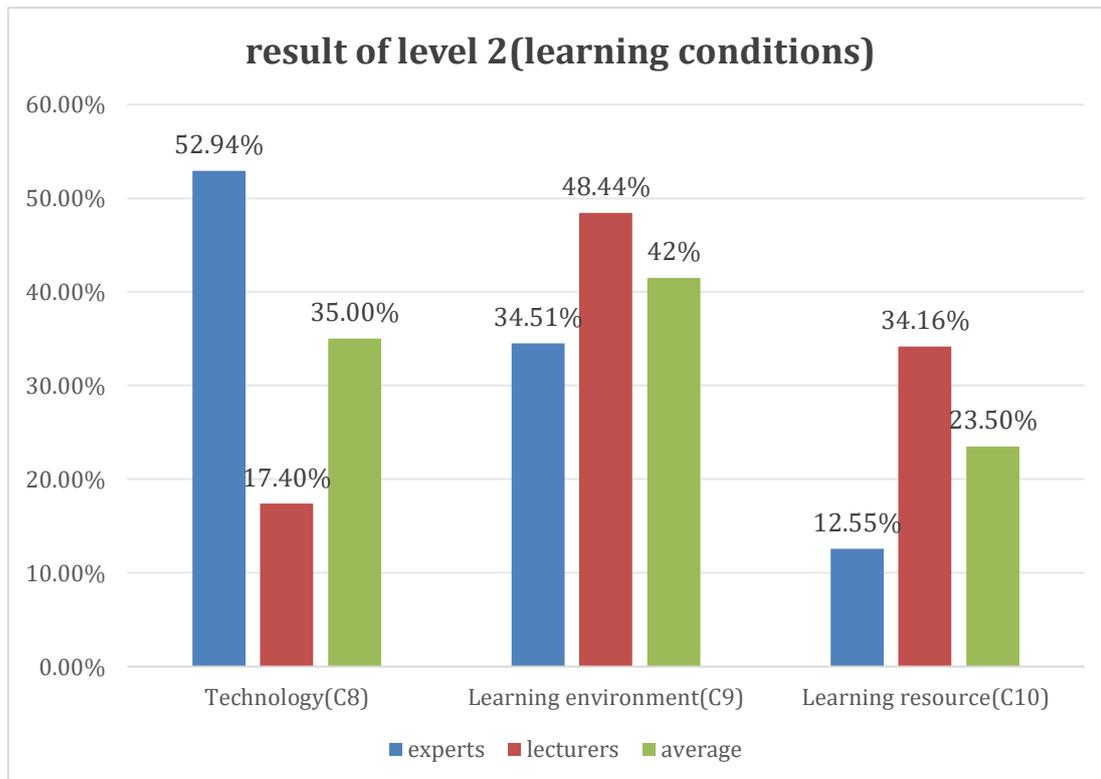
Figure 4. 19 Result of Level 2 (Learning Conditions)

In the realm of the last dimension at the second level, experts posit that technology wields the most significant impact on learning effectiveness, constituting more than 50%, followed by the learning environment. Conversely, learning resources are perceived as the least crucial factor, accounting for only 12.55%. Lecturers, on the other hand, contend that the paramount consideration is the learning environment, comprising nearly 50%, succeeded by learning resources. Notably, technology is regarded as the least influential, accounting for only 17.40%.

In summary, there is a significant disparity in the perspectives of experts and lecturers. At the first level, experts assert that the pivotal factor influencing the effectiveness of students' online learning is the teacher, while lecturers contend that it is the students. In the second instance, experts emphasize the significance of students' commitment, teacher's teaching ability, and technology, whereas lecturers prioritize students' learning ability, teacher's teaching ability, and the learning environment as the most crucial factors.
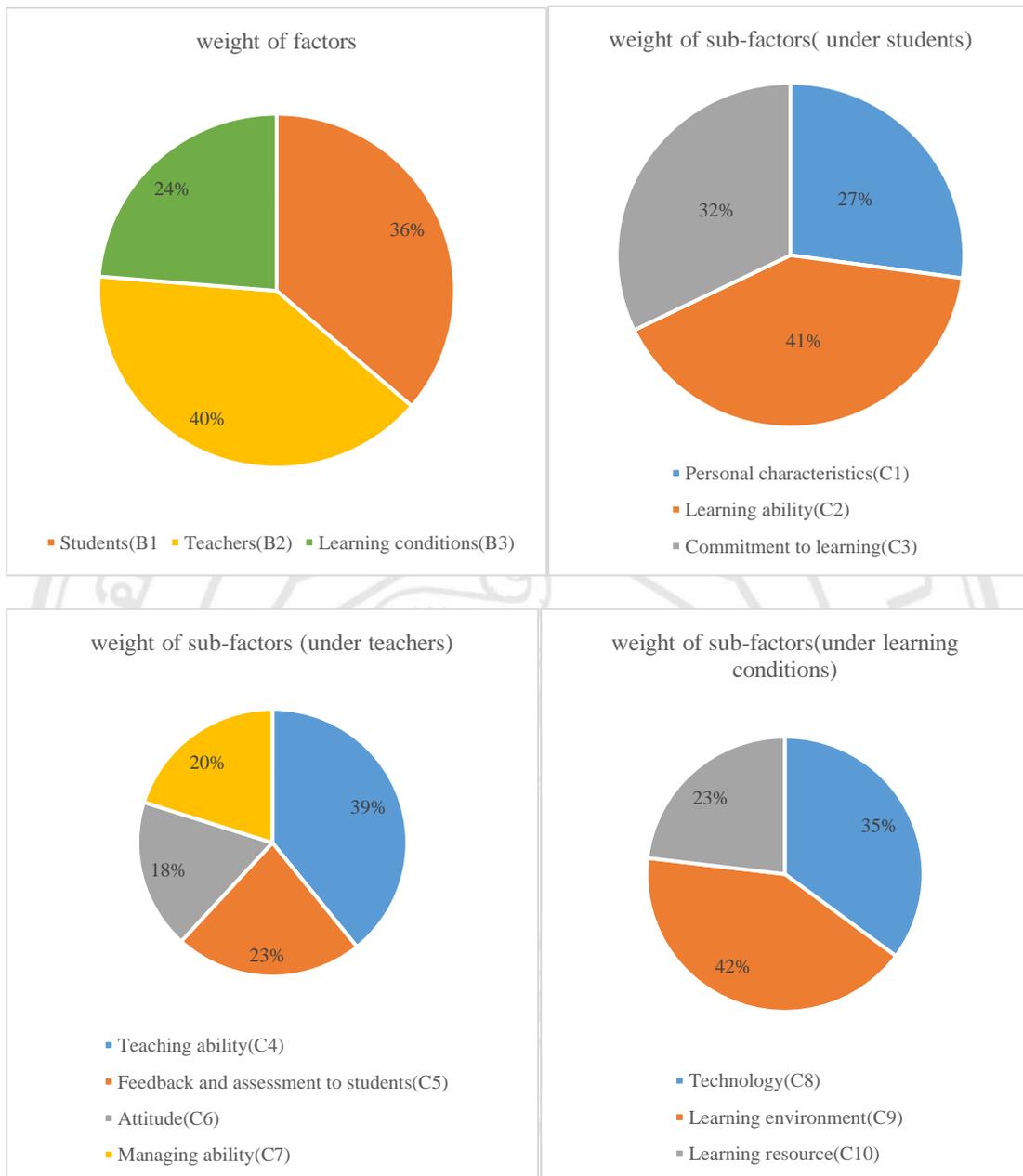
Figure 4. 20 The Result of the Weight of Factors

Through the amalgamation of insights from both the expert group and the lecturers, we have discerned the factors that influence the effectiveness of students' online learning and have ranked their significance. In the first level, teachers emerge as the most influential, contributing to 40% of the impact on learning effectiveness, followed by students and learning conditions, with respective contributions of 36.3% and 23.7%. In the second level, students' learning ability, teachers' teaching prowess, and the learning environment all assume crucial roles in students' learning, each accounting for

approximately 40%. This underscores the critical importance of students cultivating robust learning abilities, teachers enhancing their online teaching competencies, and creating a serene and conducive learning environment to enhance learning efficiency.

4.4 The Result of the Consistency Test

The consistency test evaluates whether the pairwise comparisons conducted by the decision-maker align with their preferences. It is crucial to ensure that these comparisons are both reliable and consistent, as inconsistency can lead to unreliable outcomes. If the Consistency Ratio (CR) is equal to or below a predetermined threshold (typically 0.10), the decision-maker's comparisons are considered consistent. However, if the CR exceeds the threshold, the decision-maker needs to revise the comparisons until consistency is achieved. This test stands as a vital stage within the Analytic Hierarchy Process (AHP) to validate and ensure the reliability of the results. With three experts and four lecturers involved in the AHP method, the consistency test computes the average value. The provided chart represents the outcome of the consistency test.

Table 4. 4 The Result of the Consistency Test

Levels	Factors	CR (Expert 1)	CR (Expert 2)	CR (Expert 3)	CR Average	Result
Level 1	Students(B1) Teachers(B2) Learning conditions(B3)	0.007	0.0	0.009	0.01<0.1	Pass
Level 2 (students)	Personal characteristics(C1) Learning ability(C2) Commitment to learning(C3)	0.0	0.062	0.013	0.025<0.1	Pass

79

Table 4. 4 The Result of the Consistency Test (Continued)

Level 2 (teachers)	Teaching ability(C4) Feedback and assessment to students(C5) Attitude(C6) Managing ability(C7)	0.0	0.199	0.031	0.077<0.1	Pass
Level 2 (learning conditions)	Technology(C8) Learning environment(C9) Learning resource(C10)	0.0	0.248	0.043	0.094<0.1	Pass

All evaluation results can pass the consistency test from the analysis of the results. Although the results of expert two on the second-level factors (teacher and learning conditions) are still contradictory, combined with all the results of the three experts, the average can still pass the consistency test. This shows that the research results of AHP are reasonable and logical.

Table 4. 5 The Result of the Consistency Test (Continued)

Levels	Factors	CR (lecture 1)	CR (lecture 2)	CR (lecture 3)	CR (lecture 4)	CR Average	Result
Level 1	Students(B1) Teachers(B2) Learning conditions(B3)	0	0.062	0.028	0.009	0.02475<0.1	Pass
Level 2 (students)	Personal characteristics(C1) Learning ability(C2) Commitment to learning(C3)	0	0.013	0.037	0	0.0125<0.1	Pass
Level 2 (teachers)	Teaching ability(C4) Feedback and assessment to students(C5) Attitude(C6) Managing ability(C7)	0	0.03	0.094	0	0.031<0.1	Pass
Level 2 (learning conditions)	Technology(C8) Learning environment(C9) Learning resource(C10)	0	0	0	0	0<0.1	Pass

The findings indicate that the Consistency Ratio (CR) values for the four lecturers are below 0.1, substantiating the authenticity and efficacy of their feedback.

CHAPTER 5

Conclusion

Chapters 1 to 4 provide a comprehensive overview of the research process and its outcomes. In contrast, the final chapter will present the conclusive findings of the study based on expert Feedback received through questionnaires. Additionally, this chapter will analyze the limitations inherent in this study and propose future research directions.

5.1 Conclusion

This section will reorganize the results of the AHP method and present the results to the expert who gave guidance on each of the factors that affect online learning. By analyzing the guidance given by experts, three areas of guidance on improving the effectiveness of online learning have been compiled.
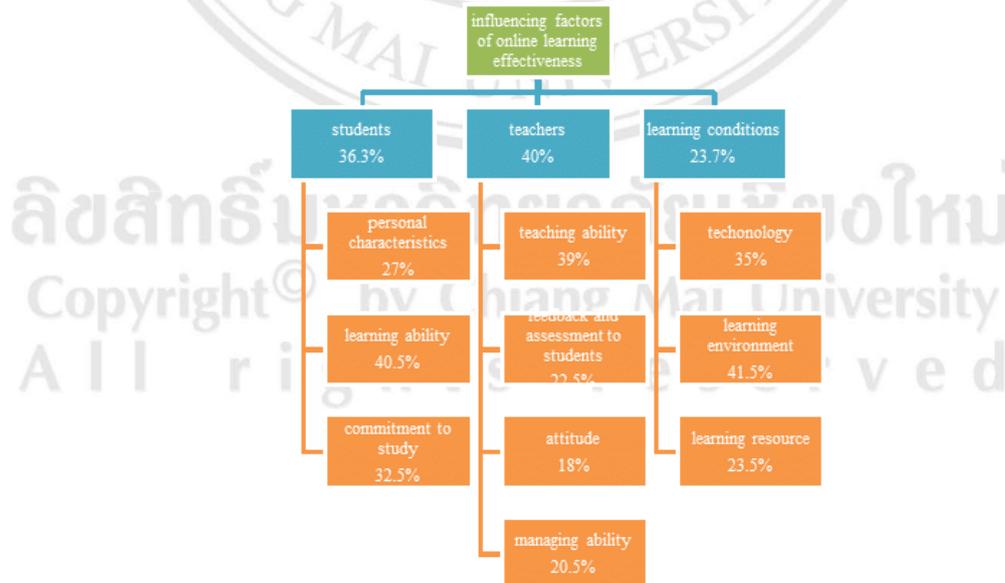
Figure 5. 1 The Result of AHP about the Weight of Influencing Factors

Table 5. 1 The Weight of Factors from Experts and Lectures

factors			Weight: Group of experts	Weight: Group of KIM lecturers
Level 1:		Teachers	23.5976666666667%	48.952%
		Students	44.5866666666667%	36.16%
		Learning condition	31.8156666666667%	14.8875%
Level 2(students):		Personal characteristics	31.5166666666667%	22.08%
		Learning ability	33.233%	48.19125%
		Commitment to learning	35.2503333333333%	29.72825%
Level 2(teachers):		Teaching ability	41.796%	36.1855%
		Feedback and assessment to students	18.2273333333333%	27.28825%
		Attitude	16.1603333333333%	20.55125%
		Managing ability	23.816%	15.975%
Level 2(learning condition):		Technology	52.9356666666667%	17.39925%
		Learning environment	34.512%	48.44325%
		Learning resource	12.5526666666667%	34.1575%

At the first level, experts and KIM instructors have relatively similar views on the impact of student factors on the effectiveness of online learning, but there is a large gap between the two groups of experts on teachers and learning conditions.

In the second level, which involves students, the two groups of teachers share very similar opinions about personal characteristics , learning abilities, and commitment to learning. The difference in how important these factors are to them is less than 10%.

In the second level, which involves teachers, both the expert group and the lecturer group agree that teaching ability is the most important factor. However, their opinions on other factors vary slightly.

In the final aspect of the second level, which is about learning conditions, the views of the lecturer group and the expert group differ significantly. The expert group believed that technology mattered the most, while the lecturer group valued the learning environment the most. Moreover, the expert group considered learning resources as the least important, whereas the lecturer group saw technology as the least significant factor.

In general, the expert group and the lecturer group are on the same level and have relatively similar views on the importance of students. Other factors vary greatly. In the second level, the expert group and the lecturer group have similar views on personal characteristics, commitment to learning, teaching ability, attitude, and learning environment. But the importance of other remaining factors is different.
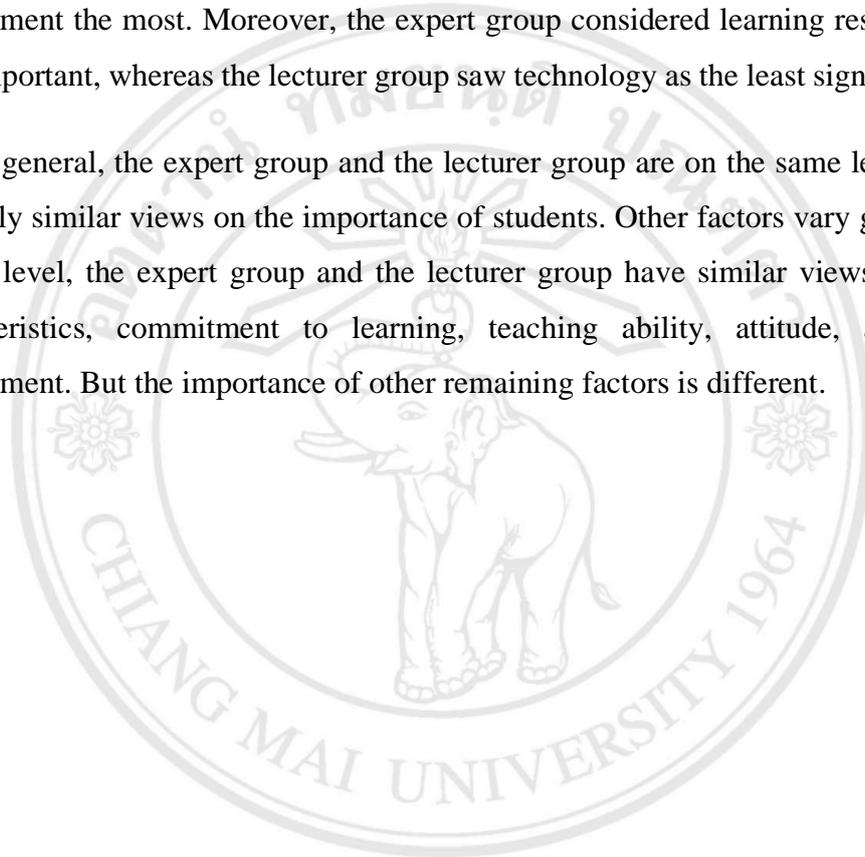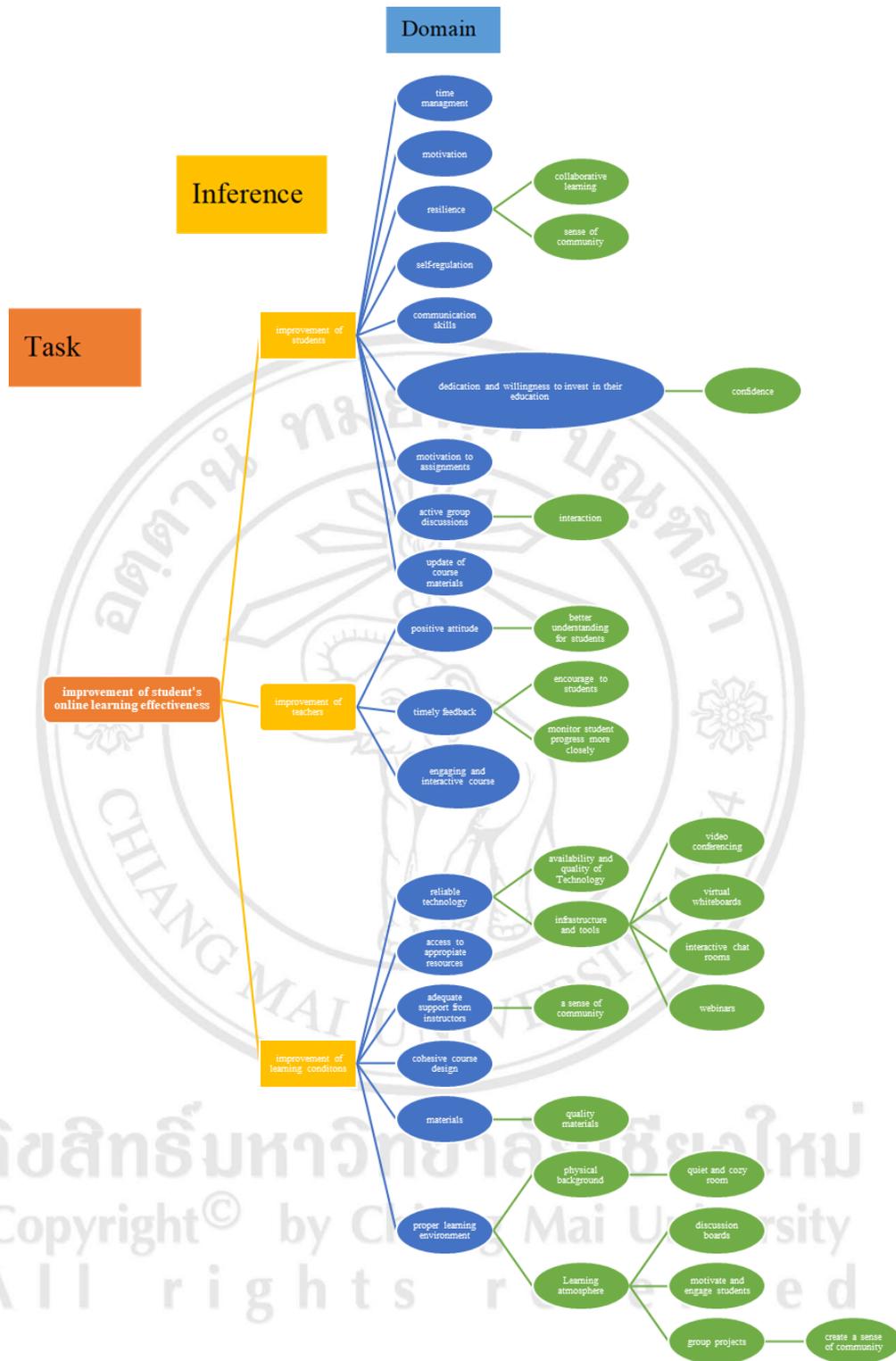
Figure 5. 2 CommonKADS (knowledge model)

Table 5. 2 CommonKADS (Knowledge Model)

	Influencing factors of online learning effectiveness	weight	definition	Guidance to improve students' online learning effectiveness (from experts)
Level 1	Students(B1)	23.5976666666667	Personal factors of the student include personality traits, learning ability, and motivation.	Self-control and time management abilities affect how successful online learning is
	Teachers(B2)	44.5866666666667	Teacher factors include the teacher's ability to teach, work ethic, and Feedback and assessment of students.	Teachers must be passionate about their careers and provide students with a welcoming and inclusive learning atmosphere.
	Learning conditions(B3)	31.8156666666667	Learning conditions refer to students' external environment and the learning resources available to them when studying online.	Online teaching platforms need to protect users' privacy and be information secure. Teachers need to consider not only the 'course objectives and learning outcomes but also students' special requirements and characteristics when designing courseware. Schools need to provide quality learning resources, and students must be self-reflective.

Table 5. 2 CommonKADS (Knowledge Model) (Continued)

Level 2 (students)	Personal characteristics(C1)	31.5166666666667	Personal characteristics include the student's educational background, age, major, gender, and other conditions.	Find the conditions that can be controlled from among the unchanging ones. For example, find out what you don't like about your field of study and overcome that difficulty.
	Learning ability(C2)	33.233	Learning abilities are the good qualities that a student demonstrates when studying, such as concentration, logical thinking, perseverance, etc.	Self-discipline requires setting clear learning goals and then patiently accomplishing them. Self-discipline improves day after day. In addition, students' reflections are important for measuring the effectiveness of their learning，such as journals, self-evaluations, and group conversations.
	Commitment to learning(C3)	35.2503333333333	This section focuses on the student's initiative in learning, including the amount of time and effort invested in learning.	To improve learning motivation, students can set achievable goals that give them a sense of purpose. Teachers and instructors play a crucial role by setting clear goals, providing constructive criticism, and encouraging active participation. Peers and study groups contribute by exchanging ideas, engaging in class discussions, and collaborating on projects, offering support and motivation to one another. Combining individual goal-setting with the support of teachers and peers enhances student motivation and overall learning experience.

Table 5. 2 CommonKADS (Knowledge Model) (Continued)

Level 2 (teachers)	Teaching ability(C4)	41.796	Teaching ability refers to whether the teacher has good online teaching ability, can quickly adapt to the conversion from face-to-face teaching to online teaching, and skillfully uses various teaching skills and methods for online teaching.	Teachers should do their best to make their classes interesting by using online or internet materials such as interactive technologies to encourage student involvement and interaction. In addition, the teacher's charisma, such as a sense of humor, will also increase students' interest in learning.
	Feedback and assessment to students(C5)	18.2273333333333	This aspect refers to whether the instructor provided Feedback and assessment to the student after the class or at the end of the semester and answered questions when the student had them.	The frequency of teachers' Feedback may vary based on the course, teaching style, and student needs. However, providing frequent feedback throughout the semester is generally beneficial. It enables students to receive relevant, detailed, and usable Feedback on time, which in turn allows them to make timely improvements by addressing specific areas of their work and following actionable instructions for improvement.
	Attitude(C6)	16.1603333333333	A teacher's work attitude is reflected in many ways, such as whether or not he or she has carefully prepared for each lesson and whether or not he or she arrives late or leaves early.	A teacher who is passionate about their topic is ready to impart information to their pupils and is excited about learning new things. They are dedicated to seeing kids achieve and use innovative teaching strategies.

Table 5. 2 CommonKADS (Knowledge Model) (Continued)

	Managing ability(C7)	23.816	The teacher's management skills are mainly concerned with classroom management, whether the learning activities required by the school are well organized, and whether messages are notified on time.	Teachers may encourage students to feel respected, encouraged, and driven to study by creating a pleasant learning environment.
Level 2 (learning conditions)	Technology(C8)	52.9356666666667	Technology mainly includes the technical conditions for students to attend classes, fast internet speeds, and an appropriate online learning platform that meets the needs of the students. These are all very important.	The reliability and usability of online learning platforms are very important; technology should be reliable and easy to use without extra training. By the way, security and privacy are crucial components.
	Learning environment(C9)	34.512	The classroom environment is mainly a quiet and comfortable place for students to attend classes without the disturbance of outsiders.	Teachers, administrators, parents, caregivers, and peers may establish a welcoming and effective learning environment for students by cooperating and supporting one another. Students and teachers also need to work together to create a positive and dynamic learning environment.

Table 5. 2 CommonKADS (Knowledge Model) (Continued)

| Learning resource(C10) | 12.5526666666667 | Learning resources focus on whether the school and teachers provide the materials needed for online learning, such as classroom materials, reading materials, online labs, etc. | Online courses must be created with specific goals and intended outcomes in mind. The course should be designed to promote the attainment of these objectives, and teachers should ensure that these aims and results are presented to students clearly and understandably. Teachers should also consider the special requirements and features of online learning, such as self-direction, time management, and self-discipline while developing online courses. Schools should provide the correct online resources for them, such as online courses, e-books, videos, and instructional websites, which are just a few of the many learning options available to students. Teachers might make lists of resources that students can use independently or suggest certain resources to their students. |

5.1.1 Students

☐Collaboration: Participating in group activities online helps students engage more, interact better, and develop important communication and teamwork skills. Studies show that working together enhances students' understanding of concepts, problem-solving abilities, and advanced thinking skills. To encourage effective collaboration, teachers can use tools like discussion boards, virtual group projects, and peer feedback. It's essential to carefully plan these activities to ensure everyone gets involved fairly and that students feel a shared responsibility for the work.

☐Self-Reflection: Activities that encourage self-reflection help students think deeply about how they learn, recognizing their strengths, weaknesses, and preferences. Through things like regular self-assessment, keeping a journal, or discussing with peers, students develop skills to understand and adjust their learning strategies. Self-reflection helps students take control of their learning, making them more motivated and improving their understanding of the material. Teachers can give prompts or structured activities to guide students in reflecting on their own learning process.

5.1.2 Teachers

☐Active Learning Environment: Environment: Teachers play a crucial role in creating an active and engaging online learning environment. By organizing discussions and activities, educators encourage students to participate in the course and interact with each other. Immediate feedback and ongoing assessments help teachers understand how well students grasp the material and address any misunderstandings quickly. Including multimedia elements like videos, simulations, and interactive quizzes makes learning more interesting and helps students understand the subject better.

☐Effective Instructional Practices: It's really important for teachers to use the right methods when teaching online to help students learn better. Being clear and direct when giving instructions and expectations is key. Teachers should show up online, maybe through video calls or live chats, to make students feel connected and part of a community. Using different online tools like learning systems, discussion boards, and online lessons helps teach in lots of different ways. When lessons are well-organized and students get

91

help when they need it, they feel more motivated, engaged, and do better in their online classes.

5.1.3 Learning Conditions

☐Technological Infrastructure: For online learning to work well, it's crucial to have a strong and reliable technology setup. Schools need to invest in good internet connections so students can access online resources without any problems. Choosing user-friendly learning systems is important for easy navigation. Schools should also provide enough computers or tablets and other necessary technology to make sure students can fully participate in online learning activities.

☐Course Design: Creating an online course that focuses on the learners is really important. Teachers should organize the course material in a clear and easy-to-follow way, giving clear instructions and goals. Using things like videos, interactive lessons, and virtual labs helps accommodate different ways students learn and keeps them engaged. Teachers should also include chances for quick assessments to give feedback and keep track of how well students are doing.

☐In conclusion, making online learning better for students involves doing many things. Schools can improve by encouraging students to work together, helping them think about their own learning, creating an active learning space, using good teaching methods, and making sure the conditions for learning are right. Using good teaching methods, technology, and making interesting learning spaces are also important for students to do well online. It's crucial to keep checking and improving how we do online learning to keep up with the changing needs and difficulties of online education.

5.2 Limitation

The present study centered on students from Chiang Mai University, which means that the findings may offer only partial insights into students' online learning experiences and challenges in other educational contexts or countries. Restricting the sample to a specific institution may constrain the extent to which the study's conclusions can be generalized to a broader population.

5.3 Future Research

Given the relatively limited sample size in the present study, it is imperative to enhance the rigor and generalizability of future research endeavors. While the COVID-19 pandemic may have subsided, there is an ongoing need to systematically synthesize the knowledge gained during this period. As a result, future studies will adopt an expanded sampling approach to encompass a more diverse group of student participants. This will involve the careful selection of schools from various countries to conduct a comprehensive comparative analysis of their online learning practices, facilitating the identification of differentiating factors and commonalities. The insights derived from this research will subsequently inform the development of holistic learning experiences that can be universally applied to students worldwide.
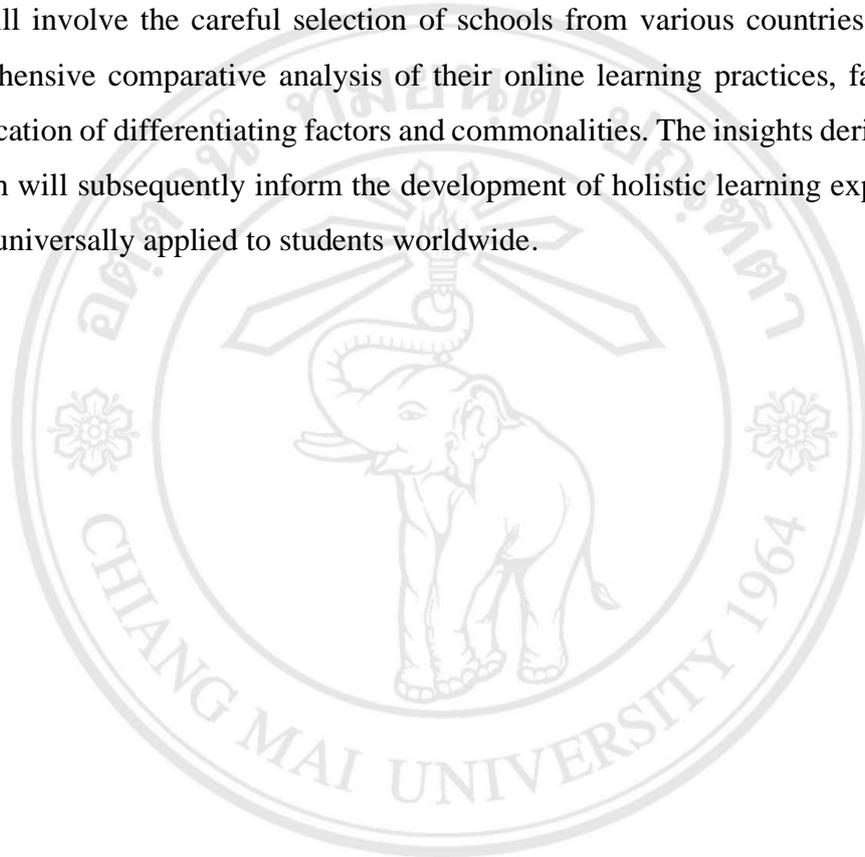
REFERENCES

Abdous, M. h. (2019). Influence of satisfaction and preparedness on online students' feelings of anxiety. The Internet and Higher Education, 41, 34-44.

Ahmad, M. (2021). Optimization of Learning Effectiveness through the Learning Environment and Learning Motivation for Students. Al-Ishlah: Jurnal Pendidikan, 13(3), 1546-1555.

Ast, J. V., & Field, D. W. (2005). Reflections of community-college students regarding mentee/instructor teaching and learning effectiveness. Community college journal of research and practice, 29(3), 173-189.

Bryson, J. R., & Andres, L. (2020). COVID-19 and rapid adoption and improvisation of online teaching: curating resources for extensive versus intensive online learning experiences. Journal of Geography in Higher Education, 44(4), 608-623.

Cao, C., Li, J., Zhu, Y., Gong, Y., & Gao, M. (2020). Evaluation of Online Teaching Platforms Based on AHP in the Context of COVID-19. Open Journal of Social Sciences, 8(07), 359.

chen, j., & Cui, r. (2020). Study on online learning effects of college students. Journal of Yancheng Normal University (Humanities and Social Sciences Edition).

Chitre, M., & Srinivasan, D. (2018). Evaluating teaching effectiveness using quantitative student feedback. 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE),

94

Geng, S., Law, K. M., & Niu, B. (2019). Investigating self-directed learning and technology readiness in blending learning environment. International Journal of Educational Technology in Higher Education, 16(1), 1-22.

Hu, P. J.-H., & Hui, W. (2012). Examining the role of learning engagement in technology-mediated learning and its effects on learning effectiveness and satisfaction. Decision support systems, 53(4), 782-792.

Irawan, A. W., Dwisona, D., & Lestari, M. (2020). Psychological impacts of students on online learning during the pandemic COVID-19. KONSELI: Jurnal Bimbingan dan Konseling (E-Journal), 7(1), 53-60.

Jena, P. K. (2020). Online learning during the lockdown period for COVID-19 in India. International Journal of Multidisciplinary Educational Research (IJMER), 9.

Kornilov, I. V., Danilov, D. A., Kornilova, A. G., Golikov, A. I., & Gosudarev, I. B. (2020). Different approaches to the development of online learning in higher education. Propósitos y Representaciones, e706-e706.

Kuo, F.-O., Yu, P.-T., & Hsiao, W.-H. (2015). Develop and evaluate the effects of multimodal presentation system on elementary student learning effectiveness: within classroom English learning activity. Procedia-Social and Behavioral Sciences, 176, 227-235.

Monorom, R., & PIANTANAKULCHAI, M. (2020). At-home activities and subjective well-being of foreign college students in Thailand during the COVID-19 pandemic outbreak. Walailak Journal of Science and Technology (WJST), 17(9), 1024-1033.

Nuankaew, P., Nuankaew, W., Nasa-Ngium, P., Phanniphong, K., Teeraputon, D., & Chaopanich, O. (2021). Attitude Towards Online Learning from the Effect of Coronavirus 2019 Disease (COVID-19) on University Students in Thailand. PalArch's Journal of Archaeology of Egypt/Egyptology, 18(4), 2498-2517.

Nurhudatiana, A., Hiu, A. N., & Ce, W. (2018). Should I use a laptop or smartphone? A usability study on an online learning application. 2018 International Conference on Information Management and Technology (ICIMTech),

Saaty, T. L. (1971). On polynomials and crossing numbers of complete graphs. Journal of Combinatorial Theory, Series A, 10(2), 183-184.

Schreiber, A. T., Schreiber, G., Akkermans, H., Anjewierden, A., Shadbolt, N., de Hoog, R., Van de Velde, W., & Wielinga, B. (2000). Knowledge engineering and management: the CommonKADS methodology. MIT Press.

Shea, P., Li, C. S., Swan, K., & Pickett, A. (2005). Developing learning community in online asynchronous college courses: The role of teaching presence. Journal of Asynchronous Learning Networks, 9(4), 59-82.

Simamora, R. M. (2020). The Challenges of online learning during the COVID-19 pandemic: An essay analysis of performing arts education students. Studies in Learning and Teaching, 1(2), 86-103.

Tanawongsuwan, P. (2020). Students Satisfaction in Onsite versus Online Teaching and Learning: A Report on an Initial Sudden Mid-Semester Switch at the Graduate School of Applied Statistics, NIDA, Thailand. Asian Journal of Research in Education and Social Sciences, 2(3), 53-61.

Tanis, C. J. (2020). The seven principles of online learning: Feedback from faculty and alumni on its importance for teaching and learning. Research in Learning Technology, 28.

Tsai, C.-H., Cheng, C.-H., Yeh, D.-Y., & Lin, S.-Y. (2017). Can learning motivation predict learning achievement? A case study of a mobile game-based English learning approach. Education and Information Technologies, 22, 2159-2173.

Tseng, T.-L. B., Akundi, A., & Love, N. (2015). Instructional Setting on Student Learning Effectiveness Using Flipped Classroom in an Engineering Laboratory. 2015 ASEE Annual Conference & Exposition,

wang, d., wang, h., zhang, w., wang, h., & shen, x. (2020). Research on Online Teaching in the Period of "Suspending Classes without Stopping Learning" ——Based on 33,240 Online Surveys across the Country. modern educational technology, 30(3), 12-18.

Wu, D., & Li, W. (2020). The phased characteristics of large-scale online teaching in colleges and universities in my country. Journal of East China Normal University (Educational Science Edition), 38(7), 1-30.

Xiao, F., Li, Q., Huang, H., Sun, L., & Xu, X. (2020). MOLEAS: a Multi-stage Online Learning Effectiveness Assessment Scheme in MOOC. 2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE),

Yang, Y. (2020). Investigation and research on the status quo of college students' online learning. modern communication.

Yuhua, D., & Jin, D. (2020). Research on the Existing Problems and Countermeasures of Online Course Learning for College Students. Rural Economy and Technology.

APPENDIX A

(Chapter 3 Step 3: Questionnaire design)

Questions About Basic Information

Basic information		
1. What is your gender?		
A. Male	B. Female	
2. What is your grade?		
A. Graduate student	B. Undergraduate student	C. Doctoral student
• First-year	• First-year	• First-year
• Second-year	• Second-year	• Second-year
• Third-year	• Third-year	• Third-year
• Fourth-year		

Questions about Learning Conditions

Learning conditions of online			
3. After the new Crown epidemic outbreak, how long did you take online classes?			
A. less than 0.5 year	B. 0.5 year-1 year	C. 1 year-2 years	D. More than two years
4. During the COVID-19 pandemic, how long did you take online classes every day?			
A. Less than 1 hour	B. 1 hour-3 hours	C. 3 hours-5 hours	D. More than 5 hours
5. What device do you usually use for online classes?			
A. cell phone	B. i-pad	C. computer	
6. Which online platforms have you used when you have online classes?			
• zoom	• Dingding	• CCTalk	Others(what is that)
• Tencent classroom	• learning pass	• Weblink	
	• QQ Live	• UMU	

98

• Tencent meeting	• flying book
• rain classroom	

Questions about a Learning Experience

Experience of online learning
7. Can you proficiently use online platforms?
A. very skilled   B. moderately skilled   C. unskilled
8. How is your concentration while studying online compared to a traditional classroom?
A. very concentrated   B. moderately concentrated   C. occasionally concentrated   D. not concentrated
9. How is your motivation to study online compared to a traditional classroom?
A. Better   B. Same   C. Worse

Questions about a Learning Experience (Continued)

10. How often do you interact with your teacher when learning online?
A. Many times   B. Only interact with   C. Topics of interest   D. sometimes   E. Almost not
11. Do you have group activities during online learning?
A. Often   B. Occasionally   C. never
12. Compared with the previous traditional learning methods, how do you think the effect of online learning is?
A. Very good   B. Good   C. Average   D. bad   E. Very bad
13. After experiencing online learning, which learning method do you think you are more suitable for?
A. Online learning model   B. Traditional learning model   C. Mixed learning model
14. Are you satisfied with online learning?
A. Very satisfied   B. generally satisfied   C. dissatisfied

Questions about Problems

Problems when study		
15. Did you encounter any problems while studying online?		
• Slow internet speed 47 • Poor stability of online teaching platform • poor self-control • Low sense of engagement	• Inadequate teacher guidance • Communication with classmates and teachers is not timely • More offline tasks	• Insufficient teaching resources • Experimental operation is difficult • others
16. In online learning, what aspects do you think need to be improved and improved?		
• Online learning form • Online learning conditions • Online learning platform • The duration and difficulty of assignments and tests	• learning attitude, attention, and learning methods, etc • Teachers' teaching attitude • Teachers' teaching methods and methods	• A class atmosphere of online classes • Interaction with teachers and classmates • others

APPENDIX B

(Chapter 3 Literature Review)

Papers that Mentioned Factors of Online Learning Effectiveness

1	Tsang, J. T., So, M. K., Chong, A. C., Lam, B. S., & Chu, A. M. (2021). Higher education during the pandemic: The predictive factors of learning effectiveness in COVID-19 online learning. Education Sciences, 11(8), 446.
2	"停课不停学"——疫情期间线上教学的思考与实施[C]//.2020 年教育信息化与教育技术 创新学术论坛（重庆会场）论文集.[出版者不详],2020:3-8.
3	李璐, 李鸣华.大学生线上学习力的影响因素分析[J].浙江师范大学学报(自然科学版),2020,43(03):269-275.
4	张健,潘伟亮,芦胜妹.大学生线上学习的效果及影响因素分析[J].大众标准化,2021(10):122-124.
5	张骞予,于国龙,付会森,吴恋.基于 Logistic 的大学生网课学习效果影响因素分析[J].科技与创新,2021(18):20-21.
6	Almaiah, M. A., Al-Khasawneh, A., & Althunibat, A. (2020). We are exploring the critical challenges and factors influencing the E-learning system usage during the COVID-19 pandemic. Education and information technologies, 25, 5261-5280.

7	蒋新军,张彩虹,张华,任珊,琚新梅,张艳,高星,王涛.新冠肺炎疫情期间本科生居家学习现状及其影响因素调查研究[J].中国高等医学教育,2020(09):3-35.
8	Mustafa, F., Khursheed, A., Rizvi, S. M. U., Zahid, A., & Akhtar, A. (2021). Factors influencing online learning of university students under the COVID-19 pandemic. IJERI: International Journal of Educational Research and Innovation, (15), pp. 342–359.
9	胡小平,谢作栩.疫情下高校在线教学的优势与挑战探析[J].中国高教研,2020(04):18-22+58.DOI:10.16298/j.cnki.1004-3667.2020.04.04.
10	王磊.新冠病毒疫情期间大学生参与网课学习的影响因素研究[J].长沙民政职业技术学院学报,2020,27(01):107-109.
11	杜若菡,钟先婷,陈孝洁,陈余佳黛,张琪悦.大学生网课认知对网课学习效果的影响——以川北医学院为例[J].大众标准化,2021(12):90-91+95.
12	邓丽,谢美林,邓焕仪,黄欣弘,黄志敏.大学生网课满意度调查及影响因素分析[J].宿州教育学院学报,2021,24(03):52-56+85.DOI:10.13985/j.cnki.34-1227/c.2021.03.011.
13	陈永林.疫情期间高职网课质量影响因素及对策[J].海南广播电视大学学报,2021,22(02):149-154.

14	谢晓颖,甘孟龙.疫情背景下影响大学生线上自主学习效率的相关因素分析[J]. 陕西学前 师范学院学报,2021,37(05):115-126.
15	Lau, S. L., & Sim, T. Y. (2020, November). Feedback from university students on online delivery learning during the COVID-19 pandemic period. In 2020 IEEE Conference on e-Learning, e-Management, and e-Services (IC3e) (pp. 13-18). IEEE.
16	Alqahtani, A. Y., & Rajkhan, A. A. (2020). E-learning critical success factors during the COVID-19 pandemic: A comprehensive analysis of e-learning managerial perspectives. Education sciences, 10(9), 216.
17	Xinran, H. (2020, December). The Influence of College Students' Self-Cognition and Learning Environment on Learning Concentration in Online Learning. In 2020 5th International Conference on Mechanical, Control and Computer Engineering (ICMCCE) (pp. 1850-1854).IEEE.
18	Su, C. Y., & Guo, Y. (2021). Factors impacting university students' online learning experiences during the COVID-19 epidemic. Journal of computer-assisted learning, 37(6), 1578–1590.
19	Wu, T., & Chang, M. (2021, July). The Impact and Gender Difference of Learning Motivation and Self-Regulation on Academic Performance in Online Learning Environment. In 2021 International Conference on Advanced Learning Technologies (ICALT) (pp. 425-427). IEEE.

20	Faza, A., Santoso, H. B., & Putra, P. O. H. (2021, August). Challenges and Opportunities of Online Learning Implementation During the COVID-19 Pandemic: Lecturers' Perspective. In 2021 4th International Conference on Information and Communications Technology (ICOIACT) (pp. 59-64). IEEE.
21	Yekefallah, L., Namdar, P., Panahi, R., & Dehghankar, L. (2021). Factors related to students' satisfaction with holding e-learning during the COVID-19 pandemic based on the dimensions of e-learning. Heliyon, 7(7), e07628.
22	Nambiar, D. (2020). The impact of online learning during COVID-19: students' and teachers' perspective. The International Journal of Indian Psychology, 8(2), 783–793.
23	游中雪. 疫情背景下高校学生线上学习效果的调查研究 [J]. 科学经济刊,2020, 28 (32):125-126.
24	姚丽娟,韩运侠.疫情期间对网络教学的调查及思考[J].公关世界,2020(12):9-10 版),2020,40(06):95-104. DOI:10.16401/j.cnki.ysxb.1003-6873.2020.06.083.
25	胡宝胤,刘润民.大学生疫情防控期居家网络课程学习行为调查[J].晋城职业技术学院学报,2020,13(04):12-16.
26	邬大光,李文.我国高校大规模线上教学的阶段性特征——基于对学生、教师、教务人员问卷调查的实证研究 [J]. 华东师范大学学报（教育科学版),2020,38(07):1-30.DOI:10.16382/j.cnki.1000-5560.2020.07.001

| 27 | Yu, Z. (2021). The effects of gender, educational level, and personality on online learning outcomes during the COVID-19 pandemic. International Journal of Educational Technology in Higher Education, 18(1), 14. |

APPENDIX C

(Chapter 3 AHP Method: Judgment Matrix)

Judgment matrix of B layer on A (3 experts)

Expert 1

A	B1	B2	B3
B1	1	1	9
B2	1	1	7
B3	1/9	1/7	1

Expert 2

A	B1	B2	B3
B1	1	1	1/7
B2	1	1	1/7
B3	7	7	1

Expert 3

A	B1	B2	B3
B1	1	1	1/8
B2	1	1	1/6
B3	8	6	1

Judgment matrix of C layer on B1 (3 experts)

Expert 1

B1	C1	C2	C3
C1	1	1	1
C2	1	1	1
C3	1	1	1

Expert 2

B1	C1	C2	C3
C1	1	5	1/3
C2	1/5	1	1/7
C3	3	7	1

Expert 3

B1	C1	C2	C3
C1	1	1/5	5
C2	2	1	7
C3	5	1/7	1

Judgment matrix of C layer on B2 (3 experts)

Expert 1

B2	C4	C5	C6	C7
C4	1	1	1	1
C5	1	1	1	1

107

C6	1	1	1	1
C7	1	1	1	1

Expert 2

B2	C4	C5	C6	C7
C4	1	7	8	9
C5	1/7	1	6	7
C6	1/8	1/6	1	5
C7	1/9	1/7	1/5	1

Expert 3

B2	C4	C5	C6	C7
C4	1	5	3	1/2
C5	1/5	1	1/2	1/5
C6	1/3	2	1	1/2
C7	2	5	2	1

Judgment matrix of C layer on B3 (3 experts)

Expert 1

B3	C8	C9	C10
C8	1	1/7	1
C9	7	1	7
C10	1	1/7	1

Expert 2

B3	C8	C9	C10
C8	1	7	9
C9	1/7	1	5
C10	1/9	1/5	1

Expert 3

B3	C8	C9	C10
C8	1	7	4
C9	1/7	1	1/3
C10	1/4	4	1

Judgment matrix of B layer on A (4 lectures)

lecture 1

A	B1	B2	B3
B1	1	1	1
B2	1	1	1
B3	1	1	1

lecture 2

A	B1	B2	B3
B1	1	7	5
B2	1/7	1	1/3
B3	1/5	3	1

lecture 3

A	B1	B2	B3
B1	1	3	1
B2	1/3	1	1/5
B3	1	5	1

lecture 4

A	B1	B2	B3
B1	1	8	1
B2	1/8	1	1/6
B3	1	6	1

Judgment matrix of C layer on B1 (4 lectures)

lecture 1

B1	C1	C2	C3
C1	1	1	1
C2	1	1	1
C3	1	1	1

lecture 2

B1	C1	C2	C3
C1	1	1/5	2
C2	5	1	7
C3	1/2	1/7	1

110

lecture 3

B1	C1	C2	C3
C1	1	3	1/3
C2	1/3	1	1/5
C3	3	5	1

lecture 4

B1	C1	C2	C3
C1	1	1/6	1
C2	6	1	6
C3	1	1/6	1

Judgment matrix of C layer on B2 (4 lectures)

lecture 1

B2	C4	C5	C6	C7
C4	1	1	1	1
C5	1	1	1	1
C6	1	1	1	1
C7	1	1	1	1

lecture 2

B2	C4	C5	C6	C7
C4	1	5	6	6
C5	1/5	1	3	2

111

| C6 | 1/6 | 1/3 | 1 | 1 |
| C7 | 1/6 | 1/2 | 1 | 1 |

lecture 3

B2	C4	C5	C6	C7
C4	1	1	1	1
C5	1	1	4	1
C6	1	1/4	1	1
C7	1	1	1	1

lecture 4

B2	C4	C5	C6	C7
C4	1	1	1	6
C5	1	1	1	6
C6	1	1	1	6
C7	1/6	1/6	1/6	1

Judgment matrix of C layer on B3 (4 lectures)

lecture 1

B3	C8	C9	C10
C8	1	1	1
C9	1	1	1
C10	1	1	1

112

lecture 2

B3	C8	C9	C10
C8	1	1/3	1/3
C9	3	1	1
C10	3	1	1

lecture 3

B3	C8	C9	C10
C8	1	1/5	1
C9	5	1	5
C10	1	1/5	1

lecture 4

B3	C8	C9	C10
C8	1	1/6	1/6
C9	6	1	1
C10	6	1	1

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