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Evaluating the Effectiveness of e-Learning Platform and Conventional Learning: A Case Study in Moodle

Cheng-Hsiang Tsao*, Nai-Bin Hsu &Shun-Chuan Ho

Digital Technology Innovation and Management Yuanpei University of Medical Technology

***Corresponding author:** Cheng-Hsiang Tsao, Digital Technology Innovation and Management Yuanpei University of Medical Technology.

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Abstract

Following the World Health Organization's (WHO) declaration in March 2020 that the COVID-19 outbreak had become a global pandemic, the world witnessed a peak period of school closures across numerous nations. At its height, 192 countries had suspended in-person classes, impacting over 90% of the global student population. During the pandemic, many students spent the majority of their time at home, reducing their frequency of going out and thereby altering their previous study habits. While students typically attend classes on campus, the pandemic necessitated a shift toward staying at home and utilizing digital learning as a substitute. A defining characteristic of digital learning is that it liberates learners from the constraints of time and space, allowing them to study autonomously and according to their own preferences. Furthermore, driven by advancements in internet speeds and the widespread application of web technologies, online instruction and learning have become increasingly prevalent. This study investigates how learning outcomes vary based on different instructional methods—specifically, by examining students' experiences utilizing digital learning platforms versus traditional classroom settings, and by analyzing how instructors employ the Moodle digital learning platform. The primary objective is to determine whether the application of the Moodle digital learning platform can effectively enhance learning outcomes within a course on Statistical Analysis. This research employs a quasi-experimental design. The study participants were students enrolled in the Department of Information Management at a university of science and technology in Hsinchu City; notably, none of these students had previously utilized a digital learning platform to study the course on Statistical Analysis Applications. For this study, a single class was selected and divided into two groups: one group utilized the Moodle digital platform to assist instruction (the experimental group), while the other employed traditional teaching methods (the control group). Following a 15-week implementation period, the students in both groups were assessed to determine whether there were significant differences across four major dimensions of learning effectiveness: Reaction, Learning, Behaviour, and Results. The research results indicated that the F-values for the different learning modes across the four dimensions—Reaction, Behaviour, Learning, and Results—were 3.333, 1.776, 1.551, and 1.488, respectively. The corresponding significance (p) values were 0.950, 0.210, 0.239, and 0.248; none of these values reached the conventional significance level of $p < 0.05$. This suggests that there was no significant difference in learning effectiveness between the learning mode utilizing a digital learning platform and the traditional teaching mode.

Keywords: Digital Learning, Learning Effectiveness, Moodle, COVID-19.

Introduction

According to the 2019 Digital Opportunity Survey Report published by the National Development Council (NDC), the survey population consisted of domestic citizens aged 12 and older. Conducted from July 2 to August 30, 2019 (Year 108 of the Republic of China calendar), the study employed computer-assisted telephone interviewing to randomly sample 13,015 valid respondents nationwide. With a confidence level of 95%, the sampling error fell within a margin of ±0.9%. The household internet connectivity rate in Taiwan rose from 84.9% in 2018

(Year 107) to 90.4% in 2019 (Year 108)—an increase of 5.5 percentage points—surpassing the 90% threshold for the first time and reaching an all-time high.

As the number of mobile devices proliferates and internet technologies continue to advance, an increasing number of people are becoming familiar with the concept of digital learning; consequently, the impact of mobile devices on the learning process is becoming ever more profound. As mobile devices and wearable technologies emerge as the new paradigm, the very nature of mobile learning is undergoing a transformation; in response, a growing volume of educational content is being developed to leverage the inherent strengths of these technologies to maximum effect.

The primary objective of integrating technology into instruction is to enhance student learning. When incorporating technology into their teaching practices, educators require a theoretical foundation to guide their efforts. Such a foundation enables teachers to internalize these principles as core pedagogical beliefs, thereby influencing their attitudes, willingness, and actions, and ultimately facilitating the effective implementation of technology-integrated instruction. Therefore, understanding the characteristics of digital learning—and identifying which instructional materials are suitable for integration into digital learning platforms—constitutes a critical imperative for contemporary educators. From the perspective of digital learning's evolution, computing devices have trended toward greater portability and mobility; this shift has fostered increased opportunities for utilizing digital instructional materials and has expanded the range of environments in which learning can take place. Furthermore, the widespread adoption of wireless communication technologies has enabled the broad application of learning modalities that were previously difficult to implement. Concurrently, advancements in multimedia and sensor technologies have resulted in digital instructional materials that are presented in more dynamic and engaging formats, featuring richer modes of human-computer interaction [1, 2].

Accordingly, this study aims to employ a combination of literature analysis and survey methodology—drawing upon the findings of relevant scholarly research—to investigate the adoption of the Moodle digital learning platform. Specifically, the study seeks to examine the challenges encountered by faculty members at higher education institutions during their use of the platform, and to determine whether such usage effectively enhances instructional efficacy, thereby leading to improved student learning outcomes.

This chapter is divided into six sections:
Section 1, covers the research background
Section 2, research motivation
Section 3, research objectives
Section 4, the research process
Section 5, definitions of terms
Section 6, research limitations.

Research Background
Originating in the United States in the 1990s, the Internet rapidly expanded across the globe; its boundless reach has enabled the realization of the ideals of open education. Currently, as the functionalities of digital learning platforms become increasingly comprehensive, the teaching activities of instructors and the learning processes of students have become more closely integrated with the Internet. Furthermore, online learning methods have transcended the traditional spatial and temporal constraints inherent in conventional instruction. The convenience and practicality of implementing formative assessments online have significantly enhanced their effectiveness; consequently, educators are increasingly moving away from traditional paper-and-pencil tests to fully leverage the benefits offered by online formative assessments.

In 2002, the Massachusetts Institute of Technology (MIT) became the first institution to systematically and institutionally publish its university course materials online for free public access and use, designating this initiative as "Open Course Ware" (OCW) [3].

Beginning in 2006, the College of Science at National Yang Ming Chiao Tung University (NYCU) initiated the promotion of Open Course Ware (OCW). This initiative expanded to encompass the entire university curriculum by 2008, leading to the establishment—under the Office of Academic Affairs—of the nation's first Open Education Office (OEO). The OEO is specifically tasked with the construction and planning of NYCU's OCW system, the integration and utilization of open digital educational resources, and research into fundamental strategies for open education. Moreover, it aims to facilitate the sharing of instructional resources among educational institutions and to provide students—as well as self-learners—with access to a broader spectrum of learning content, spanning the evolution from Open Course Ware (OCW) to the well-established Massive Open Online Courses (MOOCs). Open Course Ware not only facilitates the open sharing of resources but also integrates with emerging trends in mobile learning and cloud services, thereby evolving into a highly convenient and accessible model for digital learning [4].

Over the past few months, the COVID-19 virus has disrupted the economic and political landscapes of nations worldwide, and has—quite literally—upended the daily lives of nearly everyone on the planet. The educational challenges resulting from school closures have impacted every family member and have, in turn, caused economic downturns across numerous industries. Faced with this sudden and drastic shift, governments and schools naturally turned to "online learning" as the immediate solution for students unable to attend classes in person, coining the resounding slogan: "Classes Suspended, Learning Continues [5]."

In this context, Moodle—an open-source e-learning platform widely embraced by domestic academic institutions—has been uniquely positioned to demonstrate the inherent advantages of digital learning. However, while there is an abundance of existing research demonstrating how Moodle can enhance learning outcomes, its practical implementation within actual educational settings faces significant challenges. For instance, some teachers have conducted periodic monthly experiments utilizing Moodle's instructional modules—efforts that clearly resulted in improved student learning outcomes. Yet, once the experimental phase concluded, these teachers often ceased using the platform; this led to a precipitous drop in Moodle usage rates, ultimately

resulting in its complete abandonment. Consequently, this study aims to investigate the issues of low usage rates and platform abandonment. Specifically, it explores whether the continued utilization of the Moodle learning platform can facilitate the transformation of educational curricula, reignite professional educators' willingness to adopt the technology, and ultimately enhance student learning outcomes [6-10].

Research Motivation

During the researcher's own undergraduate years, digital learning platforms were already in existence. As a "front-line learner" myself, I observed that teachers were required to ful fill roles extending far beyond simply instructing a specific subject; they were also tasked with executing various educational initiatives and administrative duties. Consequently, the actual time available for direct instruction was often severely compressed. Within the classroom environment, the utilization rate of digital learning platforms remained relatively low; for the majority of educators, the traditional "lecture method" remained the most direct and preferred mode of instruction. However, this approach frequently encounters a critical challenge: when students lack strong self-discipline regarding their daily routines—leading to frequent absences or tardiness—they struggle to keep pace with the curriculum. Furthermore, for students with low intrinsic interest in the subject matter or limited classroom engagement, this traditional instructional method often fails to facilitate the attainment of learning objectives [7-12].

Consequently, instructors have utilized digital learning materials to provide students with greater learning flexibility, ensuring that they do not miss out on course content due to tardiness or absenteeism. However, while the use of digital learning platforms and similar instructional tools has generally met with a positive reception, its actual impact on enhancing learning outcomes remains limited. For instance, some systems offer opportunities for bonus points once a student accumulates a certain number of online hours; this incentive often leads students to simply log in while engaging in unrelated personal activities, thereby undermining their self-discipline and making it even more difficult for them to effectively master the course material. Driven by a desire to boost student interest and improve learning outcomes, the researchers hypothesized that leveraging the Moodle digital learning system to facilitate course-related discussions might serve as an effective strategy for enhancing students' overall learning performance[13-17].

Research Objectives

Globally, there are currently nearly 80,000 active Moodle systems in use; in Taiwan alone, at least 40 university campuses utilize the Moodle digital teaching system. By leveraging the course exchange standards already established within the Moodle system, these campus-based systems can easily and rapidly exchange course content with other instructional platforms, thereby facilitating interaction and exchange between open educational platforms and campus-specific digital teaching systems. Due to the impact of the COVID-19 pandemic, many educational institutions established remote teaching mechanisms during the first half of this year to meet the demands of home-based learning. The Moodle digital learning platform has played a pivotal role in creating effective online learning environments and offering distinct pedagogical advantages [18-22].

In light of the pandemic—which has prevented international students from returning to campus for classes—this presents a timely opportunity to examine the benefits of the Moodle digital learning platform from a highly practical perspective. This examination encompasses various aspects, such as course material planning, regular assignments, examination formats and grading methodologies, practical exercises, and internships; furthermore, the platform serves as a vital medium for facilitating interaction and communication between instructors and students. The pandemic raises critical questions: Has it accelerated the transformation of future educational paradigms? How must instructors and students adapt their approaches to "teaching" and "learning"? And how can they leverage their familiarity with technology—harnessing its power—to enhance both the breadth and depth of student learning? The objectives of this study are as follows:

1. To analyze the current status of instructor-student interaction and communication facilitated through learning platforms.
2. To investigate the specific patterns and characteristics of students' engagement with online teaching strategies.
3. To identify and understand the primary outcomes and effectiveness of students' learning experiences within an online educational environment.
4. To compare and contrast the learning outcomes associated with traditional teaching methods versus those achieved through online learning systems.
5. To examine the challenges and difficulties students encounter regarding the development and implementation of online teaching, and to explore potential solutions to address these issues.

Research Process

Traditional educational models have historically been predominantly lecture-based. Although educational authorities have continuously advocated for the integration of information technology into instruction—aiming to make educational methods less monotonous—such integration often amounts to merely updating teaching tools and techniques. Consequently, the underlying pedagogical strategies frequently remain expository in nature; the instructor remains the primary agent of the learning process, while student learning remains largely passive, making it difficult for students to independently develop their own cognitive understanding of specific subject matters [23,24].

The research process for this study is illustrated in Figure 1-1 and comprises the following steps:

Confirmation of the Research Topic: Formulating the specific research topic based on the challenges and issues encountered during the instruction of a statistics analysis course.

Literature Collection and Organization: Collect and organize literature relevant to the subject of this study, identifying variables associated with learning outcomes and learning satisfaction in statistics analysis courses.

Development of Research Framework and Hypotheses: Formulate the research hypotheses for this study based on the findings derived from the literature review.

Design of Assessments and Questionnaires: Design questionnaires tailored to the research objectives, covering the four dimensions of evaluation: Reaction, Learning, Behavior, and Results.

Experimentation: Conduct the actual experiment for this study; the experimental process includes selecting participating classes, delivering instruction, assessing learning outcomes, and administering satisfaction surveys.

Data Analysis: Process and analyze the data obtained from the assessments and questionnaires to test the research hypotheses.

Conclusions and Recommendations: Present the findings and offer recommendations based on the results of the data analysis.

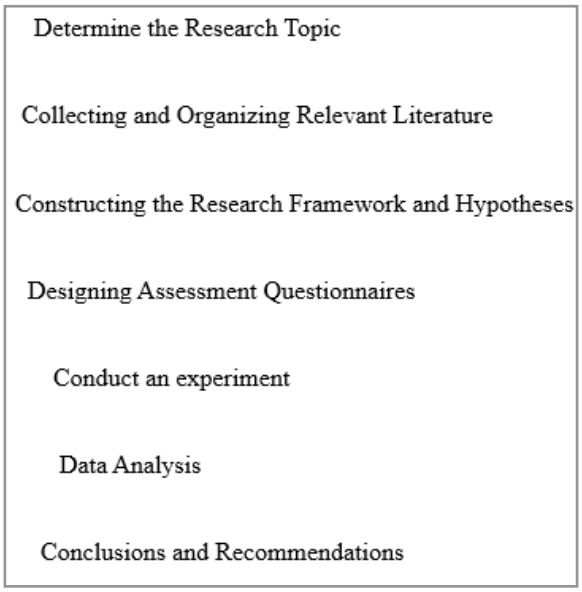

Figure 1: Research Flowchart

Consequently, student-centered educational strategies have emerged in response to evolving needs. While establishing a truly student-centered learning environment is challenging within the confines of traditional campus settings, the continuous advancement of information technology—and the resulting widespread adoption of online learning—has provided a solution. Through digital learning platforms, students can now explore topics of interest without being constrained by the limitations of time and space [25-27].

This study aims to investigate the learning effectiveness associated with the use of the Moodle digital platform amidst the COVID-19 pandemic. It conducts a comprehensive comparative analysis between traditional learners and those utilizing Moodle, addressing the following key questions:

1. Prior to the pandemic, did students possess any awareness or understanding of the various forms of distance education or online instruction?
2. During the pandemic, what specific conveniences or advantages do existing instructional software tools offer for learning?
3. Amidst the pandemic, what are students' expectations regarding the performance and effectiveness of the Moodle online learning platform?
4. What specific factors influence students to accept and adopt the Moodle platform as an instructional tool?

By exploring these questions, this study seeks to propose a conceptual framework for the information architecture of effective digital learning platforms. This framework aims to provide a suitable set of guidelines for developers and designers when constructing and configuring such platforms, thereby enabling more individuals to experience the convenience of digital learning and making a tangible contribution to the field of digital education [28-30].

Definition of Terms

Digital Learning

Based on information provided by Wikipedia, the following common characteristics of digital learning can be identified:

1. It constitutes a mode of distance education.
2. It utilizes digitized learning resources.
3. It employs various media—such as broadcasting, interactive television, CD-ROMs, and the Internet—to deliver instructional materials.
4. It primarily relies on Internet-based user interfaces.
5. It can be conducted either synchronously (in real-time) or asynchronously (at one's own pace).

Moodle Digital Learning Platform

Moodle is a free, open-source Learning Management System (LMS) written in PHP and distributed under the GNU General Public License [31].

Open Courseware (OCW)

Beginning in 2001, the Massachusetts Institute of Technology (MIT) made all course-related materials available online under the designation "MIT Open Course Ware." This initiative serves as a free and open educational resource, accessible to institutions, students, and self-learners worldwide.

MOOCs

MOOCs (Massive Open Online Courses) are also known as large-scale open online courses. These are massive, interactive, and open-access courses delivered via the internet, allowing anyone interested in taking the courses to register and enroll.

COVID-19

The COVID-19 pandemic is a global outbreak caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2).

Research Limitations

The limitations of this study are outlined as follows:

1. The photographs, images, research reports, historical data, and literature collected for this study were all obtained from publicly available documents. There was a relative scarcity of unpublished research reports and data, which constitutes the primary limitation of this study.
2. This study focused specifically on domestic samples, questionnaire topics, and target user groups relevant to Moodle usage. It explored how faculty members at this institution utilize Moodle within an educational environment, examining their perceptions of its value and their motivations for adoption. Consequently, the findings of this study cannot be generalized to other contexts [32,33].

Literature Review

"Online education," a phenomenon that has surged in recent years, constitutes an integral part of the "knowledge economy." Relative to other sectors, both the supply and demand within this industry are comparatively resilient to external shocks. Furthermore, amidst the spread of epidemics such as COVID-19, certain forms of "home-based learning" have gained momentum; digital learning is one such form—serving, in essence, as an "alternative solution" for times when physical mobility is restricted. This paper aims to further analyze the distinct characteristics of this mode of learning [34-36].

Digital learning possesses several key characteristics

It is currently in a phase of rapid growth; it is characterized by transparency and high levels of competition; and it facilitates rapid acquisition of knowledge. Within the education sector, the spectrum ranges from traditional brick-and-mortar schools to modern formats such as online video tutorials and podcasts. The former—traditional schooling—represents a mature format with limited room for further growth; from a pragmatic standpoint, it faces challenges such as declining adolescent populations, a shrinking number of schools, and fixed operating costs, relying heavily on government policy support. The latter formats, conversely, transcend traditional constraints regarding time, age, occupation, and the variety of courses available for selection. This chapter is divided into four sections, providing an explanation of learning outcomes, the definition of digital learning, Learning Management Systems (LMS), and the Moodle digital learning platform [37-40].

Learning Outcomes

Learning outcomes are defined as the indicators of students' learning achievements. The standard for measuring learning outcomes is to enable students to understand the status of their own learning, and to serve as a basis for teachers to improve their instruction and for students to enhance their learning strategies (Guay, Ratelle, & Chanal, 2008). Regarding the factors that influence learning outcomes, numerous studies have been conducted. A synthesis of the factors identified by various domestic and international sources in recent years is presented in Table 1.

Table1: Factors Influencing Learning Outcomes

Year	Author	Factors Influencing Learning Outcomes
2010	Wang Ru-zhe	First, giving equal consideration to both "direct" and "indirect" student learning outcomes. Second, placing equal emphasis on the distinct dimensions of student learning outcomes—namely, the "cognitive," "affective," and "psychomotor" domains. Finally, encompassing student learning outcomes across three distinct levels: the "institutional," "programmatic," and "classroom" levels.
2020	Chen Mei-ching	Factors across the dimensions of policy, implementation, consensus-building, time management, and action execution all collectively influence the results of learning outcomes.
2020	Wang Bo-yuan	The utilization of mobile learning models demonstrably yields superior learning outcomes compared to traditional learning methods; furthermore, the interactive component of such classrooms serves to strengthen relationships among students as well as between teachers and students, thereby fostering a warmer and more engaging classroom atmosphere.
2020	Wu Ming-jun	In the experimental group—where learning strategies were arranged in an adaptive manner—learners were enabled to follow an appropriate learning sequence and engage with instructional materials aligned with their individual learning strategies. This approach not only reduced the time required for learning but was also accompanied by positive emotional engagement, ultimately leading to excellent learning outcomes.

Continued on next page.

Table: 1 Factors Influencing Learning Outcomes (Continued)

2020	Zhou Yu-cheng	Regarding learning satisfaction in classrooms where information technology is integrated into instruction, male students reported higher levels of satisfaction than female students. The integration of information technology into teaching practices was found to provide significant assistance in enhancing student learning outcomes. However, students' information literacy did not appear to moderate or amplify the impact of learning satisfaction on learning outcomes.
2020	Guo Jia-zhen	This study explores how various programming instruction methods influence the learning outcomes of fourth-grade elementary school students, specifically examining their impact on knowledge comprehension, knowledge application, and practical performance.

Chen Mei-ching (2020) investigated the impact of energy education on learning outcomes. The study found that teachers' perceptions of students' learning outcomes—specifically regarding "energy cognition"—were positively correlated with both "energy attitudes" and "energy behaviors," reaching a level of statistical significance. Furthermore, a moderate positive correlation was observed between students' own "energy cognition" and "energy attitudes," also reaching a level of statistical significance. A moderate positive correlation was also found between "teachers' assessments of student learning outcomes" and "students' actual learning outcomes" specifically in the domain of energy behaviors, reaching a level of statistical significance. Re-

garding school background variables, no significant differences were observed in energy education—specifically concerning support systems, instructional strategies, and overall or specific dimensions of learning outcomes—across schools of different sizes. However, regarding school location variables, significant differences in learning outcomes were observed: the average learning outcomes in "special municipalities" were higher than those in "general counties and cities." Regarding teacher background variables, no significant differences in energy education outcomes were found across teachers with different professional backgrounds, educational levels, or job roles [41].

Wang Bo-yuan (2020) examined the core characteristics of mobile learning—specifically ubiquity, portability, hybridity, personalization, interactivity, collaboration, and information immediacy—and demonstrated their effectiveness within the context of a classroom experiment. The results of the analysis revealed that, compared to traditional learning models, the mobile learning model produced statistically significant differences across various dimensions, including learning motivation, learning attitudes, satisfaction with the learning model, and overall learning outcomes. This indicates that the mobile learning model is indeed superior to the traditional learning model.

Wu Ming-jun (2020) analysed the results of a study involving an experimental group that utilized an adaptive learning strategy. By arranging learning materials in a sequence tailored to each learner's specific strategies, the approach allowed students to engage with content that best suited their individual learning styles. This not only reduced the time required for learning but was also accompanied by positive emotional states during the learning process, ultimately leading to superior learning outcomes.

Zhou Yucheng (2020) investigated learning satisfaction regarding the integration of information technology into instruction, finding that male students reported higher levels of satisfaction than female students. Furthermore, whether or not students engage in online learning exerts an influence on the integration of information technology into instruction, learning satisfaction, and learning outcomes. The more extensively teachers utilize information technology in their instruction, the greater the students' learning satisfaction and the better their learning outcomes. The integration of information technology into instruction provides significant assistance in enhancing students' learning outcomes; however, students' information literacy does not appear to amplify the impact of learning satisfaction on learning outcomes [42].

Guo Jiazhen (2020) examined learning outcomes across various dimensions. In terms of knowledge comprehension, the function-oriented learning group outperformed the context-oriented learning group. Regarding knowledge application, when a function-oriented approach was adopted, the problem-guided group demonstrated superior learning performance compared to the procedure-guided group; conversely, when a problem-guided strategy was employed, the function-oriented learning group outperformed the context-oriented learning group. In terms of practical performance, when a context-oriented approach was adopted, the problem-guided group outperformed the procedure-guided group; conversely, when a procedure-guided strategy was employed, the function-oriented learning group outperformed the context-oriented learning group. Regarding learning attitudes, learners across all experimental groups maintained positive learning motivation toward the micro: bit microcontroller programming activities. Specifically, when a procedure-guided strategy was employed, learners in the context-oriented learning group perceived a higher degree of learning helpfulness and satisfaction compared to those in the function-oriented learning group [43].

Synthesizing the aforementioned literature, it can be observed that factors influencing learning outcomes include self-cognition, learning attitudes, and learning behaviors. Several studies indicate a positive correlation between learning cognition and learning outcomes, suggesting that learning cognition exerts an influence on the effectiveness of learning.

In his research, Kirkpatrick (2006) proposed a four-level model for evaluating effectiveness (the four-level training evaluation model). These four levels serve to assess the overall impact and value of a specific program or developmental process, thereby providing a framework for evaluating its performance. The four levels are: Reaction, Learning, Behavior, and Results [44].

The "Reaction" level refers to the degree of learners' liking or approval regarding the learning course, encompassing their satisfaction with aspects such as the planning of course topics, the instructor's professional expertise, and the scheduling of the course sessions.

Satisfaction regarding course scheduling and similar factors. The Learning level refers to whether students or learners have acquired specific knowledge and skills—such as principles, definitions, factual outcomes, practical skills, and observational attitudes. The Behavior level assesses whether learners demonstrate a change in their conduct following the completion of their studies. The Results level, conversely, measures the extent to which learners apply the acquired learning content in practice. Evaluating the Results level is particularly challenging; this is because it is difficult to definitively attribute changes in organizational effectiveness to specific training activities—whether singular or multifaceted—making it inherently difficult to systematically and objectively measure tangible outcomes.

In the context of this study, the assessment of learning effectiveness within a digital learning environment focuses primarily on three levels of Kirkpatrick's (2006) evaluation model: Reaction, Learning, and Behavior. The Reaction level is measured using a "five-point Likert scale" to gauge the degree of students' agreement with or satisfaction regarding the digital learning experience. The Learning level employs "knowledge acquisition" as its metric, assessing the extent to which students have absorbed the principles, facts, skills, and attitudes presented in the digital learning curriculum. Finally, the Behavior level utilizes "skill enhancement" as its metric, measuring the degree to which students apply the knowledge and skills acquired through digital learning in practical settings [45].

Digital Learning

The Evolution of Digital Learning

The American Society for Training and Development (ASTD) broadly defines digital learning as: "An application process that

integrates web-based learning, computer-based learning, virtual classrooms, and digital collaboration, utilizing various media—such as the Internet, audio/video tapes, satellite broadcasts, interactive computers, and optical discs—to deliver instructional materials and facilitate learning."

The development of digital learning in Taiwan has progressed through several distinct phases. During the 1960s and 1970s, Computer-Assisted Instruction (CAI) began to emerge domestically, as the educational sector started utilizing computers to support instructional activities. By the late 1980s, the application of multimedia technologies flourished, marking a significant advancement in the field of information education. (Information Education) became mainstream. In the mid-1990s, driven by the boom of the Internet, the education sector began leveraging the unique characteristics of the web to develop various instructional models—such as "Distance Learning," "Online Learning," "Web-Based Learning," and "Network Learning." During this same period, the concepts of "Digital Learning" and "Electronic Learning" also gradually took shape [46].

Fueled by advancements in networking and technology, digital learning has continuously progressed and evolved; consequently, today's learning concepts and methodologies differ vastly from those of the previous century. The field has transitioned from its first generation—characterized by digital courseware delivered via standalone personal computers—to the currently booming era of mobile learning. Concurrently, the pedagogical focus has shifted from being teacher-centric to adopting student-centered instructional approaches. Since the turn of the 21st century, with the advent of the wireless internet era, the tools facilitating online learning are no longer confined to desktop computers; e-books, tablet computers, and smartphones have all become viable instruments. As a result, "Distributed Learning," "Mobile Learning," and "Ubiquitous Learning" have emerged as the dominant paradigms within the realm of digital learning.

In mid-March 2020, the World Health Organization (WHO) declared that the COVID-19 outbreak had escalated into a global pandemic. This announcement coincided with the peak period of school closures across nations worldwide; at the height of the crisis, 190 countries had suspended in-person classes, impacting over 90% of the global student population. Due to the pandemic, all physical school-based activities were compelled to transition entirely to online environments. Consequently, various digital learning platforms witnessed significant growth in their user bases. A notable example is Chegg—a U.S. educational technology firm that provides textbook rental and online learning services to higher education students—where online services now account for over 80% of the company's total revenue. Furthermore, in the second quarter of 2020, the number of online learning subscriptions surged by 67% compared to the same period the previous year. Future trends in education are expected to move toward the vertical integration of "one-stop-shop" digital platforms, while simultaneously enhancing data collection capabilities to better accommodate the increasingly diverse learning preferences of students [47].

Methods of Digital Learning

Learning can be broadly categorized into two types: a narrow definition and a broad definition. A narrow definition of learning describes it as the process of acquiring knowledge or skills through various means—such as reading, listening to lectures, research, observation, comprehension, exploration, experimentation, and practice. It is a mode of behaviour that enables an individual to undergo continuous transformation (specifically, the improvement and elevation of knowledge, skills, methods, processes, emotions, and values). An example of this is the process of acquiring knowledge through formal schooling. A broader definition of learning characterizes it as a relatively enduring change in behaviour—or behavioural potential—that occurs as an individual gains experience throughout the course of life.

To truly understand digital learning, it is best to engage in it firsthand; only through such experiential participation can one fully grasp its inherent characteristics. Nevertheless, before delving into a deeper exploration, it is necessary to establish a simple working definition. Wikipedia (wikipedia.org) offers the following definition: "Electronic learning (or e-Learning or eLearning) is a term where the student and the teacher use online technology to interact and participate. No in-person interaction takes place." Based on this definition, online technology serves as the indispensable tool for those participating in digital learning. Furthermore, in its purest form, digital learning involves no direct, face-to-face human interaction; instead, all interaction must take place within an environment mediated and constructed by technology. Simply put, digital learning is a mode of learning conducted through the use of online technologies [48].

Since digital learning transcends the constraints of the traditional physical classroom, the instructional environment it creates is commonly referred to as a "Virtual Classroom." In synchronous instructional activities, both teachers and students must communicate simultaneously via an online platform, utilizing audio, video, and various other presentation formats to achieve their pedagogical objectives. In asynchronous instructional activities, teachers and students are not required to be online at the same time; consequently, effective instructional design is essential to pre-configure specific learning activities and employ asynchronous collaborative learning techniques to attain the desired educational outcomes.

Self-regulated learning constitutes another distinct form of digital learning, wherein learners utilize resources available within the virtual classroom—such as online course materials—to engage in independent study. However, for this approach to be effective, the instructional materials themselves must be designed with features that facilitate self-study, thereby guiding the learner in establishing an appropriate and manageable pace for their learning progression.

Learning Management System

Basic Architecture of the Learning Management System

The Learning Management System (LMS) serves as a virtual learning space for use outside of regular class hours. In addition to facilitating interaction between teachers and students, the system records students' learning trajectories and performs statistical analyses. By utilizing this data, teachers can gain insights into their students' learning status and effectiveness, thereby assisting them in identifying more suitable instructional models. Figure 2 illustrates the basic architecture of the Learning Management System [49].

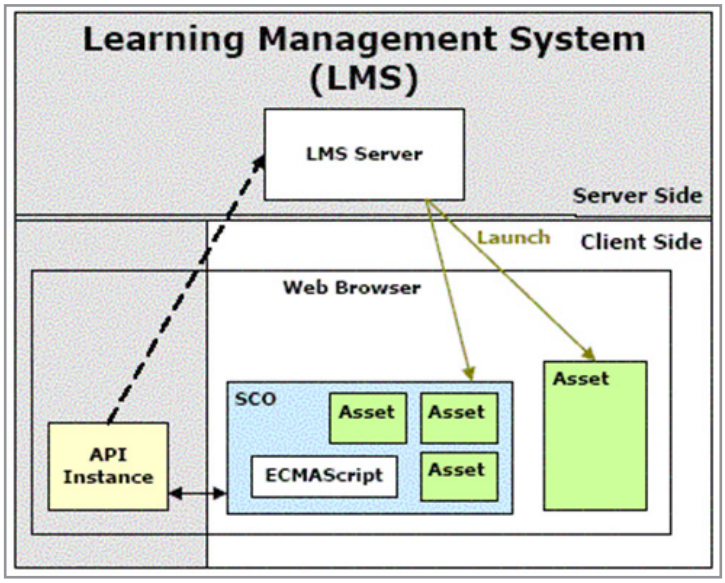

Figure 2: Basic Architecture of a Learning Management System

The functionalities of an LMS encompass the management of various instructional activities, course participants (e.g., instructors, teaching assistants, students, etc.), courses, instructional materials, assignments/quizzes, and learning progress records. Different users possess varying levels of access privileges; user roles can be broadly categorized into three types: Course Administrators, Instructors, and Students. An individual may hold the dual role of both Course Administrator and Instructor.

The functionalities required by administrators primarily involve configuring course-related data and settings, with minimal direct interaction with students. Instructors, conversely, require tools to manage instructional materials, assignments/quizzes, and teaching activities. Furthermore—specifically regarding student interaction—instructors can utilize learning progress data to analyze and derive students' "Learning Patterns," thereby gaining insights into their learning status and performance. Students, for their part, primarily engage in the various instructional activities designed by the instructor—such as participating in discussion forums and submitting assignments and quizzes [50].

Current Developments in Learning Management Systems

The digital learning environment is built upon a Learning Management System (LMS). An LMS encompasses a wide range of learning-related functions, including learning resources, instructional management, and interactive platforms. The following section compiles a list of both commercial and non-commercial LMSs, summarized in Table 2.

Table 2: Contemporary Learning Management Systems

Cloud-based Learning Management Systems	Open-source Learning Management Systems
Docebo	Moodle
Adobe Captivate Prime	Chamilo
Talent LMS	Open edX
SAP Litmos LMS	Totara Learn
Learn Upon LMS	Canvas

Chen Nian-xing and Yang Jin-tan (2006) posit that an LMS platform comprises the following components:

(1) Course Management: responsible for the administration of courses, instructors and students, and learning assessments; (2) Media Resource Center: responsible for the management of assignments, quizzes, surveys, and grades; and (3) Virtual Classroom: utilized for conducting asynchronous online learning activities. From the perspective of users, the system is categorized into three distinct roles:

- Students log in to the LMS to access learning resources embedded within digital course materials, utilizing various learning tools to engage in learning activities; students' individual learning progress and history are recorded within the digital platform.
- Instructors log in to the LMS to provide instructional resources within the digital course materials, utilizing various teaching tools to facilitate instruction; instructors' teaching activities and history are recorded within the digital platform.
- Administrators log in to the LMS to perform system-level operations—such as basic system configuration, user account management, and database backups—utilizing various administrative management tools.

Different LMSs feature varying sets of learning tools; however, the tools listed above represent the fundamental, essential components that constitute a comprehensive Learning Management System.

Moodle Digital Learning Platform

Martin Dougiamas—the founder and lead developer of Moodle—grew up in the Australian outback during the late 1970s. His experiences working with Web CT inspired him to explore

an alternative approach to online instruction. In 1999, he began testing early prototypes of a new Learning Management System (LMS); the insights gained from this experience formed the basis of his thesis, Improving the Effectiveness of Online Learning. He registered the term "Moodle" as a trademark for Moodle Pty Ltd, and several years later, in a forum post, he explained the rationale behind the system's name [51].

In addition to being free to use, Moodle is also open-source software; this means that anyone—provided they adhere to the terms of the GPL (General Public License)—is free to modify and redistribute it. Consequently, a continuous stream of new versions and add-on modules are constantly being developed and shared, enabling users to easily construct fully functional, interactive websites. By March 2020, the platform boasted over 190 million registered users across more than 145,000 active sites.

Moodle remains an ongoing software project that is constantly being developed and refined. Recognizing that many commercial educational platforms on the market present high technical barriers—both in terms of installation and usage—and entail prohibitively high implementation and deployment costs, Martin Dougiamas sought to provide a highly usable online learning platform with significantly lower setup costs. His goal was to empower educators to easily adapt their teaching methodologies for the online environment. Consequently, when he released the software, he chose to adopt an open-source distribution model. By leveraging the GNU licensing framework, he harnessed the collective power of the online community to collaboratively develop and design new features and functionalities, thereby keeping pace with the future evolution of online learning. This approach also allows users to acquire the core software package at a very low cost—or even entirely for free—and encourages programmers, educators, and students within the online community to actively participate in the software's research, development, and improvement, ultimately driving the entire system toward ever-greater perfection [52].

Moodle System Architecture

The architecture of the Moodle digital learning system is complex (Ou Zhanjia, 2012). In the book Moodle 2.X: Usage and Module Development for Online Teaching Websites, the author outlines the various architectural components of Moodle, as summarized in Table 3:

Table 3: Moodle System Architecture Diagram

S No	Moodle System Architecture
1	Site System Administration
2	Course Block Management
3	Online Course Resource Management
4	Course Activity Management
5	Course-Specific System Administration

Moodle System Functions

The functions of the Moodle system essentially constitute the method by which website content is categorized. Since Moodle serves as an information platform enabling teachers and students to engage in teaching and digital learning activities, teachers must formulate an organized plan—guided by their specific instructional objectives—when arranging digital course materials.

The Moodle system is analysed across four major categories—Course Format, Course Structure, Course Arrangement, and Course Implementation—to facilitate the design of the analytical framework.

1. The Course Format component refers to the specific course layout selected by a teacher when creating a new course. These formats are automatically generated by the system and consist of three types: the Calendar Format (Figure 3), the Site Home Page Theme Format (Figure 4), and the Dashboard Format (Figure 5).

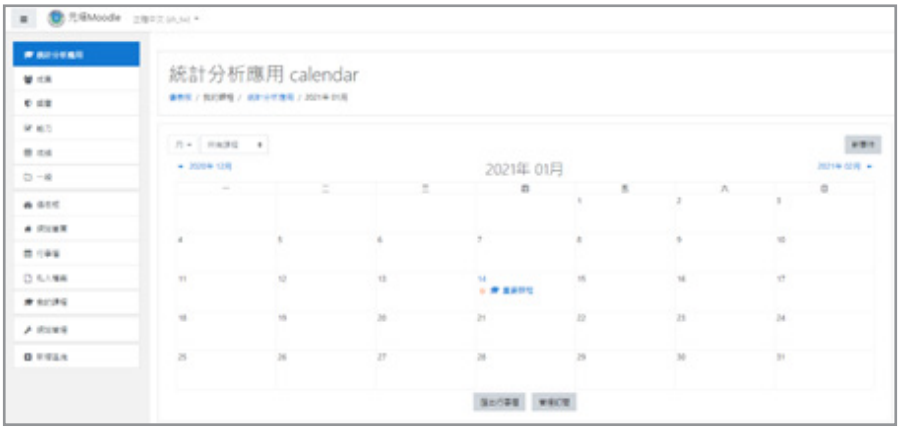

Figure 3: Calendar Format Diagram

Figure 4: Website Homepage Theme Format Diagram

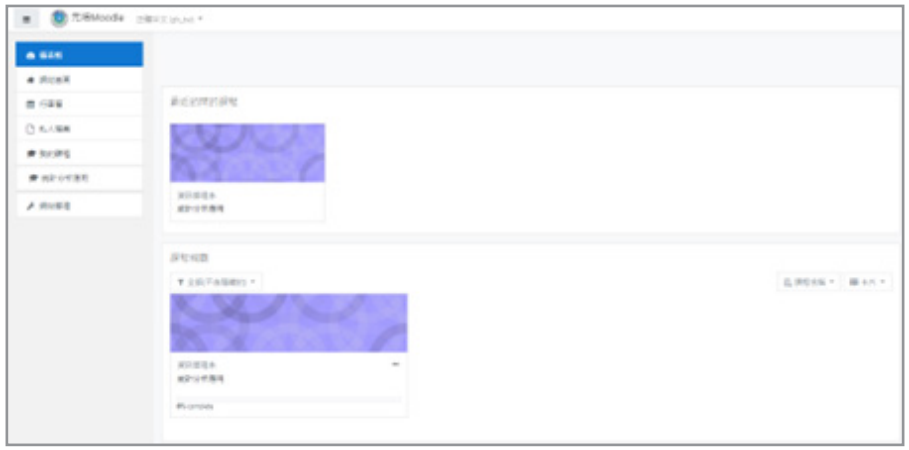

Figure 5: Dashboard Layout Diagram

The calendar adopts a traditional format, arranged week by week, with the system automatically generating clear start and end dates. Each week incorporates various learning activities; alternatively, the layout can be displayed in a monthly calendar format, or via daily planners and "upcoming events" views (as illustrated in Figure 6). The website homepage features a simple theme layout, with content displayed in the chronological order in which it was added. The dashboard interface presents key information such as learning plans, recently accessed courses, course overviews, and course categories.

Figure 6: Daily Plan and Future Events Chart

The course structure diagram (Figure 7) is designed based on the number of unit blocks and hierarchical levels within the course.

Figure 7: Course Structure Diagram

Course Structure: Figure 8 analyses how instructors arrange the content and sequence of instructional units—for instance, by organizing them according to the number of class sessions or the number of topics covered.

Figure 8: Course Arrangement Chart

Course Implementation: Section 9 focuses on planning the content features utilized by the instructor. The rationale for planning this specific aspect here is that the instructor's use of features—such as discussion forums, wikis, assignments, feedback forms, and quizzes—directly influences the presentation and layout of the course unit content.

Figure 9: Course Implementation Diagram

Features of Moodle

Ou Zhanjia (2008), in the book Moodle Mashang Hui (Moodle Made Easy), outlines the following features of Moodle:

- Moodle places a strong emphasis on security; all form submissions undergo rigorous procedures involving confirmation, data validation, and cookie encryption.
- Courses can be categorized and searched; theoretically, a single Moodle site can host thousands of courses.
- Moodle offers a high degree of flexibility, allowing it to be utilized for conducting entire courses online or simply for supplementing instruction with specific educational resources.
- It features comprehensive logging of user activity, enabling the generation of graphical reports that visualize each student's activity trends within specific modules. It also tracks details such as the IP address of the computer from which a student last logged in, the number of times they accessed content, and the posts or journal entries they submitted to the site.
- It supports the batch uploading of student profile data, thereby significantly reducing the administrative workload for instructors.
- It includes built-in functions for course backup and restoration, thoughtfully addressing the practical needs of instructors.

In addition to the features listed above, Moodle supports a wide variety of instructional material file formats, question formats, student enrolment methods, and authentication mechanisms. Furthermore, it can be installed on various operating systems (such as Windows, Linux, FreeBSD, and Unix) and paired with different databases (such as MySQL and PostgreSQL). This demonstrates the high degree of compatibility inherent in the Moodle system—a positive benefit directly attributable to its open-source nature. Of course, for secondary schools, the most significant feature of all is that it is free of charge [53].

Synthesizing the points outlined above, the development of Learning Management Systems places a strong emphasis on requirements regarding system quality; only through robust system quality can an LMS function effectively and realize its full potential in terms of enhancing learning outcomes.

Research Design and Experimental Methods

Research Framework

This chapter is divided into four sections: the first section outlines the research framework; the second section describes the research design employed in this study; the third section identifies the research subjects; and the fourth section details the research instruments.

This study aims to investigate the factors influencing learning outcomes in a course on applied statistical analysis. Learning methods are treated as the independent variable, while the learning outcomes of the applied statistical analysis course serve as the dependent variable. These learning outcomes are further categorized into four dimensions: Reaction, Learning, Behavior, and Results. Meanwhile, the instructor, instructional content, and instructional duration are designated as control variables. In the context of digital learning, this study's assessment of learning outcomes focuses primarily on Kirkpatrick's (2006) evaluation model. The Reaction level refers to the learners' degree of satisfaction with the learning course; its measurement involves assessing learners' sentiments regarding various aspects of the training program—including the course topics, instructors, and course organization. The Learning level refers to whether learners have acquired specific knowledge and skills—such as principles, facts, technical skills, and attitudes. The Behavior level assesses whether learners demonstrate changes in their conduct following the completion of the learning process. Finally, the Results level measures the extent to which learners apply the learned content [54].

The overall research framework is illustrated in Figure 3-1.

Figure 3-1: Research Framework

Based on the framework diagram, the research hypotheses formulated for this study are as follows:

H1: Different teaching methods result in significant differences in the reaction learning outcomes within the course on Applied Statistical Analysis.

H2: Different teaching methods result in significant differences in the learning outcomes within the course on Applied Statistical Analysis.

H3: Different teaching methods result in significant differences in the behavioral learning outcomes within the course on Applied Statistical Analysis.

H4: Different teaching methods result in significant differences in the results (outcomes) within the course on Applied Statistical Analysis.

Research Design

Research Planning

This study necessitated actual classroom instruction. Due to constraints regarding time, classroom availability, and fixed class rosters—which precluded the reorganization of test classes or the random assignment of students to either an experimental group or a control group—and given that the number of participants in both the experimental and control groups was fewer than 30, this study adopted a small-sample research design. Control variables included: instruction provided by the same teacher, a consistent learning environment for all participants, identical instructional content, and consistent pre-study baseline characteristics among the research subjects; these measures were implemented to minimize interference from extraneous variables during the experiment [55].

Course Content

The course examined in this study spanned a duration of fifteen weeks. Its primary objective was to equip students with operational proficiency in statistical software packages, encompassing skills such as generating statistical charts and graphs, performing descriptive and inferential statistics, conducting experimental design tests, and executing regression analysis—as well as the ability to interpret statistical data and draw conclusions. Through statistical analysis, students were expected to gain an understanding of the results and significance of research findings

Table 4: A comprehensive schedule of the course progression and the locations where instruction took place is presented in

Week	Course Topics	Implementation Site
1	Scientific Research and Quantitative Methods	Classroom (equipped with computers and projection equipment)
2	Variables and Measurement	Classroom (equipped with computers and projection equipment)
3	Data Encoding and Database Construction	Classroom (equipped with computers and projection equipment)
4	Data Verification and Preparation	Classroom (equipped with computers and projection equipment)
5	Descriptive Statistics and Visualization	Classroom (equipped with computers and projection equipment)
6	Analysis of Categorical Data	Classroom (equipped with computers and projection equipment)
7	Mean Test	Classroom (equipped with computers and projection equipment)
8	Analysis of Variance	Classroom (equipped with computers and projection equipment)
9	Multifactor Analysis of Variance	Classroom (equipped with computers and projection equipment)
10	Analysis of Linear Relationships	Classroom (equipped with computers and projection equipment)
11	Multiple Regression	Classroom (equipped with computers and projection equipment)
12	Scale Development and Issues of Reliability and Validity	Classroom (equipped with computers and projection equipment)
13	Item Analysis and Reliability Estimation	Classroom (equipped with computers and projection equipment)
14	Questionnaire Test	Classroom (equipped with computers and projection equipment)

Research Subjects

The subjects of this study were students enrolled in the Department of Information Management at a specific university of science and technology in Hsinchu City. None of these students had previously utilized a digital learning platform to study the course on "Applied Statistical Analysis." The study selected one specific class and divided it into two groups: one group utilized the Moodle digital platform to assist with instruction (the Experimental Group), consisting of two members—both male; the other group employed traditional teaching methods (the Control Group), consisting of eleven members—nine male and two female. Among the respondents who completed the questionnaire for this study, there were 11 males (accounting for 84.7%) and 2 females (accounting for 15.3%).

Research Instruments

This study employed a questionnaire survey method, utilizing an instrument titled "Analysis of Differences in Learning Effectiveness Between Digital Learning Platform Models and Traditional Teaching Models: A Survey Based on the Moodle Digital Learning Platform."

Regarding software applications, Microsoft Excel and IBM SPSS Statistics 21.0 were utilized in conjunction with one another. Furthermore, the study drew upon the methodologies outlined in the book Quantitative Statistical Research and Statistical Analysis: Case Studies Using SPSS and R to guide the data analysis process. Based on the results of this statistical analysis, the conclusions of the study were subsequently formulated.

Development of Learning Effectiveness Assessment Items

The research items were formulated by referencing relevant academic literature and textbooks, as well as by taking into account the actual context and current practices of classroom instruction.

Reaction Level

This dimension refers to the degree of affinity or preference learners hold toward the learning course itself. It encompasses three specific items, including satisfaction with the course subject matter, the instructor (lecturer), and the overall course arrangement.

Learning Level

This dimension assesses whether students or learners have successfully acquired specific knowledge and skills. It comprises four specific items, such as the acquisition of theoretical principles and definitions, factual information and results, practical skills training, and observational attitudes.

Behavior Level

This dimension evaluates whether learners have demonstrated a change in their behavior following the completion of the learning process. It consists of five specific items.

Results Level

This dimension measures the extent to which learners are able to apply the learned content in practical contexts. It consists of two specific items.

Learning Outcome Assessment Items

For the assessment of learning outcomes in the Applications of Statistical Analysis course, this study employed a paper-based questionnaire format. Assessment items were designed in accordance with the learning objectives of the course—as presented in Table 5—and the actual assessment instrument administered is provided in Appendix I [56].

Table 5: Learning Outcomes Assessment Items

Questionnaire Dimension	Responsiveness in Traditional Instruction
Objective 1	Complete the responsiveness assessment to understand the differences in responsiveness levels between traditional and digital learning platforms.
Question 1	The presentation of course topics in Statistical Analysis is simple and easy to understand.
Question 2	The Statistical Analysis course curriculum covered the anticipated content
Item 3	The teaching methods used in the statistics course are engaging and captivating
Objective 2	Complete the learning assessment to understand the differences in learning proficiency levels between traditional and digital learning platforms
Questionnaire Dimension	Learning Engagement in Traditional Instruction
Question 4	Following the statistical analysis course, my breadth and depth of knowledge regarding statistical principles have improved
Question 4	Following the statistical analysis course, my breadth and depth of knowledge regarding statistical principles have improved
Question 6	After completing the statistical analysis course, understanding the difficulty level of each unit helps clarify the direction of my studies
Item 7	It has a positive influence on attitudes toward learning statistical analysis
Objective 3	Complete the behavioural engagement assessment to understand the differences in behavioural engagement levels between traditional and digital learning platforms.
Questionnaire Dimension	Behavioural Aspects in Traditional Instruction
Item 8	Following the statistics analysis course, the duration of focused study time increased
Item 9	My learning efficiency has improved after each session of the Statistical Analysis course
Item 10	The course on statistical analysis provided significant assistance to peer-to-peer learning among students
Item 11	The statistical analysis course provided significant assistance with thesis writing
Item 12	Following the statistics analysis course, the frequency of weekly study sessions increased
Objective 4	Respond to the outcome assessment to understand the differences in outcome levels between traditional and digital learning platforms
Questionnaire Dimension	Outcome-based Aspects of Traditional Instruction
Item 13	The Statistics Analysis course has a positive impact on final grades
Item 13	The Statistics Analysis course has a positive impact on final grades

Research Procedures

This study primarily employs a questionnaire survey methodology. The questionnaire consists of two main components: the "Subject Demographic Information Survey," designed to collect basic data on the students, and the "Learning Effectiveness Assessment Questionnaire," administered to evaluate student learning outcomes. Additionally, the "Moodle Online System" serves as a key instructional tool in this study. The following sections detail the questionnaire development process, its main content, and the procedures for assessing its reliability and validity.

Questionnaire Development Process

Prior to conducting content analysis of relevant documents, a preliminary draft of the questionnaire was formulated based on the directions established during the literature review phase. This draft was subsequently submitted to a panel of experts with practical experience in education for discussion and consensus-building. Following this expert review, the questionnaire underwent a pilot test and item revisions to produce the final, formal survey instrument.

Questionnaire Formulation

The questionnaire utilized in this study—titled "Analysis of Differences in Learning Effectiveness Between Digital Learning Platform-Based and Traditional Instructional Modes" (see Appendices I and II)—was designed for student completion. Its formulation was guided by a review of relevant literature and publications—specifically referencing Chen Mei-ching's (2020)

A Study on the Relationships Among Energy Education Support Systems, Instructional Strategies, and Learning Effectiveness in Elementary Schools and Ou Chan-chia's (2008) Mastering Moodle Immediately—and was further refined by taking into account the realities of current instructional practices [57].

Expert Validity Analysis

Upon the initial formulation of the questionnaire (Appendices I and II), the items (listed in Table 3-2) were submitted to three experts and scholars for a validity analysis. The principle for item reduction was applied in a prioritized sequence: first, items that all three experts unanimously recommended for deletion were removed; second, items that two of the three experts recommended for deletion were removed. The remaining items were then adjusted in accordance with the revision suggestions provided by the supervising professor to produce the final pilot-test version of the questionnaire.

Development of Questionnaire Scales

The questionnaire employs a five-point Likert scale for scoring; the scales for each construct are presented in Table 6.

Table 6: Questionnaire for "Analysis of Differences in Learning Outcomes Across Learning Modes" Questionnaire Dimensions Measurement Tool Type Scoring Method Problem Number

Basic Information	Categorical Variable	By Option Category
Reaction	Likert Scale	Options are assigned points ranging from 5 to 1, in descending order from left to right. 1 to 3
study	Likert Scale	Options are assigned points ranging from 5 to 1, in descending order from left to right. 4 to 7
Behaviour	Likert Scale	Options are assigned points ranging from 5 to 1, in descending order from left to right. 8 to 12
Achievements	Likert Scale	Options are assigned points ranging from 5 to 1, in descending order from left to right. 13 to 14

Questionnaire Pilot Testing

For the survey titled "Analysis of Differences in Learning Effectiveness Between Digital Learning Platform-Based and Traditional Instructional Models," a pilot test was conducted involving three instructors and a total of 10 participants from a university of science and technology in Hsinchu City. The participants provided feedback regarding the clarity of the questions, wording, and arrangement of response options. Following a consolidation of this feedback and appropriate revisions, the final content of the scale was confirmed.

Questionnaire Administration

Based on the course curriculum outlined in Table 3-1, this study first proceeded with course instruction. Subsequently, at the conclusion of the course in the fifteenth week, an assessment of the participants' learning effectiveness was conducted. The assessment of learning effectiveness employed the following methods:

1. Use of a questionnaire to assess learning effectiveness in terms of reactions.
2. Use of a questionnaire to assess learning effectiveness in terms of learning.
3. Use of a questionnaire to assess learning effectiveness in terms of behaviour.
4. Use of a questionnaire to assess learning effectiveness in terms of results.

Statistical Analysis

Following the collection of the questionnaires and verification of the data, the statistical analysis method employed in this study was the Independent Samples t-test. The Independent Samples t-test is used to examine the significance of differences between two independent variables; specifically, it is applied when the independent variable is a categorical variable with multiple levels, and the dependent variable is a continuous variable used to measure differences in the sample means of the respondents.

Conclusions and Recommendations

Based on the data obtained from the analysis of differences in learning effectiveness between the digital learning platform model and the traditional instructional model, the statistical significance of the differences between various variables will be analyzed. This analysis aims to infer whether relationships exist between these variables and how they mutually influence one another. Finally, conclusions and recommendations will be proposed based on the results of the data analysis.

Analysis of Questionnaire Reliability Regarding Learning Effectiveness Differences

After distributing the survey questionnaires to the study participants, the responses were collected, preliminarily organized, coded, and entered into a computer database for data analysis. Statistical analysis was performed using SPSS 21 software. To validate the reliability of the formal questionnaire, this study utilized Cronbach's alpha (α) as the primary coefficient for reliability measurement. As shown in Table 7, the reliability analysis of the various constructs within the questionnaire revealed that the overall scale yielded a Cronbach's alpha coefficient of .904, indicating excellent stability and reliability of the questionnaire.

Table 7: Summary Table of Alpha Coefficients for Test and Questionnaire Reliability Analysis

Questionnaire Dimensions	α Coefficient
Reactions	.751
Learning	.804
Behavior	.791
Results	.755
Overall Dimensions	.904

Research Results

Differences in Learning Outcomes (at the Reaction Level) Between Traditional Instruction and Digital Learning Platforms

To determine whether there were significant differences in learning outcomes between the two groups, an independent-samples t-test was conducted. Based on the data derived from the analysis of learning outcomes—comparing the digital learning platform model against the traditional instructional model—this study examines the differences in learning effectiveness between the two groups [58].

Item: The presentation of course topics in the statistical analysis module was simple and easy to understand (Reaction Level). Referring to Table 8 (Summary of Group Statistics) and Table 9 (Summary of Independent-Samples t-Test Results), the scores for each item and their relevance to the research questions are discussed below, drawing upon the data presented in these two summary tables

Table 8: Group Statistics Regarding the Simplicity and Clarity of Course Topic Presentation in Statistical Analysis

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Fraction	Control group	11	3.2727	.64667	.19498
	Experimental Group	2	4.0000	.0000	.00000

Table 9: Independent Samples t-Test for the "Simple and Easy-to-Understand Presentation of Course Topics" in Statistical Analysis

	Equal variances Levene's Test		t-Test for Equality of Means						
Assuming Equal Variances	F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
	4.715	.053	-1.534	11	.153	-.72727	.47397	The Lower Realm -1.77046	Upper Realm .31592
			-.3730	10.000	.004	-.72727	.19498	-1.16171	-.29283

Based on the aforementioned tables, it can be observed that the means for the two samples are 3.1875 and 4.0000, respectively, and the correlation between the two samples reached F = 4.715 (p = .053). The independent samples t-value was -1.534, with p = .053; since the test result (p = .053) did not reach the conventional level of statistical significance—that is, p > .05—it indicates that there is no significant difference between the two groups of students regarding this specific question. Furthermore, based on the t-value and significance level derived under the assumption of equal variances, the test results were found to be non-significant; this suggests that there is no significant difference in questionnaire scores between the control group and the experimental group regarding their learning experiences via traditional instruction versus the digital learning platform. The conclusion for this specific item is that there is no significant difference between the two groups regarding the extent to which the presentation of statistical analysis course topics was perceived as simple and easy to understand.

Item: The course arrangement units for statistical analysis fulfilled the anticipated content (Response Aspect). Based on Table 10 (Summary of Group Statistics) and Table 11 (Summary of Independent Samples Tests), the scores for each item and their relevance to the research questions are discussed below, drawing upon the data presented in these two summary tables.

Table 10: Group Statistics for the Item "The Course Arrangement Units for Statistical Analysis Fulfilled the Anticipated Content"

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Score Experimental Group	Control Group	11	3.2727	.46710	.14084
	Experimental Group	2	3.5000	.70711	.5000

Table 11: Independent Samples t-Test for the Attainment of Intended Content within the Statistical Analysis Course Module

	Levene's Test for Equality of Variances		t-Test for Equality of Means							
Scores		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
	Not Assuming Equal Variances	.441	.520	-.599	11	.561	-.22727	.37956	-1.06268	.60813
				-.438	1.164	.729	-.22727	.51946	-4.98726	4.53272

As indicated by the aforementioned report, the means of the two samples are 3.2727 and 3.5000, respectively, and the correlation between the two samples is F = 0.441 (p = 0.520). The independent samples t-value is -0.599 (p = 0.520); since the test result (p = 0.520) does not reach the level of statistical significance—that is, p > 0.05—it indicates that there is no significant difference between the two groups of students regarding this specific test item. Furthermore, based on the t-value and significance level derived under the assumption of equal variances, the test results were found to be non-significant, implying that there is no substantial difference in questionnaire scores between the control group and the experimental group regarding their learning experiences with traditional instruction versus the digital learning platform. The conclusion regarding this specific item is that, in terms of the "Course Arrangement" unit within the statistical analysis curriculum, there is no significant difference between the two groups regarding the extent to which the content met their expectations [59].

Item: The Instructional Methods used in the Statistics Analysis course are engaging and captivating (Affective Dimension). Based on Table 12 (Summary of Group Statistics) and Table 13 (Summary of Independent Samples t-Test), the scores for each item and their relevance to the research questions are discussed below, drawing upon the findings presented in these two summary tables.

Table 12: Group Statistics for the Item: "The instructional methods used in the Statistics Analysis course are engaging and captivating"

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Fraction	Control group	11	3.0000	1.09545	.33029
	Experimental Group	2	3.5000	.70711	.5000

Table 13: Independent-Samples t-Test for the Perceived Interest and Engaging Delivery of Instructional Methods in the Statistics Analysis Course

	Levene's Test for Equality of Variances		t-Test for Equality of Means							
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
Scores									The Lower Realm	Upper Realm
	Not Assuming Equal Variances	.156	.701	-.610	11	.554	-.50000	.81944	-2.30358	1.30358
				-.834	2.025	.491	-.50000	.59924	-3.40855	2.04855

As indicated by the aforementioned report, the means of the two samples are 3.0000 and 3.5000, respectively, and the correlation between the two samples is F = 0.156 (p = 0.701). The independent-samples t-value is -0.610, with p = 0.701; since the test result (p = 0.701) does not reach the level of statistical significance—that is, p > 0.05—it indicates that there is no significant difference between the two groups of students regarding this specific test item. Furthermore, based on the t-value and significance level derived under the assumption of equal variances, the test results were found to be non-significant, implying that there is no substantial difference in questionnaire scores between the control group and the experimental group regarding their learning experiences with traditional instruction versus the digital learning platform. Consequently, the results for this specific item demonstrate that, in terms of the statistical analysis course, there is no significant difference between the two groups regarding the perception of the teaching methods as being "interesting and engaging."

Differences in Learning Outcomes Between Traditional and Digital Learning Platforms (Learning Dimension)

To determine whether there were significant differences in learning outcomes between the two groups, an independent-samples t-test was conducted. Based on the data derived from the comparative analysis of learning outcomes—specifically contrasting the digital learning platform model with the traditional instructional model—this study examines the differences in learning effectiveness between the two groups.

Item: Knowledge regarding the breadth and depth of statistical principles improved following the statistics analysis course (Learning Dimension).

Based on Table 14 (Summary of Group Statistics) and Table 15 (Summary of Independent-Samples t-Test Results), the scores for each item and their relevance to the research questions are discussed separately below.

Table 14: Group Statistics for the Item: "Knowledge regarding the breadth and depth of statistical principles improved following the statistics analysis course" Group Statistics

	Control group and experimental group	Quantity	Quantity	Standard deviation	Standard Error of the Mean
Score	Control Group	11	3.2727	.46710	.14084
	Experimental Group	2	4.0000	.00000	.00000

Table 15: Independent Samples t-Test on the Improvement in the Breadth and Depth of Knowledge of Statistical Principles Following the Statistics Analysis Course

	Levene's Test for Equality of Variances		t-Test for Equality of Means							
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
	Assume equal variances.	6.498	.207	-2.124	11	.057	-.72727	.34235	-1.48079	.02624
	Do not assume equal variances.			-5.164	10.000	.000	-.72727	.14084	-1.04107	-.41347

Based on the aforementioned tables, it can be observed that the means of the two samples are 3.2727 and 4.0000, respectively, and the correlation between the two samples yields an F-statistic of 6.498 (p = .207). The independent samples t-test result is t = -2.124 (p = .207); since the p-value of .207 does not reach the level of statistical significance—that is, p > .05—it indicates that there is no significant difference between the two groups of students regarding this specific question. Furthermore, an examination of the t-value and significance level (assuming equal variances) reveals that the test results are not statistically significant, implying that there is no significant difference in questionnaire scores between the control group and the experimental group regarding their learning experiences via traditional instruction versus the digital learning platform. The conclusion regarding this specific question is that, following the course on statistical analysis, there was no significant difference between the two groups in terms of the improvement in the breadth and depth of their knowledge of statistical principles.

Item: Proficiency in the application of statistical analysis software improved following the statistical analysis course (Learning Aspect). Based on Table 16 (Summary of Group Statistics) and Table 17 (Summary of Independent Samples Tests), the scores for each item and the relevant research questions are discussed separately below.

Table 16: Group Statistics Regarding the Improvement in Proficiency in Statistical Analysis Software Application Skills Following the Statistical Analysis Course Group Statistics

	Control group and experimental group	Quantity	Average	Standard deviation	Standard deviation
Score	Control Group	11	3.4545	.82020	.24730
	Experimental Group	2	3.5000	.70711	.5000

Table 17: Independent Samples t-Test for the Improvement in Proficiency in Statistical Software Application Skills Following the Statistical Analysis Course

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	Difference in Standard Error	
Scores Not Assuming Equal Variances	Assuming Equal Variances	.492	.497	-.073	11	.943	-.04545	.62309	-1.41687	1.32596
				-.081	1.540	.944	-.04545	.55781	-3.28256	3.19165

Based on the aforementioned tables, it can be observed that the mean scores for the two samples are 3.4545 and 3.3125, respectively, and the correlation between the two samples yields an F-value of .492 (p = .497). The independent samples t-test result is t = -.073 (p = .497); since the p-value of .497 does not reach the level of statistical significance—that is, p > .05—it indicates that there is no significant difference between the two groups of students tested regarding this specific issue. Furthermore, an examination of the t-value and significance level (assuming equal variances) reveals that the test results are not statistically significant, implying that there is no significant difference in questionnaire scores between the control group and the experimental group regarding their learning experiences via traditional instruction versus the digital learning platform. The conclusion regarding this specific item is that, following the statistics analysis course, there was no statistically significant difference between the two groups in terms of the improvement in their proficiency with statistical analysis software applications.

Item: Understanding the difficulty levels of the various units within the statistics analysis course helps clarify learning direction (Learning Dimension). Based on Table 18 (Summary of Group Statistics) and Table 19 (Summary of Independent Samples Tests), the scores for each specific item and their relevance to the research questions are discussed separately below.

Table 18: Group Statistics regarding the statement: "Understanding the difficulty levels of the various units within the statistics analysis course helps clarify learning direction" (following the statistics analysis course)

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Score	Control Group	11	3.7273	.78625	.23706
		2	4.0000	.00000	.00000

Table 19: Independent Samples t-Test on the Perceived Difficulty of Course Units Following the Statistical Analysis Course, and How This Clarifies Learning Direction

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
Fraction	Assume equal variances.	5.925	.033	.473	11	.645	-.27273	.57626	-1.54108	.99562
	Do not assume equal variances.			-1.150	10.000	.277	-.27273	.23706	-.80093	.25548

As indicated by the aforementioned report, the mean scores for the two samples are 3.7273 and 4.0000, respectively, and the correlation between the two samples reached F = 5.925 (p = .033). The independent-samples t-value was -0.473, with a p-value of 0.033; since the test result reached a significance level of .033—meaning p < .05—it indicates that there is a significant difference between the two groups of students regarding this specific question. Furthermore, based on the t-value and significance level derived from the assumption of equal variances, the test results were found to be statistically significant, indicating a distinct difference in questionnaire scores between the control group and the experimental group regarding their learning experiences—specifically, traditional instruction versus the digital learning platform. The specific finding regarding this question is that, following the statistical analysis course, the two groups differed significantly in the extent to which understanding the difficulty levels of the course's various units helped clarify their learning direction [60].

Topic: The Course in Statistical Analysis Exerts a Positive Influence on Learning Attitudes (Learning Dimension) Based on Table 20 (Summary of Group Statistics) and Table 21 (Summary of Independent Samples t-Test), the scores for each item and their relevance to the research questions are discussed below, drawing upon the findings presented in these two summary tables.

Table 20: Group Statistics Regarding the Positive Influence of the Statistical Analysis Course on Learning Attitudes

	Control group and experimental group	Quantity	Average	Standard deviation	Standard deviation
Score	Control Group	11	3.5455	1.03573	.31228
	Experimental Group	2	4.5000	.70711	.5000

Table 21: Independent Samples t-Test for the Positive Impact of Coursework on Attitudes toward Statistical Analysis

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
Fraction	Assume equal variances.	1.152	.306	-1.229	11	.254	-.95455	.77661	-2.66385	.75475
	Do not assume equal variances.			-1.619	1.903	.253	-.95455	.58951	-3.61849	1.70940

Based on the aforementioned report, it can be observed that the means of the two samples are 3.5455 and 4.5000, respectively, and the correlation between the two samples yields an F-statistic of 1.152 (p = .306). The independent samples t-test result is t = -1.229 (p = .306); as the p-value (.230) does not reach the level of statistical significance—that is, p > .05—it indicates that there is no significant difference between the two groups of students tested regarding this specific issue. Furthermore, an examination of the t-value and significance level (assuming equal variances) reveals that the test results are not statistically significant, implying that there is no substantial difference in questionnaire scores between the control group and the experimental group regarding their learning experiences via traditional instruction versus a digital learning platform. Consequently, the results for this specific inquiry indicate that there is no statistically significant difference between the two groups regarding the positive influence on their attitudes toward learning the course on statistical analysis.

Differences in Behavioural Learning Outcomes Between Traditional and Digital Learning Platforms

To determine whether there are significant differences in learning outcomes between the two groups, an independent-samples t-test was conducted. Based on the data derived from the analysis of learning outcome differences—specifically comparing the digital learning platform model against the traditional instructional model—this study examines the disparities in learning outcomes between the two groups.

Item: Increased duration of focused attention during each study session following the Statistics Analysis course (Behavioural Aspect) Based on Table 23 (Summary of Group Statistics) and Table 24 (Summary of Independent-Samples t-Test Results), the scores for each item and their relevance to the research questions are discussed below.

Table 23: Group Statistics Regarding Increased Duration of Focused Attention During Each Study Session Following the Statistics Analysis Course

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean	.24730
		2	4.5000	.70711	.50000

Table 24: Independent Samples t-Test for the Increase in Study Concentration Duration Following the Statistical Analysis Course

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
	Assumed Equal Variances	.351	.566	-1.678	11	.122	-1.04545	.62309	-2.41687	.32596
	Do not assume equal variances.			-1.874	1.540	.238	-1.04			
	545	.55781	-4.28256	2.19165						

Based on the aforementioned report, it can be observed that the means of the two samples are 3.4545 and 4.5000, respectively, and the correlation between the two samples is F = 0.351 (p = 0.566). The independent samples t-value is -1.678, with a p-value of 0.566; since the test result (p = 0.566) does not reach the level of statistical significance—that is, p > 0.05—it indicates that there is no significant difference between the two groups of students regarding this specific issue. Furthermore, an examination of the t-value and significance level (assuming equal variances) reveals that the test results are not statistically significant, implying that there is no significant difference between the control group and the experimental group regarding their questionnaire scores on learning via traditional instruction versus a digital learning platform. The conclusion regarding this specific issue is that, following the course on statistical analysis, there was no significant difference between the two groups concerning the extent to which their concentration levels improved during each learning session.

Item: Improvement in Learning Efficiency Following Each Session of the Statistics Analysis Course (Behavioral Aspect) Based on Table 25 (Summary of Group Statistics) and Table 26 (Summary of Independent Samples Test), the scores for each item and their relevance to the research questions are discussed below, drawing separately from these two summary tables.

Table 25: Group Statistics for "Improvement in Learning Efficiency Following Each Session of the Statistics Analysis Course

	Control group and experimental group	Quantity	Quantity	Standard deviation	Standard Error of the Mean
Score	Control Group	11	3.5455	.82020	.24730
	Experimental Group	2	4.0000	1.41421	1.00000

Table 26: Independent Samples t-Test for the Improvement in Learning Efficiency per Session Following the Statistics Analysis Course

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
Scores	Assuming Equal Variances	1.154	.306	-.664	11	.520	-.45455	.68470	-1.96157	1.05248
				-.441	1.126	.729	-.45455	1.03012	-10.54937	9.64028

Based on the aforementioned tables, it can be observed that the means for the two samples are 3.6250 and 3.3750, respectively, and the correlation between the two samples yielded F = 1.154 (p = .306). The independent samples t-test result was t = -.664 (p = .306); since the p-value of .306 did not reach the level of statistical significance—that is, p > .05—it indicates that there is no significant difference between the two groups of students tested regarding this specific issue. Furthermore, examining the t-value and significance level under the assumption of equal variances reveals that the test results were not statistically significant, indicating that there is no significant difference in questionnaire scores between the control group and the experimental group regarding their learning experiences via traditional instruction versus the digital learning platform. The conclusion regarding this specific item is that, following the course on statistical analysis, there was no statistically significant difference between the two groups concerning the extent to which their learning efficiency improved over time.

Table 27: Independent Samples t-Test on the Significant Contribution of the Statistics Analysis Course to Peer Learning

	Control group and experimental group	Quantity	Average	Standard deviation	Standard deviation
Score	Control Group	11	3.4545	.52223	.15746
	Experimental Group	2	4.0000	.00000	.00000

Table 28: Independent Samples t-Test on the Significant Contribution of the Statistics Analysis Course to Peer Learning

		Levene's Test for Equality of Variances		Levene's Test for Equality of Variances						
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
Score	Assuming Equal Variances	203.077	.000	-1.425	11	.182	-.54545	.38276	-1.38791	.29700
				-3..464	10.000	.006	-.54545	.15746	-.89630	-.19461

Based on the aforementioned reports, the following observations can be made: the means of the two samples are 3.4545 and 4.0000, respectively, and the correlation between the two samples reached F = 203.077 (p = .000). The independent samples t-value was -1.425, with a p-value of .000; since the test result reached a significance level of .000—meaning p < .05—it indicates that there is a significant difference between the two groups of students regarding this specific test item. Furthermore, based on the t-value and significance level derived under the assumption of equal variances, the test results were found to be statistically significant, indicating a distinct difference in questionnaire scores between the control group and the experimental group regarding their learning experiences via traditional instruction versus the digital learning platform. The result for this specific item reveals a significant difference between the two groups regarding the extent to which the "Statistical Analysis" course provided distinct assistance for peer-to-peer learning among students [61].

Item: The "Statistical Analysis" course provided distinct assistance for thesis writing (Behavioral Aspect). Based on Table 29 (Summary of Group Statistics) and Table 30 (Summary of Independent Samples Tests), the scores for each item and the corresponding research questions are discussed separately below.

Table 29: Group Statistics for the Item: "The 'Statistical Analysis' course provided distinct assistance for thesis writing"

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Score	Control Group	11	3.7273	1.00905	.30424
	Experimental Group	2	4.0000	.00000	.00000

Table 30: Independent Samples t-Test on the Perceived Significant Benefit of the Statistics Analysis Course for Thesis Writing

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
Scores	Assuming Equal Variances	5.593	.037	-.369	11	.719	-.27273	.73957	-1.90050	1.35505
	Not Assuming Equal Variances			-.896	10.000	.391	-.27273	.30424	-.95062	.40516

As indicated by the aforementioned report, the mean scores for the two samples are 3.7273 and 4.0000, respectively, and the correlation between the two samples reached F = 5.593 (p = .037). The independent-samples t-value was -0.369, with a p-value of 0.037; since the test result reached a significance level of .037—that is, p < .05—it indicates that there is a significant difference between the two groups of students assessed regarding this specific issue. Furthermore, based on the t-value and significance level derived under the assumption of equal variances, the test results were found to be statistically significant, indicating a distinct difference in questionnaire scores between the control group and the experimental group regarding their learning experiences with traditional instruction versus a digital learning platform. Specifically, the results for this particular item reveal a significant difference between the two groups regarding the extent to which the course on statistical analysis provided substantial assistance for their thesis writing.

Item: Increase in Weekly Study Frequency Following the Statistics Analysis Course (Behavioral Aspect) Based on Table 31 (Summary of Group Statistics) and Table 32 (Summary of Independent Samples Test), the scores for each item and their relevance to the research questions are discussed below, drawing upon the findings presented in these two summary tables.

Table 31: Group Statistics Regarding the Increase in Weekly Study Frequency Following the Statistics Analysis Course

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Score	Control Group	11	3.5455	.52223	.15746
		2	4.0000	1.41421	1.00000

Table 32: Independent Samples t-Test for the Increase in Weekly Study Frequency Following the Statistics Analysis Course

		Levene's Test for Equality of Variances	t-Test for Equality of Means

		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
Score	Assuming Equal Variances	209.903	.000	-.902	11	.386	-.45455	.50393	-1.56369	.65459
				-.449	1.050	.728	-.45455	1.01232	-11.95311	11.04402

Based on the aforementioned report, it can be observed that the means of the two samples are 3.5455 and 4.0000, respectively, and the correlation between the two samples reached F = 209.903 (p = .000). The independent samples t-value was -0.902, with a p-value of .000; since the test result reached a significance level of .000—meaning p < .05—it indicates that there is a significant difference between the two groups of students regarding this specific item. Furthermore, an examination of the t-value and significance level (assuming equal variances) reveals that the test results are statistically significant, indicating a distinct difference in questionnaire scores between the control group and the experimental group regarding their learning experiences via traditional instruction versus the digital learning platform. Specifically, the results for this item demonstrate a significant difference between the two groups regarding the increase in their weekly frequency of study following the statistical analysis course.

Differences in Learning Outcomes Between Traditional and Digital Learning Platforms

To determine whether there were significant differences in learning outcomes between the two groups, an independent-samples t-test was conducted. Based on the data derived from the comparative analysis of learning outcomes—specifically contrasting the digital learning platform model with the traditional instructional model—this study examines the differences in learning effectiveness between the two groups.

Item: The Statistics Analysis Course Had a Positive Impact on Final Grades (Outcome Perspective) Based on Table 33 (Summary of Group Statistics) and Table 34 (Summary of Independent-Samples t-Test Results), the scores for each item and their relevance to the research questions are discussed below, drawing upon the data presented in these two summary tables.

Table 33: Group Statistics for the Item: "The Statistics Analysis Course Had a Positive Impact on Final Grades"

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Score	Control Group	11	3.3636	1.20605	.36364
		2	3.5000	.70711	.50000

Table 34: Independent Samples t-Test on the Positive Impact of the Statistical Analysis Course on Final Grades

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F-Verification	Significant	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
	Assuming Equal Variances	.716	.402	-.152	11	.882	-.13636	.89901	-2.11508	1.84235
				-.221	2.274	.844	-.13636	.61825	-2.51174	2.23902

Based on the aforementioned report, it can be observed that the means of the two samples are 3.3636 and 3.5000, respectively, and the correlation between the two samples is F = 0.716 (p = .402). The independent samples t-value is -0.152, with p = 0.402; since the test result (p = .402) did not reach the level of statistical significance—that is, p > .05—it indicates that there is no significant difference between the two groups of students tested regarding this specific issue. Furthermore, an examination of the t-value and significance level (assuming equal variances) reveals that the test results were not statistically significant, indicating that there is no significant difference in questionnaire scores between the control group and the experimental group regarding their learning experiences via traditional instruction versus a digital learning platform. The conclusion regarding this specific issue is that, following the course on statistical analysis, there was no significant difference between the two groups concerning the extent to which the course contributed positively to their final grades [62-64].

Item: Possessing sufficient confidence in using analytical tools to address research problems following the statistics analysis course (Outcome Aspect) Based on Table 35 (Summary of Group Statistics) and Table 36 (Summary of Independent Samples t-Test), the scores for each item and their relevance to the research problem are discussed below, drawing upon the findings presented in these two summary tables.

Table 35: Group Statistics Regarding Sufficient Confidence in Using Analytical Tools to Address Research Problems Following the Statistics Analysis Course

	Control group and experimental group	Quantity	Average	Standard deviation	Standard Error of the Mean
Score	Control Group	11	3.2727	1.10371	.33278
		2	4.0000	.00000	.00000

Table 36: Independent-Samples t-Test on Confidence in Using Analytical Tools to Address Research Problems Following the Statistics Analysis Course

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F-Verification	Significance	t	Degrees of Freedom	Significance (Two-tailed)	Average Difference	Difference in Standard Error	95% Confidence Interval for the Difference	
Score	Assuming Equal Variances	3.030	.110	-.899	11	.388	-.72727	.80895	-2.50775	1.05321
				-2.185	10.000	. 054	-.72727	.33278	-1.46876	.01421

As indicated by the aforementioned report, the mean scores for the two samples are 3.2727 and 4.0000, respectively, and the correlation between the two samples yields an F-value of 3.030 (p = .110). The independent-samples t-test result is t = -0.899 (p = .110); since the p-value of .110 does not reach the level of statistical significance—that is, p > .05—it suggests that there is no significant difference between the two groups of students tested regarding this specific issue. Furthermore, an examination of the t-value and significance level (assuming equal variances) reveals that the test results are not statistically significant, indicating that there is no substantial difference in questionnaire scores between the control group and the experimental group—students who engaged in traditional instruction versus those who utilized a digital learning platform. In summary, the results for this specific item demonstrate that, following the course on statistical analysis, there is no statistically significant difference between the two groups regarding their confidence in using analytical tools to address research problems [65-67].

Differences in Learning Effectiveness for Various Questions Under Different Instructional Approaches

Based on the aforementioned research—which categorized the subject matter into four major dimensions comprising fourteen specific items, followed by independent-samples t-tests conducted on these four dimensions—a summary comparing the observed differences is presented in the figure below.

Table 37: Summary of Differences in Learning Effectiveness for Various Questions Under Different Instructional Approaches

Reaction Surface	In the statistical analysis course, the topics are presented in a simple and easy-to-understand manner.
	Independent-samples t-test: t = -1.534, p = 0.053; not statistically significant.
	The statistical analysis course module covered the anticipated content.
	Independent-samples t-test: t = -0.599, p = 0.520; not statistically significant.
	Independent-samples t-test: t = -0.599, p = 0.520; not statistically significant.
	Independent samples t-test: t = -0.610, p = 0.701; not statistically significant.
Scope of Study	Independent samples t-test: t = -0.610, p = 0.701; not statistically significant.
	Independent samples t-test: t = -2.124, p = 0.207; not statistically significant.
	Independent samples t-test: t = -2.124, p = 0.207; not statistically significant.
	Independent-samples t-test: t = -0.073, p = 0.497; not statistically significant.
	After completing the statistical analysis course, understanding the difficulty level of each of its units has helped clarify my direction for further study.
	Independent-samples t-test: t = -0.473, p = 0.033, statistically significant.
	It exerts a positive influence on attitudes toward learning in statistics courses.
	Independent-samples t-test: t = -1.229, p = 0.306; not statistically significant.
	Following the statistical analysis course, the duration of my focused study time has increased.
	Independent samples t-test: t = -1.678, p = 0.566; not statistically significant.

Behavioral Interview	Following the course on statistical analysis, my learning efficiency has improved with each study session.
	Independent Samples t-test: t = -0.664, p = 0.306; not statistically significant.
	Independent Samples t-test: t = -0.664, p = 0.306; not statistically significant.
	Independent Samples t-test: t = -1.425, p = 0.000, statistically significant.
	The course on statistical analysis provided significant assistance with thesis writing.
	The course on statistical analysis provided significant assistance with thesis writing.
	Following the course on statistical analysis, the frequency of weekly study sessions increased.
	Independent-samples t-test: t = -0.902, p = 0.000; statistically significant
Performance/Results	The course in statistical analysis has a positive impact on final grades.
	Independent samples t-test: t = -0.152, p = 0.402; not statistically significant.
	Following the course on statistical analysis, I possess sufficient confidence in using analytical tools to address research problems.
	Independent Samples t-test: t = -0.899, p = 0.110; not statistically significant.

Reaction Level: F = 3.333, t = -1.270, p = 0.95.
Learning Level: F = 1.551, t = -1.133, p = 0.239.
Behavior Level: F = 1.776, t = -1.715, p = 0.210.
Results Level: F = 1.488, t = -0.612, p = 0.248.

Conclusions and Recommendations

This chapter is divided into two sections. The first section presents the research conclusions, summarizing the findings regarding the current status, differences, and relationships concerning the learning effectiveness of university of science and technology students utilizing digital learning platforms versus traditional instructional methods. The second section offers recommendations—specifically addressing future research and pedagogical practices—to serve as a reference for subsequent researchers.

Conclusions

Overall Findings

Regarding the comparison between the digital learning platform mode and the traditional instructional mode, the calculated F-value was 0.001, with a significance p-value of 0.973. As this value did not reach the significance level of $p < 0.05$, the results indicate that, overall, there is no significant difference in learning effectiveness between the digital learning platform mode and the traditional instructional mode.

Findings by Dimension

As indicated in Section 4.5, the F-values for the different learning modes across the four dimensions—"Reaction," "Behavior," "Learning," and "Results"—were 3.333, 1.776, 1.551, and 1.488, respectively. The corresponding significance p-values were 0.950, 0.210, 0.239, and 0.248; none of these values reached the significance level of $p < 0.05$. This demonstrates that there is no significant difference in learning effectiveness between the digital learning platform mode and the traditional instructional mode across these specific dimensions.

Findings by Specific Item

Based on the research questions and the findings presented in Chapter 4, this study draws the following conclusions:

1. Following the course on statistical analysis, students utilizing the digital learning platform mode demonstrated superior performance compared to those in the traditional instructional mode regarding their understanding of the difficulty levels of individual course units, which helped clarify their learning direction.
2. Following the course on statistical analysis, students utilizing the digital learning platform mode demonstrated superior performance compared to those in the traditional instructional mode regarding the extent to which the learning process facilitated mutual learning among classmates.
3. Following the course on statistical analysis, students utilizing the digital learning platform mode demonstrated superior performance compared to those in the traditional instructional mode regarding an increase in the frequency of weekly study sessions.
4. For all other specific items, the results indicated that there was no significant difference in learning effectiveness between the digital learning platform mode and the traditional instructional mode.

Recommendations

Recommendations Regarding Research Findings

This study focused on graduate students in the Department of Information Management. In the future, undergraduate students in the same department could be included as research subjects to broaden our understanding of the perspectives associated with different learning modes across four dimensions: "Reaction," "Behavior," "Learning," and "Results." This would lend greater comprehensiveness to the research findings.

Recommendations for the Project Implementation Unit

1. Base the construction of the digital learning platform on a thorough assessment of the school's specific needs. Researchers must gain a deep understanding of what the teachers require and what the principal expects.
2. Invite nearby research institutions—specifically those with a genuine willingness to collaborate and the capacity for long-term cooperation—to serve as project partners, thereby establishing a rich and extensive database of digital teaching materials.
3. Endeavor to bridge the resource gap between urban and rural regions by allocating additional learning resources to schools in rural townships, thereby balancing the disparity in resources between city and countryside.
4. Proactively forge strategic alliances with private-sector companies to introduce relevant digital resources, ensuring the project's continuity and consistency in implementation .

Recommendations for School Administration and Instruction

1. Every teacher and student must embrace the philosophy behind the digital learning platform. Through internal evaluations of the effectiveness of the school's "digital learning education" initiatives, administrators can identify the specific digital teaching systems that teachers require for effective implementation.
2. School administrators must personally engage in the process, actively guiding and motivating teachers to participate; this constitutes the most effective form of support for promoting digital learning education.
3. Establish channels for cooperative exchange with the local school community; by securing the participation, cooperation, and support of families within the community, the implementation of digital education can be effectively realized.
4. Leverage community-building mechanisms to stimulate enthusiasm among teachers and students, encouraging their active participation in digital learning education. By fostering an environment where individuals can pose questions and collaborate with other teachers, information literacy is enhanced, and teaching resources can be shared and exchanged.

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Appendix I: Questionnaire (Traditional Instruction)
Analysis of Learning Outcome Differences Between Digital Learning Platform and Traditional Instructional Modes

Dear Respondent
Thank you for taking the time to complete this questionnaire. The purpose of this survey is to conduct an "Analysis of Learning Effectiveness Differences Between Digital Learning Platform Models and Traditional Teaching Models—A Case Study Using the Moodle Digital Learning Platform." We sincerely hope to utilize your valuable input to successfully complete this research study. When responding, please answer based on your actual experiences and circumstances, and kindly ensure that you do not omit any questions.
This questionnaire is anonymous; the information you provide will be used solely for the analytical purposes of this study. The results of the aggregate data analysis will not involve the disclosure of any personal information; therefore, please feel free to answer with complete confidence. We sincerely appreciate your assistance and support.
Wishing you:
Peace, Good Health, and Happiness
Graduate Institute of Digital Innovation, Department of Information Management (Master's Program)
Yuanpei University of Medical Technology
Supervisor: He Shun-quan
Researcher: Cao Cheng-xiang
Respectfully yours
Basic Information (Based on your actual situation, please check [✓] the appropriate box □)
1. Age: □ 15–20 □ 21–25 □ 26–30 □ 31 or older
2. Are you familiar with any of the following digital learning platforms? (Select all that apply)
□ MOODLE □ MOOCs □ Docebo □ Tron Class □ None of the above
3. Which of the following digital learning platforms do you currently use most frequently? (Select all that apply)
□ Tron Class □ MOOCs □ MOODLE □ None of the above
4. What do you frequently use digital learning platforms for? (Select all that apply)
□ Submitting assignments □ Viewing study plans online □ Reviewing course content □ Previewing course content
□ Completing practice exercises □ Discussing course content with classmates online

Part II: Traditional Instruction (Based on your actual situation, please circle the appropriate number)
Traditional Instruction | Scoring Scale: 5 points for "Strongly Agree," decreasing to 1 point for "Strongly Disagree."

Responsiveness
1. The presentation of topics in the Statistics Analysis course was simple and easy to understand.
5 4 3 2 1
2. The arrangement of units in the Statistics Analysis course met my expectations regarding content.
5 4 3 2 1
3. The teaching methods used in the Statistics Analysis course were engaging and interesting.
5 4 3 2 1

Learning Outcomes
4. After completing the Statistics Analysis course, my breadth and depth of knowledge regarding statistical principles have improved.
5 4 3 2 1
5. After completing the Statistics Analysis course, my proficiency in applying statistical analysis software has improved.
5 4 3 2 1
6. After completing the Statistics Analysis course, my under-

standing of the difficulty level of each unit has made my learning direction clearer.
5 4 3 2 1
7. The Statistics Analysis course has had a positive influence on my attitude toward learning.
5 4 3 2 1

Behavioral Impact
8. After completing the Statistics Analysis course, the duration of my focused attention during each study session has increased.
5 4 3 2 1
9. Following the Statistical Analysis course, my study efficiency has improved.
5 4 3 2 1
10. Following the Statistical Analysis course, I feel sufficiently confident that it has significantly aided peer-to-peer learning among classmates.
5 4 3 2 1
11. Following the Statistical Analysis course, I feel it has significantly aided my thesis writing.
5 4 3 2 1
12. Following the Statistical Analysis course, the frequency of my weekly study sessions has increased.
5 4 3 2 1
Outcomes
13. Following the Statistical Analysis course, I feel it has had a positive impact on my final grades.
5 4 3 2 1
14. Following the Statistical Analysis course, I feel sufficiently confident in using analytical tools to address research problems.
5 4 3 2 1
This concludes the questionnaire. Please review your responses to ensure nothing has been omitted. Thank you for your assistance.

Appendix II: Questionnaire (Online Instruction)
Analysis of Learning Outcome Differences Between Digital Learning Platform-Based and Traditional Instructional Models

Dear Respondent
Thank you for taking the time to complete this questionnaire. The purpose of this survey is to conduct an "Analysis of Learning Effectiveness Differences Between Digital Learning Platform Models and Traditional Teaching Models—A Case Study Using the Moodle Digital Learning Platform." We sincerely hope to utilize your valuable input to successfully complete this research study. When responding, please answer based on your actual experiences and circumstances, and kindly ensure that you do not omit any questions.

This questionnaire is anonymous; the information you provide will be used solely for the analytical purposes of this study. The results of the aggregate data analysis will not involve the disclosure of any personal information; therefore, please feel free to answer with complete confidence. We sincerely appreciate your assistance and support.
Wishing you:
Peace, Good Health, and Happiness
Graduate Institute of Digital Innovation, Department of Information Management (Master's Program)
Yuanpei University of Medical Technology
Supervisor: He Shun-quan
Researcher: Cao Cheng-xiang
Respectfully yours
Send feedback

Basic Information (Based on your actual situation, please check [✓] the appropriate box [□])
1. Age: □ 15–20 □ 21–25 □ 26–30 □ 31 or older
2. Are you familiar with any of the following digital learning platforms? (Select all that apply)
□ MOODLE □ MOOCs □ Docebo □ TronClass □ None of the above
3. Which of the following digital learning platforms do you currently use most frequently? (Select all that apply)
□ TronClass □ MOOCs □ MOODLE □ None of the above
4. What do you frequently use digital learning platforms for? (Select all that apply)
□ Submitting assignments □ Viewing study plans online □ Reviewing course content □ Previewing course content
□ Completing practice exercises □ Discussing course content with classmates online

Part II: Online Instruction (Based on your actual situation, please circle the appropriate number)
Online Instruction: Scoring ranges from 5 points ("Strongly Agree") to 1 point ("Strongly Disagree") in descending order.

Responsiveness
1. The presentation of topics in the Statistics Analysis course is simple and easy to understand.
5 4 3 2 1
4. The arrangement of units in the Statistics Analysis course met my expectations regarding content.
5 4 3 2 1
5. The teaching style in the Statistics Analysis course is engaging and pleasant to listen to.
5 4 3 2 1
Learning Outcomes
4. After completing the Statistics Analysis course, my breadth and depth of knowledge regarding statistical principles have improved.
5 4 3 2 1
5. After completing the Statistics Analysis course, my proficiency in applying statistical analysis software has improved.
5 4 3 2 1
6. After completing the Statistics Analysis course, I have a better understanding of the difficulty level of each unit, making my learning direction clearer.
5 4 3 2 1
7. The Statistics Analysis course has had a positive influence on my attitude toward learning.
5 4 3 2 1

Behavioral Aspects
8. After completing the Statistics Analysis course, the duration of my focused attention during each study session has increased.
5 4 3 2 1
9. Following the Statistical Analysis course, my study efficiency has improved.
5 4 3 2 1
10. Following the Statistical Analysis course, I feel sufficient-

ly confident that it has significantly aided peer-to-peer learning among classmates.
5 4 3 2 1
11. Following the Statistical Analysis course, I feel it has significantly aided my thesis writing.
5 4 3 2 1
12. Following the Statistical Analysis course, the frequency of my weekly study sessions has increased.
5 4 3 2 1
Outcomes
13. Following the Statistical Analysis course, I feel it has had a positive impact on my final grades.
5 4 3 2 1
14. Following the Statistical Analysis course, I feel sufficiently confident in using analytical tools to address research problems.
5 4 3 2 1
This concludes the questionnaire. Please review your responses to ensure nothing has been omitted. Thank you for your assistance.

Appendix III: Formal Questionnaire (Traditional Instruction)
Analysis of Learning Outcome Differences Between Digital Learning Platform-Based and Traditional Instructional Learning Modes.

Dear Respondent
Thank you for taking the time to complete this questionnaire. The purpose of this survey is to conduct an "Analysis of Learning Effectiveness Differences Between Digital Learning Platform Models and Traditional Teaching Models—A Case Study Using the Moodle Digital Learning Platform." We sincerely hope to utilize your valuable input to successfully complete this research study. When responding, please answer based on your actual experiences and circumstances, and kindly ensure that you do not omit any questions.

This questionnaire is anonymous; the information you provide will be used solely for the analytical purposes of this study. The results of the aggregate data analysis will not involve the disclosure of any personal information; therefore, please feel free to answer with complete confidence. We sincerely appreciate your assistance and support.
Wishing you:
Peace, Good Health, and Happiness
Graduate Institute of Digital Innovation, Department of Information Management (Master's Program)
Yuanpei University of Medical Technology
Supervisor: He Shun-quan
Researcher: Cao Cheng-xiang
Respectfully yours
Part 1: Basic Information (Please check the appropriate option with a □ based on your situation)
1. Age: □ 15~20 □ 21~25 □ 26~30 □ 31 and above
2. Do you recognize any of the following digital learning platforms? (Multiple choice)
□ MOODLE □ Mo Course Master □ Docebo □ Tron Class (Course Creation) □ None of the above
3. Which of the following digital learning platforms do you currently use most frequently? (Multiple choice)
□ Tron Class (Course Creation) □ Mo Course Master □ MOODLE □ None of the above
4. What do you usually use digital learning platforms for? (Multiple selections allowed)
□ Submitting assignments □ Reviewing learning plans online □ Reviewing course content □ Previewing course content
□ Doing practice questions □ Discussing course content online with classmates

Part 2: Traditional Teaching (Circle the appropriate number based on your situation)
Traditional Teaching Scoring method: 5 to 1 points, scaled down from "Strongly Agree" to "Strongly Disagree".

Responsiveness
1. The presentation of the statistical analysis course topics was simple and easy to understand.
5 4 3 2 1
6. The statistical analysis course units achieved the expected content.
5 4 3 2 1
7. The statistical analysis course teaching methods were interesting and engaging.
5 4 3 2 1

Learning Ability
4. After the statistical analysis course, the breadth and depth of knowledge of statistical principles improved.
5 4 3 2 1
5. After the statistical analysis course, proficiency in statistical analysis software applications improved.
5 4 3 2 1
6. After the statistical analysis course, understanding the difficulty level of each unit made the learning direction clearer.
5 4 3 2 1
7. The statistical analysis course had a positive impact on learning attitude.
5 4 3 2 1
Behavioral Ability 8. My focus time during each study session improved after the statistical analysis course.
5 4 3 2 1
9. Following the Statistics Analysis course, my study efficiency has improved.
5 4 3 2 1
10. Following the Statistics Analysis course, I feel significantly more confident in engaging in mutual learning with my classmates.
5 4 3 2 1
11. Following the Statistics Analysis course, I have found it to be of significant help in writing academic papers.
5 4 3 2 1
12. Following the Statistics Analysis course, the frequency of my weekly study sessions has increased.
5 4 3 2 1

Achievement Outcomes
13. Following the Statistics Analysis course, I believe it has had a positive impact on my final grades.
5 4 3 2 1
14. Following the Statistics Analysis course, I feel sufficiently confident in using analytical tools to address research problems.
5 4 3 2 1
This concludes the questionnaire. Please review your responses

to ensure nothing has been omitted. Thank you for your assistance.

Appendix IV: Formal Questionnaire (Online Instruction)
Analysis of Learning Outcome Differences Between Digital Learning Platform-Based and Traditional Instructional Learning Models

Dear Respondent
Thank you for taking the time to complete this questionnaire. The purpose of this survey is to conduct an "Analysis of Learning Effectiveness Differences Between Digital Learning Platform Models and Traditional Teaching Models—A Case Study Using the Moodle Digital Learning Platform." We sincerely hope to utilize your valuable input to successfully complete this research study. When responding, please answer based on your actual experiences and circumstances, and kindly ensure that you do not omit any questions.

This questionnaire is anonymous; the information you provide will be used solely for the analytical purposes of this study. The results of the aggregate data analysis will not involve the disclosure of any personal information; therefore, please feel free to answer with complete confidence. We sincerely appreciate your assistance and support.
Wishing you:
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Yuanpei University of Medical Technology
Supervisor: He Shun-quan
Researcher: Cao Cheng-xiang
Respectfully yours
Send feedback

Part I: Basic Information (Based on your actual situation, please mark the appropriate option with a √ in the box □)
1. Age: □ 15–20 □ 21–25 □ 26–30 □ 31 or older
2. Are you familiar with any of the following digital learning platforms? (Select all that apply)
□ MOODLE □ MOOCs □ Docebo □ TronClass □ None of the above
3. Which of the following digital learning platforms do you currently use most frequently? (Select all that apply)
□ TronClass □ MOOCs □ MOODLE □ None of the above
4. What do you frequently use digital learning platforms for? (Select all that apply)
□ Submitting assignments □ Viewing study plans online □ Reviewing course content □ Previewing course content
□ Completing practice exercises □ Discussing course content with classmates online

Part II: Online Instruction (Based on your actual situation, please circle the appropriate number)
Online Instruction Scoring Scale: Ranging from "Strongly Agree" (5 points) to "Strongly Disagree" (1 point)
2-1 Responsiveness
1. The presentation of topics in the Statistics Analysis course was simple and easy to understand.
5 4 3 2 1
8. The units arranged within the Statistics Analysis course met my expectations regarding content.
5 4 3 2 1
9. The teaching style in the Statistics Analysis course was engaging and pleasant to listen to.
5 4 3 2 1

Learning Outcomes
4. After taking the Statistics Analysis course, my breadth and depth of knowledge regarding statistical principles have improved.
5 4 3 2 1
5. After taking the Statistics Analysis course, my proficiency in applying statistical analysis software has improved.
5 4 3 2 1
6. After taking the Statistics Analysis course, my understanding of the difficulty levels of each unit has made my learning direction clearer.
5 4 3 2 1
7. The Statistics Analysis course has had a positive influence on my attitude toward learning.
5 4 3 2 1

Behavioral Outcomes
8. After taking the Statistics Analysis course, the duration of my focused attention during each study session has increased.
5 4 3 2 1
9. Following the Statistics Analysis course, my study efficiency has improved.
5 4 3 2 1
10. Following the Statistics Analysis course, I feel significantly more confident in engaging in mutual learning with my classmates.
5 4 3 2 1
11. Following the Statistics Analysis course, I have found it to be of significant help in writing academic papers.
5 4 3 2 1
12. Following the Statistics Analysis course, the frequency of my weekly study sessions has increased.
5 4 3 2 1

Achievement Outcomes
13. Following the Statistics Analysis course, I believe it has had a positive impact on my final grades.
5 4 3 2 1
14. Following the Statistics Analysis course, I feel sufficiently confident in using analytical tools to address research problems.
5 4 3 2 1
This concludes the questionnaire. Please review your responses to ensure nothing has been omitted. Thank you for your assistance.