The Development of U-Learning Innovation to Promote Research Potential: Analysis by Advanced Statistics, Srinakharinwirot University, Thailand

Kanchana Pattrawiwat* and Khwanying Sriprasertpap

Behavioral Science Research Institute, Srinakharinwirot University, Thailand
Email: kanchanapa@g.swu.ac.th (K.P.); khwanying@g.swu.ac.th (K.S.)
*Corresponding author
Manuscript received June 7, 2023; revised June 27, 2023; accepted September 4, 2023; published January 18, 2024

***Abstract*—Although the COVID-19 pandemic required teachers to adjust their teaching methods, there remains a lack of high-quality and inclusive instructional media for theoretical and practical content. This study analyzed the instructional management, design, and development of ubiquitous-learning (U-Learning) to promote the research potential: data analysis for advanced statistics course at Srinakharinwirot University, Thailand. The research participants were divided into three assessment groups: 10 graduate students, 5 statistics experts, and 20 course users. The qualitative data were analyzed using content analysis while the quantitative data were analyzed using arithmetic means and standard deviations. The study found that learning innovation (C-TAPE) was composed of five main components, namely, content, teaching, activity, practice, and evaluation. Additionally, the statistics experts and course users had the highest score for learning innovation efficiency among the assessment groups.**

***Keywords*—innovation for learning, MOOCs, online learning, U-Learning**

I. Introduction

In this age of disruptive technology, many countries have become focused on developing digital economies. Thailand's National 20-Year Strategy (2018–2037) for human capital development, which is focused on economic and social development to ensure security, prosperity, and sustainability, includes the development of a digital economy and a digital society to enhance development efficiencies in areas such as infrastructure, innovation, data, human capital [1], and education. Furthermore, there are plans to develop learning support systems blended with teacher value and quality learning media on digital platforms to promote self-development and inculcate digital research skills in students [2].

Digital technology has become a key resource for learning and study, which is why Thailand is implementing national digital technology and innovation reforms to address its national challenges and provide future opportunities. However, the variety and suitability of Thai digital content are insufficient because of content inequality)Content Divide), which is a lack of knowledge about how to develop digital content, and digital inequality)Digital Divide), which is a lack of access to digital technologies. This is why most Thais only use digital technologies, particularly mobile devices, for entertainment [3].

The COVID-19 pandemic resulted in the so-called new normal, wherein most educational institutions were unable to deliver face-face instruction and had to develop virtual online [4] in-class environments. Many institutions chose to develop online learning platforms to promote learning efficiency and provide students the opportunity to interact with each other and search for knowledge [5]. Blended learning instructional approaches, which combine in-class instruction with learning media, online media, and open media (MOOCs), integrate technology into curriculum and course designs. The ubiquitous-learning (U-learning) innovation design that is discussed in this study integrates blended learning, online media, and open media (MOOCs), and allows students to access their courses anywhere and at any time.

Knowledge of quantitative research methodologies is vital for data analysis and problem-solving, especially in courses such as advanced statistics. Quantitative data analysis comprises three steps; data analysis preparation, and presentation of the results. Researchers need to pay careful attention to all three steps, especially when selecting statistics to meet their research objectives. The presentation of the results is a key step, which requires students to transform the statistical data into simple language for readers to understand [6].

Society must be prepared for the educational management challenges in this age of disruptive change. Therefore, Thai educational reforms and technology-based learning developments need to be congruent with the national reform policy to ensure a secure, prosperous, and sustainable future. U-Learning was developed as part of these plans to elevate students' advanced statistical analysis research abilities, which are vital in the digital age for problem-solving and advanced analytical thinking, both of which are needed for difficult subjects.

So far, most of the research conducted in this field can be classified into three categories:

The first category includes the use of U-learning during COVID-19, including implementing effective learning with U-learning technology [7], using U-learning as a learning method to achieve vocational competencies in higher education during the COVID-19 pandemic [8], studying the factors influencing the use of U-learning in higher education in the aftermath of the pandemic [9], and investigating the advantages and disadvantages of e-learning in university education from students' perspectives [10]. Ubiquitous learning a new challenge of ubiquitous computing: state of the art [11].

The second category includes a meta-analysis of

U-learning, such as a meta-analysis of the effects of augmented reality technologies in interactive learning environments [12], and a U-learning model for education and training processes supported by television platforms. A literature review between 2002 and 2018 on U-learning models yielded little information about its implementation; in particular, this demonstrated a lack of alternatives that could provide access to television regardless of place and device [13].

The third category includes course learning systems, such as an open ubiquitous system to assist in learning English [14], a blended mobile learning model for learning through tablets from local science learning stations [15], and the effect of a ubiquitous learning management system using imagineering to enhance learning achievement and multimedia creation skill for those enrolled in a digital multimedia course [16].

In addition, the statistics course of the Thailand Massive Open Online Course Thai platform (MOOC) only covers basic statistics, such as Basic Statistics for Data Analytics—Descriptive Statistics, Introduction to Statistics and Data Analytics, Essential Data Science and Applications, and Business Statistics. Unfortunately, there was neither media nor online instructional management for many courses, especially advanced statistical analysis. Consequently, this study analyzed U-learning's design, development, and instructional management to determine its effectiveness in promoting research skills in students of advanced statistics.

II. Methodology

Both quantitative and qualitative data were collected for this study, with data drawn from the following three populations.

Group (1): 10 graduate students studying RB 711—Multivariate Statistics for Data Analysis in Behavioral Science and RB 712: Advanced Multivariate Statistics for Data Analysis in Behavioral Science.

Group (2): Five experts with Ph.Ds. in statistics or other related fields and with teaching experience of no less than 10 years to evaluate the learning content.

Group (3): 20 students registered in RB 711 and RB 712, comprising Ph.D. students enrolled in research-based and non-course-based curricula, researchers, and people interested in advanced statistical data analysis for research, participated in the assessment of U-learning's ability to promote advanced statistical data analysis research skills.

The research process was divided into three phases:

Phase 1: To analyze the U-learning instructional management, the Group 1 participants were interviewed using a semi-structured interview form.

Phase 2: To assess the design and development of the U-learning innovation, the online content instructional management design to be used in a future massive online open course (MOOC) course was evaluated by the Group 2 participants.

Phase 3: To trial and assess the U-learning innovation efficiency, Group 3 participants completed a questionnaire focused on assessing the "*U-learning innovation to promote research potential: analysis by advanced statistics*" modules, in which the questions were answered on a five-point Likert scale [17]. The index of congruence for this questionnaire was calculated to be 0.6–1.0 and the Cronbach's alpha was 0.91, which indicated that the assessment tool was appropriate for the purpose [18].

The research protocol was approved by the institutional review board of Srinakharinwirot University (Certificate of approval No. SWUEC-160/2565E).

III. Results

A. U-Learning Instructional Management

The results from the semi-structured interviews with the Group 1 participants were organized under three main headings: teaching methods, courseware content, and technology.

1) Teaching methods

The lecturer's teaching methods/transfer/communication, course content, and teaching design were all found to be suitable. "The lecturer started by teaching the principles of each statistic, before going into the calculation details. Then, SPSS was run as a demonstration. The supporting documents described each table and ended with report writing. Therefore, the overall advantage of the teaching was the example report writing, so we knew what points were necessary and applicable."

However, it was felt that greater instruction was needed on problem solving; "to increase student attention, problem-based learning could be used so that students realize the problems leading to the content and what to do further in our theses." The students liked the demonstration VDOs, teaching VDO records, suitable evaluation methods, and exercises with answers at the end of every class so they could learn to apply the knowledge. One interviewee said; "I liked the way she gave exercises with answers at the end of class. This helped me better understand how to choose each particular statistic. When I answered incorrectly, her answers made it clear what parts I still did not understand, and I could understand them correctly. I liked it very much."

2) Courseware content

The course content comprised six modules. The overall content was judged to be generally suitable. However, the following suggestions were given for each module.

Canonical Analysis. While it was found to be suitable, it was felt that less time should be spent on this topic because this method is rarely used for data analysis.

Discriminant Analysis: This module was seen to be suitable and "applicable to real life."

Logistic Regression. Overall, the module was found to be suitable for presenting the concepts related to binary logistic regression and multinomial logistic regression without going into too much detail.

Factor Analysis. Overall, the module was found to be "suitable in terms of detail and completeness of content. It is applicable for research through teaching and exercises for skill development before using this statistic in real situations. But I personally expected an adjustment as Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were essentially the same subject. Both analysis methods can be connected because EFA can be extended to CFA to develop the tool's quality."

Path Analysis. Overall, the module was found to be "suitable, but model interpretation could be added because some international research uses complicated writing that results in misunderstanding or misinterpretation."

Structural Equation Modeling. Overall, the module was found to be "suitable and could be separated as another subject because it is necessary and applied widely nowadays. Thus, there should be detailed descriptions of the academic content and the applications." Another participant commented that "both theoretical and practical sessions were suitable. The lecturer taught us how to adjust the model in detail along with the command manual and topic definitions, which facilitated real practice for better understanding. When applying this analysis to our own research, we become more familiar with the commands and different topics in the output."

In conclusion, all modules were found to have suitable theoretical and practical sessions.

3) Technology

Because all six modules are being developed as a MOOC to allow interested students to learn on their own or review lessons, the group was asked to give suggestions on how to make it more attractive and more beneficial. Group 1 participants expressed interest in the possibility of the modules becoming MOOCs, but added that "there should be more attractive clips, with examples or attractive productions before getting into the content so that they are more persuasive. There should also be means for questioning. The lecturer should come and answer questions promptly to enhance further understanding of the content." Another participant commented that "I personally agree because we had to record the lecturer's voice by phone in the past so we could retrieve the information and write in missing points later. This wasted time, and sometimes led to an incomplete understanding of some points. Fortunately, current communication technology allowed me to retrieve information from those VDOs several times to enhance my understanding. The documents were sufficient because it was like studying in general classes. There are handbooks/manuals for the theoretical and practical sessions, and exercises in all chapters to measure understanding. From the observation of other students, what motivated them more toward online courses was the certificate after passing the tests."

It was also suggested that additional content be included on statistical programming and gamification, and lessons should be published. Interviewee 1 commented that "apart from the key analysis programs, such as SPSS or LISREL, other non-copyright or free programs may be required, such as R, because copyright matters are stricter." Interviewee 2 said "I expect "U-learning innovation" could be used by current and former graduate students interested in an additional statistics subject. Interested alumni or general people may consider registering to receive the certificate from this course. Interviewee 3 commented that "gamification should be applied to the instructional process; for example, besides the regular evaluations during their study, bonus points could be given for those who complete bonus assignments, and reward badges)an extra certificate) could be awarded to those with total scores in the top three ranks in each round along with class notifications. For example, the first 0%–25% of content shows that there are beginners to advanced level or newly hatched owl babies to graduate owls wearing glasses, with praises or congratulations after subject completion. Although these are small matters, students will feel glad to get smiles when they pass this subject."

Overall, the U-learning instructional management was assessed to have suitable teaching methods, content, and technology. The main suggestions for improvement were to introduce problem-based instruction, include additional statistics programs, and separate the content into new subjects when there is a large amount of content. Interviewees believed the course was suitable for a MOOC, but suggested that the lessons could be extended into gamification in the future.

B. U-Learning Content Quality and Design Evaluation

1) Content quality evaluation

The content quality evaluation was assessed for each of the six modules: 1) Canonical Analysis; 2) Discriminant Analysis; 3) Logistic Regression; 4) Factor Analysis; 5) Path Analysis; and 6) Structural Equation Modeling (SEM). The results of the content quality evaluation by the Group 2 statistical experts are shown in Table 1.

Table 1. Learning Innovation efficiency

Criteria	Mean	SD	Interpretation
Suitable content in accordance with the objectives	4.50	0.52	High
Correct content in accordance with academic principles, and suitable for knowledge building	4.57	0.51	Highest
Complete and suitable lesson structures	4.57	0.51	Highest
Suitable content difficulty	4.57	0.51	Highest
Attractive/challenging content that motivates further learning	4.36	0.50	High
Clear and simple to understand content	4.57	0.51	Highest
Congruent and respective connection to topics	4.50	0.52	High
Suitable content for 3 hrs. of a certain lesson	4.36	0.50	High
Content with applicable main ideas for research	4.71	0.47	Highest
Applicable practical sessions for research	4.71	0.47	Highest
Suitable exercises and tests for evaluation	4.57	0.51	Highest
Suitable supporting documents and PowerPoints	4.50	0.52	High
Total	**4.54**	**0.27**	**Highest**

The overall mean was relatively high (mean = 4.54). The highest mean was for item 9 (mean = 4.71), and the lowest mean was for item 8 (mean = 4.36).

2) U-learning innovation design

The analysis results for the content quality evaluation and its suitability for online learning lesson development are detailed in the following (Fig. 1).

C-TAPE learning innovation is a subject management system learning process comprising five components: content, teaching, activity, practice, and evaluation.

C: Content—The content included theoretical and practical sessions, activities, exercises, and evaluation. The lecturer prepared digital platforms, i.e., documents, VDOs, e-tests, online activities, content sequencing, and learning durations. The implementation was in accordance with the module lesson design and U-learning concepts.

T: Teaching—The online instructional management facilitated self-study at any time and in any place. The instructional management was integrated in accordance with the TPACK concept, which is a technology integration framework that identifies three types of knowledge instructors need to combine for successful ed-tech integration: technological, pedagogical, and content knowledge. This research implemented online or virtual-classroom instructional management using the subject management system before developing the course for the open-source system)MOOC(.

A: Activity—The lecturer designed online interactions for the students during instruction, such as a web board, brainstorming, online opinions, and online exercises. Instructional management between the lecturer and students included periodical feedback and provided students with the opportunity to present concepts through various activities.

P: Practice—The lecturer assigned practice problems because advanced statistics include complicated theoretical and practical content. Therefore, to develop the students' statistical data analysis skills, the practical sessions were designed to have simultaneous step-by-step demonstration and practice and moved from easy/simple to more difficult content.

E: Evaluation—The lecturer evaluated the students in the theoretical and practical sessions using active learning, such as evaluations during the study and post-evaluations after each module. Therefore, the students received prompt feedback and improved their analysis skills on their own through online instruction and evaluation.

The C-TAPE learning process was applied to the U-learning innovation to promote research potential. Therefore, the learning management process required the development of suitable instructions, activities, practice/exercises, and evaluation.

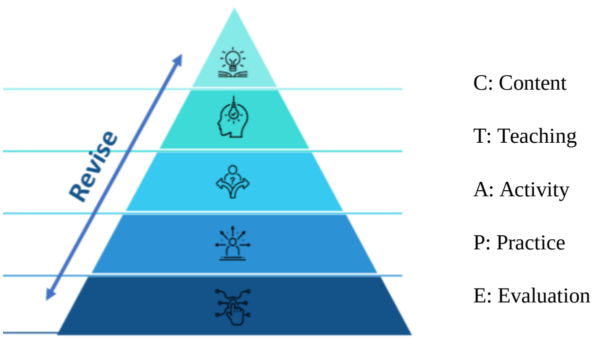

Fig. 1. C-TAPE learning innovation.

3) Screenshots of the course management system for usability before developing the Thai MOOC

Figs. 2–4 are screenshots of the course management system used for teaching and learning in an online course on Moodle LMS.

A. *U-Learning Efficiency Evaluation*

Table 2 shows that the overall mean was high (mean = 4.45). The means for items 1 and 8 were the highest (mean = 4.75), and the lowest means were for items 4 and 5 (mean = 4.00).

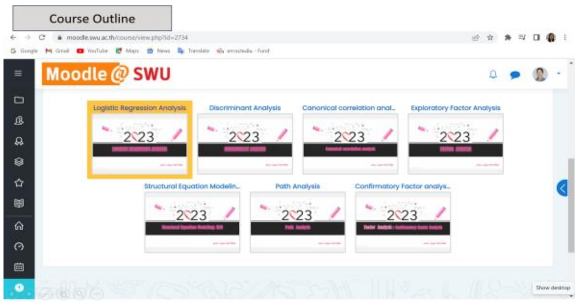

Fig. 2. Moodle SWU screenshot example.

Fig. 3. Exam content screenshots from YouTube.

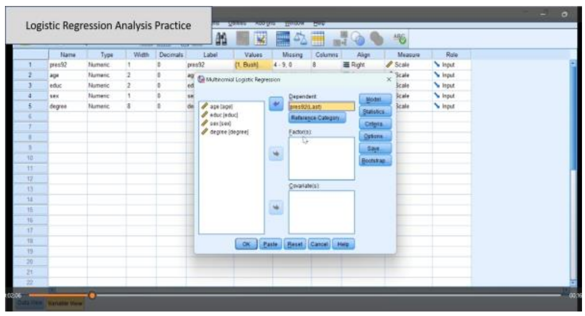

Fig. 4. Exam practice course screenshots.

Table 2. Learning Innovation Efficiency: Content

Criteria	Mean	SD	Interpretation
Suitable content in accordance with the objectives	4.75	0.43	Highest
Content can develop knowledge	4.70	0.46	Highest
Complete and suitable lesson structure	4.45	0.50	Highest
Suitable content difficulty levels	4.00	0.77	High
Attractive/challenging content that motivates further learning	4.00	0.55	High
Clear and easily understandable content	4.30	0.46	Highest
Congruent and respective connection to topics	4.65	0.48	Highest
Content with applicable main ideas for research	4.75	0.43	Highest
Total	**4.45**	**0.60**	**Highest**

Table 3 shows that the overall mean was relatively high (mean = 4.29). The means for items 1 and 4 were the highest (mean = 4.75), and the lowest means were for item 8 (mean = 3.95).

Table 3. Learning innovation efficiency: Instruction

Criteria	Mean	SD	Interpretation
The lecturer had clear, intelligible communication and content explanations	4.75	0.43	Highest
Instruction focused on active learning to arouse or motivate student knowledge accumulation	4.05	0.50	High
Instructional design promoted or motivated student thinking processes	4.00	0.55	High
The learning process facilitated self-study/student-centered	4.75	0.43	Highest
Instructional learning with research-based learning	4.60	0.49	Highest
Activities and skills practice facilitated lesson understanding	4.00	0.55	High
Instructional process facilitated conceptualization	4.30	0.46	Highest
The lecturer cultivated morality and ethics	3.95	0.22	High
The lecturer delivered learning activities to strengthen knowledge sharing	4.00	0.77	High
Suitable evaluation procedures	4.45	0.74	Highest
Suitable supporting documents	4.30	0.46	Highest
Students can contact the lecturer conveniently for advice	4.30	0.46	Highest
Total	**4.45**	**0.60**	**Highest**

Table 4 shows that the overall mean was relatively high (mean = 4.23). The highest system usage mean was item 8 (mean = 4.85) and the lowest system usage mean was item 3 (mean = 3.45).

Table 4. Learning innovation efficiency: Technology

Criteria	Mean	SD	Interpretation
System Usage	**4.19**	**0.66**	**Highest**
Convenient and easy access to the system	4.15	0.65	High
Suitable, comprehensive, and clear menu bars	4.00	0.55	High
Suitable font styles and sizes	3.45	0.50	High
Suitable prioritization of presented information	4.15	0.36	High
Links facilitated access to other information	4.40	0.49	Highest
System provided an opportunity for students to contact the lecturer	4.10	0.83	High
Information could be added, edited, or deleted correctly	4.40	0.49	Highest
Students could review lessons anywhere and anytime	4.85	0.36	Highest
System Safety	**4.17**	**0.66**	**High**
Suitable setting for accessibility	4.25	0.70	Highest
The system was safe for access to information	4.25	0.70	Highest
Suitable warning alert in case of input errors	4.00	0.55	High
System Benefits	**4.36**	**0.48**	**Highest**
Instructional management responded to student needs	4.30	0.46	Highest
Instructional system was a valuable and useful innovation	4.55	0.50	Highest
Instructional style promoted self-directed learning, along with the self-literacy test	4.30	0.46	Highest
Students could utilize the knowledge obtained from this innovation	4.30	0.46	Highest
Total	**4.23**	**0.62**	**Highest**

IV. Discussion

The instructional management analysis of the six U-learning modules; 1) Canonical Analysis, 2) Discriminant Analysis, 3) Logistic Regression, 4) Factor Analysis, 5) Path Analysis, and 6) SEM; found that the teaching methods, content, and technology were suitable. However, it was suggested that large content subjects be divided into new subjects. The mean for learning innovation efficiency as assessed by the Group 2 statistical experts was the highest (mean = 4.54).

The U-learning design and development learning innovation analysis reviewed five components (C-TAPE): 1) C: Content, 2) T: Teaching, 3) A: Activity, 4) P: Practice, and 5) E: Evaluation.

The five C-TAPE learning innovation components were found to have innovative designs, with the development found to be in accordance with the U-learning concept and characteristics [19], i.e., a learning model that was responsive to student needs under different learning conditions. While some on-demand or just-in-time learning may need to be added, the U-learning innovation had a help center that facilitated self-study. The learning modules could be easily accessed without limitations [20] and had integrated concepts. The instructional TPACK Model management facilitated knowledge transfer and had efficient ICT integration. However, the teachers must understand the technology and instructions and be able to interactively present the knowledge [21]. Innovative design and efficient applications were also studied by Matua *et al.* [22]. MOOCs have influenced higher education curricula by encouraging participation, attraction, and motivation. Likewise, Masanetet *et al.* [23] collected pre- and post-treatment efficiency life cycle assessment survey data on 1,257 students for an Economics MOOC, finding that only 262 students could complete this subject. The research revealed that the online MOOC curriculum could: 1) attract and encourage a large number of students, and 2) facilitate basic analytical skills to pass the tests. The quantitative student skills at enrolment were arranged in sequence: 2.1) program usage skills; 2.2) types of calculation tables; 2.3) data collection skills; 2.4) problem-solving skills from equations; 2.5) interpretation from environmental data; and 2.6) the development and application of mathematical models for mass collection and/or energy balancing. The online curriculum and MOOC also created an opportunity to build a measurement cycle that could shape next-generation students.

Among the participants, the learning innovation efficiency assessed by the Group 3 users was the highest, and the overall content, instruction, and technology means were respectively 4.45, 4.29, and 4.23.

The U-learning innovation efficiency analysis ratings for the content, instruction, and technology were high, and the "*U-learning innovation to promote research potential: data analysis by advanced statistics*" course was motivating and easy to understand. Students were able to easily review the lessons anywhere and anytime, the instructional style promoted self-directed learning and developed self-literacy, and the students were able to utilize the knowledge in the real world. These U-learning advantages were also recognized in several similar studies [7, 11]. In a similar study, Pruekpramool *et al.* used a blended mobile learning model for learning on tablets through local science learning stations in SaKaeo province, Thailand. Their results revealed that teachers' conceptual understanding of three aspects; 1) using tablets as tools of learning, 2) scientific concepts of learning stations, and 3) the mobile learning model and approaches, all significantly increased ($p < 0.05$). Moreover, teachers were satisfied with the project and some of them applied the knowledge they gained from the project in their teaching [15].

Ubiquitousness refers to the state of existing everywhere at any time. In education, U-learning integrated education makes it possible for people to gain information, knowledge, and experience at any time and could transform nations into life-long learning communities. It has been suggested that as education platforms and the ownership of tablets and computers become commonplace, traditional and distance education may disappear [17]. Likewise, Yu presented a meta-analysis of the effects of augmented reality technologies in interactive learning environments (2012–2022). The study's moderating analysis found that augmented reality in interactive learning environments significantly enhances (1) students' acceptance of technological systems and attitude toward the courses, (2) comfort, engagement, and self-efficacy, (3) learning motivations (measured by attention, perceived relevance to learning objectives, confidence, satisfaction, and interest), (4) critical thinking and practical skills, and (5) knowledge acquisition outcomes (including memorization, retention, and application). Interactive augmented reality has insignificant influences students' flow experience, collaboration, and communication, while significantly reducing cognitive load at the 0.05 level. The findings may enlighten further studies on educational technologies and extend applications of augmented reality in education [12].

As it was found that the "*U-learning innovation to promote research potential: data analysis by advanced statistics*" course facilitated student participation and had good in-class instructional management, the review revealed that it was suitable for further online development and could also be developed as a MOOC that could gain high education credit in Thailand in accordance with government policy. Gulatee and Nilsook [24] examined the design principles and elements of MOOCs associated with teaching, learning design, and teaching materials and identified nine key elements: 1) course syllabus, 2) group learning, 3) management, 4) reading material, 5) video lectures and discussion forums; 6) assignments, 7) practical tasks, 8) projects, and 9) certificates. They also found that the associated webpage design had to have five key elements: 1) basic requirements, unit outlines, measurement and evaluation methods; 2) grouping, such as details of communication channels, emails, record media, and activities; 3) instructional media; 4) VDOs, with live lectures and broadcasting to attract students; and 5) tools and communication channels for students, such as web boards, blogs, chat rooms, and popular social media such as LINE and Facebook.

V. Conclusion

This study has conducted a research to analyze U-learning's design, and instructional management to determine its effectiveness in promoting research skills among students of advanced statistics. Quantitative and qualitative research methods were used for this purpose. This study examined the instructional management, design, and development of U-Learning, specifically regarding data analysis, for the advanced statistics course at Srinakharinwirot University, Thailand.

The research results have revealed that learning innovation (C-TAPE) was composed of five main components, namely, content, teaching, activity, practice, and evaluation. Additionally, the statistics experts and course users had the highest score for learning innovation efficiency among the assessment groups. The findings demonstrate that the learning activity model was effective in improving both digital technology and digital content development skills in graduate students.

In future research, researchers could develop lessons by adding online game techniques as part of the instructional process and problem-based/research-based techniques so that students could apply their knowledge in real situations.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Kanchana Pattrawiwat conducted the research. Khwanying Sriprasertpap designed the system. Kanchana Pattrawiwat and Khwanying Sriprasertpap collected and analyzed the data, wrote the paper, both authors approved the final version.

Acknowledgment

This project was supported by Behavioral Science Research Institute, Srinakharinwirot University, Bangkok, Thailand.

References

[1] Office of the National Digital Economy and Society Commission (April 2019). National policies and plans on digital development for economy and society (2018–2037). *Royal Gazette.* [Online]. *136(47)*, pp. 1–7. Available: https://onde.go.th/assets/portals/1/files/620425-Government%20Gazette.PDF

[2] Office of the Secretary of the National Strategy Committee Office of the National Economic and Social Development Board (October 2018). National strategy 2018–2037. *Royal Gazette*. [Online]. *135(82)*, pp. 30–34. Available: https://drive.google.com/file/d/1XSBMp8OCsauJqECOB-XZLB91

[3] Office of the Permanent Secretary for Higher Education, Science, Research and Innovation Office of Higher Education Policy and Planning. *Higher Education Plan to Produce and Develop the National Manpower* 2021–2027, Bangkok, Thailand, 2020, pp. 59–71.

[4] W. Wayo, A. Charoennukul, C. Kankayan, and J. Yai, "Online teaching and learning under the epidemic situation of the COVID-19 virus: concepts and applications for teaching and learning," *Journal of Health Center*, vol. 14, no. 34, pp. 285–298, September 2020.

[5] S. Pahe. (2019). Virtual classroom. [Online]. pp. 1–12. Available: http://www.mbuisc.ac.th/phd/academic/flipped%20classroom1.pdf

[6] H. Thongdaeng, P. Methikul, S. Tumwong, and P. Sombatmai, "Data analysis and analysis results presentation for behavioral science researchers," *Journal of Marketing and Management, Rajamangala University of Technology Thanyaburi*, vol. 3, no. 2, pp. 13–36, 2016.

[7] H. F. El-Sofany and S. A. El-Seoud, "Implementing effective learning with ubiquitous learning technology during coronavirus pandemic," *Computer Systems Science and Engineering*, vol. 40, no. 1, pp. 389–404, November 2021.

[8] P. B. Herlandy, and H. Purwanto, "Ubiquitous learning as a learning method for achieving vocational competencies in higher education during the COVID-19 pandemic," *Jurnal Pendidikan Teknologi dan Kejuruan*, vol. 28, no. 1, pp. 93–108, May 2022.

[9] M. Huang, "Factors influencing the use of ubiquitous learning in higher education in Sichuan, China in the aftermath of COVID-19 pandemic," *ABAC ODI Journal*, vol. 9, no. 1, pp. 74–90, October 2021.

[10] A. Z. Rawashdeh. E. Y. Mohammed, A. R. Arab, M. Alara, and B. Al-Rawashdeh, "Advantages and disadvantages of using e-learning in university education: Analyzing students' perspectives," *The Electronic Journal of e-Learning*, vol. 19, no. 2, pp. 107–117, May 2021.

[11] M. Guettala, S. Bourekkache and O. Kazar, "Ubiquitous learning a new challenge of ubiquitous computing: State of the art," in *Proc. 2021 International Conference on Information Systems and Advanced Technologies (ICISAT)*, Tebessa, Algeria, December 27–28, 2021, pp. 1–5.

[12] Y. Zhonggen, "Meta-analyses of effects of augmented reality on educational outcomes over a decade," *Interactive Learning Environments*, pp. 1–15, April 2023.

[13] G. A. Moreno-López, D. Burgos, and J. A. Jiménez-Builes, "A ubiquitous learning model for education and training processes supported by TV everywhere platforms," *International Journal of Emerging Technologies in Learning*, vol. 17, no. 11, pp. 128–145, June 2022.

[14] L. Garcia, E. Neto, R. Francisco, Rosemary J. Barbosa, L. Silva, Luis, and V. Leithardt. (July 2021). ULearnEnglish: An open ubiquitous system for assisting in the English vocabulary. *Electronics*. [Online]. pp. 1–14. Available: https://doi.org/10.3390/electronics10141692

[15] C. Pruekpramool, G. Hwang, T. Sangpradit1, and P. Khumwong, "Using a blended mobile learning model for learning on tablets through local science learning stations in SaKaeo Province, Thailand," *International Journal of Science Education and Teaching*, vol. 1, pp. 1–15, Janurary–April 2022.

[16] P. Champakula, S. Bengthongb, and K. Boonphakb, "The effect of ubiquitous learning management system using imagineering to enhance learning achievement and multimedia creation skill for upper secondary school," *Kasetsart Journal of Social Sciences*, vol. 43, pp. 465–472, April 2022.

[17] R. Likert, *The Human Organization: Its Management and Value*, New York: McGraw-Hill, 1967, p. 179.

[18] S. Tiraganun, *Developing Assessment Tool in Social Science Research: Approaches to Practice*, Bangkok, Chulalongkorn, Thailand: University Printing House, 2008, pp. 145–163.

[19] C. E. Watson and W. O. Plymale. (March 2012). The pedagogy of things: Ubiquitous learning, students culture and constructivist pedagogical practice. [Online]. ch. 1, pp. 1–15. Available: http://eddiewatson.net/pdf/watson_plymale.pdf

[20] N. Boonparit and S. Ondet, "Ubiquitous technology and ubiquitous learning," *Rangsit Information Center*, vol. 14, no. 2, pp. 28–31, 2008.

[21] M. J. Koehler, P. Mishra, and W. Cain, "What is technology pedagogical content knowledge," *Journal of Education*, vol. 193, no. 3, p. 13, 2013.

[22] G. M. Amandu, J. K. Muliira, and D. C. Fronda, "Using model e-learning platform to foster student self-directed learning: Experiences with utilization of the software in undergraduate nursing courses in a Middle Eastern university," *Procedia-Social and Behavioral Sciences*, vol. 93, pp. 677–683, 2013.

[23] J. Ross, C. Sinclair, J. Knox, S. Bayne, and H. Macleod. (March 2014). Teacher experiences and academic identity: The missing components of MOOC pedagogy. *Journal of Online Learning & Teaching*. [Online]. *10(1)*. pp. 57–69. Available: http://search.ebscohost.com/login.aspx

[24] G. Yuwanuch and N. Prachyanun, "Elements of learning design for MOOCs," presented at the Fifth TCU International E-learning Conference, Bangkok, Thailand, August 5–6, 2014.