

# The Effectiveness of an Online Learning Platform in Collaboration with Virtual Technology using a Digital Ecosystem to Develop Information, Media and Technology Skills of Undergraduate Students

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This research aims to study the results of an online learning platform in collaboration with virtual technology using a digital ecosystem to develop the information, media and technology skills of undergraduate students who learnt with a digital ecosystem. The sample group was 79 undergraduate students who were randomised with a cluster sampling method. The participants were divided into two groups, with 40 students in the experimental group and 39 students in the control group. The research tools used were (1) the teaching plan for online learning platform in collaboration with virtual technology using digital ecosystem, in accordance with the Dick and Carey Model; (2) an academic achievement evaluation form and (3) the student's information skill evaluation form. The data was analysed using mean ( $\bar{X}$ ), standard deviation, and Multivariate Analysis of Variance (MANOVA). The research found that, with significance level of 0.5, the academic achievement and information skills of the students who learned using online learning platform in collaboration with virtual technology using a digital ecosystem was higher compared to the students who using the normal learning method.

**Key words:** *Online learning, digital ecosystem, augmented reality, information skills.*



## Introduction

The Government's "Thailand 4.0 policy" forms an operational plan to develop educational personnel, research, and technology (B.E. 2017-2021). The policy focuses on producing role models, as well as educating science and technology in order to boost learning and teaching achievements. The policy seeks to also develop curriculum to produce manpower which leads the teaching and learning of higher education institute to the goal. Therefore, the qualifications framework for higher education must be set according to Thai Qualifications Framework for Higher Education (TQF) in order to support the graduates so that they can be efficiently proficient in their future careers. Subsequently, the students will be equipped with the essential skills and capabilities for professions, developed through learning with information technology, to support information use and skills in developing innovative media for professions (UNESCO, 2008; Ministry of Education, 2016; Teachers and Basic Education.2010; Personnel Development Ministry of Education. (2016). Ministry of Education. (2017). This corresponds to education management in the 21<sup>st</sup> century which focuses on life and work skills, learning and innovation skills, and information media and technology skills (Partnership for 21st Century Learning, 2009).

Students' information technology is more important currently and in the future. Yuhyun PC, (2016) mentioned that in the next decade, 90% of the world's population must access to the internet which is used to drive and connect the global society to the world of internet (Internet of Everthing) or (Internet of Things). Therefore, it's presently important to prepare students for this future. This was conformed to PISA THAILAND, (2018) which revealed low assessment results score of Thai students in both math and science and the literacy assessment scores are likely to gradually decline. From the literacy assessment, the students received information from a single and various resources to correspond with the real-life information use of the people in the current world. The Thai education system should therefore encourage the implementation of digital technology in learning to efficiently develop the students' familiarity and boost their proficiency in literacy in the digital world, and ensure that they can keep pace with the global development. The Organization for Economic Cooperation and Development (OECD), (2019) mentioned that information technology can help with good communication and information exchange, and it also creates new opportunities for students to learn outside of school. It allows teachers to manage their teaching and follow the curriculum so that they can change the instruction method and exchange students' learning experiences to enhance their digital learning. Information media and technology competencies and digital literacy are essential skills for students in education in the digital world. The government must urgently ensure that students have proper information skills for this digital century.



However, instruction in Thai higher education institutes continue to face issues from the lack of diverse instruction methods. Practice is less common compared to the lecture, even though practice lessons actually contributes more to the development of future essential skills (Aumgri.C and Petsangsri.S, 2019; Pradubthong, et. al, 2018; Office of the Education Council, 2018) which affects students in the future. Meanwhile, Monchai Tiantong. (2011) stated that online virtual classroom learning can facilitate more effective and widespread learning, corresponding with Keeratikorn (2015) who said that another future essential skill is the virtual collaboration. Therefore, it's necessary to develop the future Thai workforces, and manage instruction and learning of Rajabhat University, which is the government's higher education institute that has been playing an important role in producing teachers for over 90 years and sets the goal in producing computer science teachers. These 41 universities throughout Thailand are under the Office of the Higher Education Commission, Ministry of Education and are able to produce local manpower with mid and high levels of education (Penchan Sangkaew, 2002: Sommai Piathanom, 2008; The History of Rajabhat University, 2019;) by diversely managing the instruction in each subject, depending on the readiness of those universities, and by adjusting the instruction to the local and national contexts. Lara, 2018; Reeve, 2016, from BETT educational technology 2018 also studied the importance of the implemented strategies and technologies which support the education, and found that 82% of the sample group accepted that technology is an important tool which well enhances modern skills.

In reflection of this issue, the researcher decided to develop an online learning platform in collaboration with virtual technology using a digital ecosystem to the develop information media and technology skills of students and improve the academic achievement of undergraduate students, with the intention that this will be implemented as instructional guidelines. Biljana and Dragana, (2017) and Phanich (2012) mentioned that teaching innovations is the important factor which raises the competency and the quality of teaching. It well enhances the 21<sup>st</sup> century skills, guides the development of instruction, and produces quality graduates who are equally equipped with information skills to live in the future daily digital world.

### **Research Objectives**

1. Develop an online learning management plan in collaboration with virtual technology using digital ecosystem to develop the quality of information, media and technology skills.
2. Develop online learning in the collaboration with virtual technology using a digital ecosystem to develop quality and efficient information, media and technology skills.

3. Compare the information, media, and technology against the students' academic performance before and after practicing in the online learning platform in collaboration with virtual technology using a digital ecosystem.

### **Research Hypothesis**

It is hypothesised that the students' information, media, and technology skills as well as their academic achievement of students will improve after participating in the online learning platform.

### **Research Methodology**

The populations of this study were 118 undergraduate students from the Faculty of Education, Nakhon Pathom Rajabhat University who were enrolled in the Digital Media Development and Design course in the first semester of the academic year 2019. The research participants were divided into four groups. The populations were randomised by the cluster sampling method. There were 40 people in the experimental group and 39 people in the control group. The sample size was calculated with G\*power Version 3.1.7 package software by determining F-test, Manova test (MANOVA: Global effects), and the type of analysis on power of the test. The researcher determined the appropriate sample size before conducting the research (A priori: Compute required sample size – given  $\alpha$ , power, and effect size). One - Tailed Test was defined by determining 1) the large effect size according to the criteria of effect size for T-test following Cohen's concept (Cohen, 1977; Nongluck Wiratchai, 2012) which is equal to .80. 2) the probability of type 1 error ( $\alpha$ ) = 0.05. 3) power of the test (1- $\beta$ ) = 0.80, which was equal to 22 people resulted from the calculation of the sample size. This corresponds to the sample size determination which uses MANOVA when at least 20 people should be determined on each sample group (Hair et al., 2010).

### **The Research Tools Used Were Developed by the Researcher and Tested as the Follows; *Online Learning Management Plan***

There were 10 steps for the online learning management plan of the collaboration of virtual technology using a digital ecosystem to develop the information media and technology skills, following the steps of the Dick and Carey Model (2005). As shown in table 1, this consisted of the lesson content comprising of educational digital media design, media and instruction plan evaluations by five experts. The quality of the instruction plan was high, with a mean score of 4.68 (SD = 0.34). The evaluation results were divided into five levels: 4.50-5.00 (highest); 3.50-4.49 (high); 2.50-3.49 (average); 1.50-2.49 (low); and 1.00-1.49 (lowest).

### ***Academic Achievement Assessment Form***

The objective test comprised of 40 items. Index of Item Objective Congruence (IOC) was calculated from the assessment of five experts. The acquired IOC score ranged between 0.60-1.00, the difficulty index was between 0.27-0.63, and discrimination value was between 0.27-0.68, and the test reliability calculated by Cronbach Alpha Coefficient was 0.88.

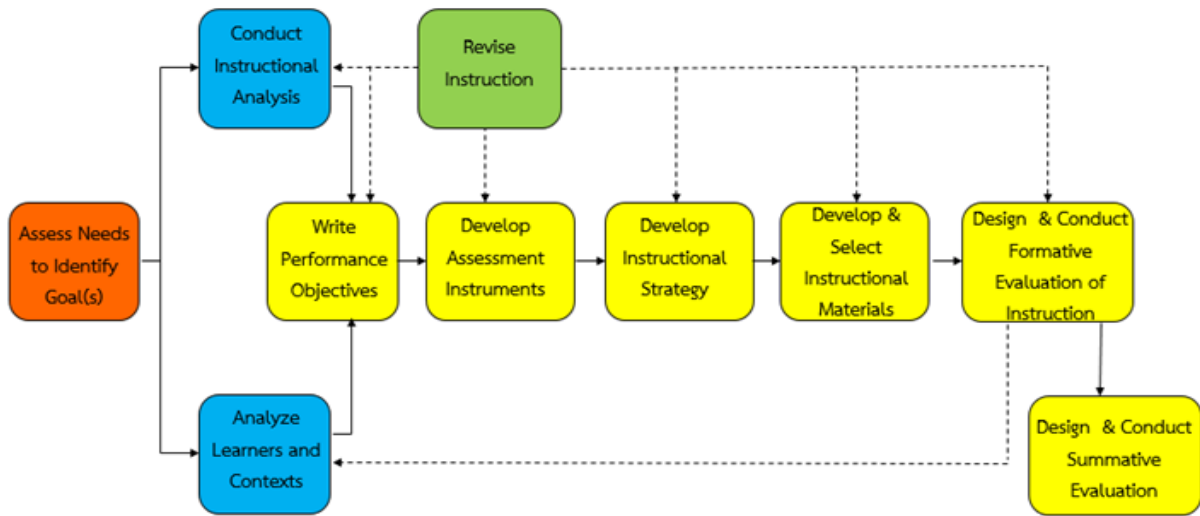
### ***Information, Media and Technology Skills***

This tested the students' information, media, and technology skills and included eight items of the objective test (the weighting of each choice is based on the level of Kohlberg's Moral Development (1976)). The IOC was calculated by five experts with the acquired IOC between 0.60-1.00 and the test reliability calculated by Cronbach Alpha Coefficient was 0.83.

### **Data Collection**

1. Give advice on the management of online learning platform of the collaboration of virtual technology using digital ecosystem to improve students' information, media, and technology skills for teachers and students for their mutual understandings.
2. Students signed an agreement to participate in the online learning platform of the collaboration of virtual technology using digital ecosystem to improve information, media, and technology skills in Digital Media Development and Design course so that the researcher granted their permissions and coordinated in collecting data with the sample group. The students were aged between 22 to 25 years old.
3. Prior to the learning process, the experimental and control sample groups must be tested using an academic achievement assessment form. The test results were used to compare the students' learning background.
4. The online learning platform of the collaboration of virtual technology using digital ecosystem to improve information, media, and technology skills applied ten instructional steps of the Dick and Carey Model (2005) and lasted for a total of ten weeks as shown in Table 1.

**Figure 1.** Instructional steps of the Dick and Carey Model (2005)



**Table 1:** Shows instructional steps of Dick and Carey Model

Steps	Activities
Step 1: Assess needs to identify instructional goal(s)	The course's objectives were determined at this stage. The objectives must be correspondingly adjusted to the educational goals. The researcher studied the course, and course description of the Digital Media Development and Design course (course id: 4143606) which is a basic course for undergraduate students on the Computer Education Program at the Faculty of Education, Nakhon Pathom Rajabhat University. The description and content of educational digital media design of the course are presented (Charinthorn Aumgri, 2017).
Step 2: Conduct instructional analysis	<p>The analysis of instruction is the process when the instructional goals must be pursued for students to achieve in three targeted skills, including academic achievement and information use skills. The designer then analysed the indicators of the designated course so it corresponds with the learning outcome.</p> <div style="border: 1px solid red; padding: 5px; text-align: center; margin: 10px 0;"> <p><b>Learning Outcomes on Academic achievement</b></p> </div> <ol style="list-style-type: none"> <li>1. Tell the definition of information system correctly.</li> <li>2. Tell the elements of information system's main function process correctly.</li> <li>3. Tell characteristics of good information system correctly.</li> <li>4. Explain the definitions of information system's characteristics correctly.</li> <li>5. Categorise the type of information system correctly</li> <li>6. Tell the elements of information system correctly.</li> </ol>

Steps	Activities
	7. Tell the definitions of information system's elements correctly. 8. Tell the functions of the designated devices in information system correctly. 9. Tell the function of the programs used in information system correctly. 10. Tell the function of information system's elements correctly, 11. Tell the operation process of information system correctly. 12. Explain basic information of Canva program correctly. 13. Use Canva program correctly. 14. Create infographic for digital classroom with Canva program. 15. Explain basic information of Plickers program correctly. 16. Use Plickers program correctly. 17. Design digital online classroom with Plickers program correctly. 18. Explain basic information of Book Creator program correctly. 19. Use Book Creator program correctly. 20. Design online E-book correctly. 21. Explain basic information of Aurasma is now HP correctly. 22. Use Aurasma is now HP Reveal correctly. 23. Create virtual media with Aurasma is now HP.
Step 3: Identify entry behaviours, characteristics	The researcher created an entry behavior assessment form by individually analysing students. This can be classified into two aspects; <ol style="list-style-type: none"> <li>1. Knowledge, competency, and experience               <ol style="list-style-type: none"> <li>(1) Basic knowledge of the course available in that level.</li> <li>(2) Problem-solving abilities</li> <li>(3) Interest and concentration in learning.</li> </ol> </li> <li>2. Intelligence readiness               <ol style="list-style-type: none"> <li>(1) Creative initiation</li> <li>(2) Rationality</li> <li>(3) Learning competency / thinking prioritisation</li> </ol> </li> </ol>
Step 4: Write performance objectives	The researcher designed purposive objectives or behavioural objectives which conform to instructional and learning objectives.
Step 5: Develop assessment instruments	The researcher created an assessment tool which explains the relationship between the assessment form, learning objectives, and learning activities. This consisted of information searching skills and a report writing assessment, a data collection assessment, assessment of the group process, experiment operation, knowledge seeking, an assessment of conceptual map management, and knowledge assessment.



Step 6: Develop instructional strategy	The researcher analysed the mission or instructional steps following Gagne's theory (Gagne. 1985) by applying nine events of the instruction model in designing the computer lesson, and made the lesson become like actual learning which adhered to content presentation principle and interactive learning activities.
Step 7: Developing and select instructional materials	The development of instructional media was used when the designer is not an instructor. The team was required to communicate and cooperate to share their skills. With a standard operation process to communicate between the designer and the material developer, the workflow would not be repeated. This would be the combination between the design and skill development by each participant. Hybrid instruction was used, with the instructor was selected and existing materials were adjusted to be appropriate for the instructional strategy.
Step 8: Design and conduct formative Evaluation of instruction	<p>The evaluation was conducted during the operation. The learning content was be analysed by experts in contents and multi-media technology. The media was put on trial.</p> <p>One-to-one evaluation:</p> <ol style="list-style-type: none"> <li>1. Involvement of students from the target group</li> <li>2. Involvement of the experts in that learning content</li> <li>3. The outcomes of the formative evaluation</li> <li>4. Evaluation of the field trial.</li> </ol> <p>Small-group evaluation:</p> <ol style="list-style-type: none"> <li>1. The involvement of the students from the target group.</li> </ol> <p>Field Trial:</p> <ol style="list-style-type: none"> <li>2. Selected appropriate samples to the target group</li> <li>3. The selected instructional materials</li> <li>4. Instructor Led Instruction</li> </ol>
Step 9: Revise instruction	The adjustment process of instructional media according to the recommendations of the five experts in instructional media.
Step 10: Design and conduct summative evaluation	Designed and evaluated the conclusions; both content and media production technique, in order to test the efficiency of online lessons in collaboration with the virtual technique using digital ecosystem. The efficiency calculation criteria of Promwong (1978) (E1 / E2) was used. This tool is accepted and widely used in Thailand to evaluate the quality of instruction (Wichian, 2017; Semphuech & Sukkamart , 2019; Komanee, Hoxsuwan, & Phuseeon, 2013; Meksophawannagul & Hiranburana, 2013 & Kannarik, 2014).

4. After completing the instructional session, the students from the experimental group and the control group were asked to undergo a knowledge assessment, composing of 40 items of a



four-choice objective test. Content validity was checked by five experts. The index of the item and definition of each item was checked by calculating the IOC (index of item - objective congruence) which was equal to 1.00 for every item. The researcher adjusted the questions according to the experts' recommendations before testing them with students in Mattayom 4 and 30 research participants who were not in either of the two sample groups. This was undertaken to analyse the difficulty index which was .29-.79 and the discrimination index was .30-.60. The reliability index for the whole test was analysed with the KR-20 formula, with a result of .78. Each 12 items of assessment form the information, media, and technology skills was scored from 0-5 and the IOC was 1.00 in all evaluated items. The IOC was scored by two auditors and calculated with RAI (rater agreement index), which was .92.

5. Data was collected from the academic performance assessment form and the assessment form for information, media, and technology skills. The one-tail test was used to analyse the data.

## Research Results

The researcher analysed the collected data from the online learning platform in collaboration with virtual technology using a digital ecosystem to develop information, media and technology skills which followed 10 steps of Dick and Carey Model (2005). Pre-test and post-test mean scores for the information, media and technology skills, as well as students' academic performance were compared when students enrolled in Digital Media Development and Design course's online learning platform in collaboration with virtual technology using digital ecosystem. This research then evaluated the hypothesis of MANOVA. The results are detailed in table 2.

**Table 2:** Test results of basic assumption test of MANOVA analysis

Statistical Test	Assumption	Data analysis	Test Results
Correlation of variables by applying Barlett's Test	Sig < $\alpha$	.00*	The dependent variables did not correlate, which caused multicollinearity
Variance-covariance matrix by applying Box's M Test	Sig > $\alpha$	.06	The variance-covariance matrix are equal.
Data distribution by applying Shapiro-Wilk	Sig > $\alpha$	.05	The data is normally distributed and classified into two groups.

\*p < .05

Table 2 shows that the overall results of every item have complied with the basic assumption of the MANOVA analysis. The test of basic agreement shows the following results. First, by applying Barlett's Test, it's found that  $Sig < \alpha$  meaning that the variables did not correlate, thus causing multicollinearity. Second, by applying Box's M Test, it was found that  $Sig > \alpha$  which can be interpreted that the variance-covariance matrix was equal. Third, by applying Shapiro-Wilk, it was found that  $Sig > \alpha$  which identifies that the data was normally distributed. Therefore, one-way MANOVA was conducted.

**Table 3:** The results from the analysis of students' academic achievement and information, media, and technology skills between the experimental group and the control group

Group	Achievement score (30 points)		Score of information, media, and technology skills (40 points)	
	Mean	SD	Mean	SD
Experimental Group (n=40)	27.92	1.118	38.15	1.001
Control Group (n=39)	17.21	2.105	30.74	2.826

Note, Box's M = 55.404,  $df = 1090273.816$ ,  $p = .00$ , Bartlett's Test: Likelihood = .109, Approx. Chi-Square = 4.265,  $df = 2$ ,  $p = .00$

Table 3 shows that the students' academic achievement and information, media, and technology skills score is higher after enrolling in online learning platform in collaboration with virtual technology using digital ecosystem. The mean post-test score of students' problem-solving skill ( $\bar{x} = 10.84$ , S.D. = 2.11) is higher than the pre-test score ( $\bar{x} = 6.00$ , S.D. = 2.10). Meanwhile, the post-test score of the students' academic achievement ( $\bar{x} = 12.43$ , S.D. = 3.33) is higher than the pre-test score ( $\bar{x} = 9.57$ , S.D. = 3.28) (Tabachnick and Fidell, 2013).

**Table 4:** Statistical test in comparison of academic achievement information, media, and technology skills after the learning for the experimental group and the control group

Source of variance	Statistical test	Value	F	Hypothesis df	Sig.
GROUP	Pillai's Trace	.953	549.462	2.000	.000
	Wilks' Lambda	.065	549.462	2.000	.000
	Hotelling's Trace	14.460	549.462	2.000	.000
	Roy's Largest Root	14.460	549.462	2.000	.000

\* $p < 0.05$

From table 4, it's shown that the variance of post-test scores for the academic achievements of the experimental group and the control group are different at significance level of 0.05. This indicates that at least one instructional method affects the difference in at least one

dependent variable of the experimental group and control group. The results from multi-variables test are as follows.

Pillai's trace is used as a test statistic in MANOVA, which has a positive value from 0 to 1. Increasing the statistical value contributes more to the model (Berry, et.al, 2016; Santhuenkeaw.t, 2019). The study results show a value of 0.953

Wilks' Lambda is a positive-valued statistic that ranges from 0 to 1, with decreasing values indicating effects that contribute more to the model (0.65).

Hotelling's trace is the sum of the eigenvalues of the test matrix, which is a positive-valued statistic with increasing values indicating effects that contribute more to the model (14.460). Hotelling's trace is always larger than Pillai's trace.

Roy's largest root is the largest eigenvalue of the test matrix. Thus, it is a positive-valued statistic for which increasing values indicate effects that contribute more to the model. Roy's largest root is always less than or equal to Hotelling's trace. As the study's two statistics are equal (14.460), the resultant interpretation is that there is a strong correlation between the dependent variables.

**Table 5:** Tests of between – subjects effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Couple Comparison
Group	IT Skill	1083.211	1	1083.211	243.499	.00	Experiment > Controls
	Achievement	2269.220	1	2269.220	804.710	.00	Experiment > Controls
Error	IT Skill	342.536	77	4.449			
	Achievement	217.134	77	2.820			
Total	IT Skill	95421.000	78				
	Achievement	42954.000	78				

Note, \*\*p < .05

From table 5, it is found that the variance of information, media, and technology skills and the academic achievement of experimental group are higher after the enrolment in the online learning platform at a significance level of 0.5. The analysis of information, media, and technology and academic achievement has already designed pre-test and post-test assessment; therefore, paired sample test was not conducted. The analysis results indicate that the



students' information, media, and technology skills and academic achievement are higher after enrolling in the online learning platform.

## **Conclusion**

The findings from the online learning platform in collaboration with virtual technology using a digital ecosystem to improve information, media, and technology skills following 10 steps of Dick and Carey Model can be concluded as follows. First, the appropriateness of the plan scored 0.67-1.00 by experts, which comprises the elements of learning management, learning objectives, contents, learning activities, learning media, and assessment and evaluation. Second, the mean scores of information, media, and technology and academic achievement were considered higher than the control group at a significance level of 0.5, both in content and in the media production technique which is categorised in a "very good" level. The efficiency of the online's process towards the efficiency of outcomes is equal to 81.69/87.28. The students' information, media, and technology skills and academic achievement is higher after the enrolment in a online learning platform in collaboration with virtual technology using a digital ecosystem to improve information, media, and technology skills at a significant level of 0.5.

Since there are various forms of studies on appropriate thinking skills for the 21<sup>st</sup> century, it's necessary to equip students with capabilities, especially their innovation and technology skills, which can be adapted to their daily life. It can also enhance the efficiency of teaching and learning computer (Aumgri.C & Pimdee.P (2018); Radicelli, et. al (2018); Titova, et. al (2018). Online learning is currently a popular instructional strategy which can serve to enhance information, media, and technology skills of students wound the world.



## REFERENCES

- Aumgri.C & Petsangsri.S (2019). Computational thinking for preservice teachers in Thailand: A confirmatory factor analysis. *Revista ESPACIOS*, 40(29), 12-29
- Aumgri.C & Pimdee.P (2018). Model component analysis of computational-thinking STEM Education in enhancing the ICT literacy skills for the 21st-century undergraduates students. *Journal of Thai Interdisciplinary Research* . 13(3), 30 - 35.
- Berry, K. J., Mielke, P. W., & Johnston, J. E. (2016). *Permutation statistical methods: An Integrated Approach*. Berlin, Germany: Springer Books.doi: <https://doi.org/10.1007/978-3-319-28770-6>
- Biljana, N. C., & Dragana, S. (2017). Education need of teacher for introduction and application of innovative models in education work to improve teaching. *International Journal of Cognitive Research in Science, Engineering and Education*, 5(1). 178-189. doi: <https://doi.org/10.5937/IJCRSEE1701049N>
- California Emerging Technology Fund: CETF. (2008). Digital literacy. [Online]. Available:<http://www.cetfund.org/investments/initiative-digital-literacy/digital-literacy>
- Cohen, J. (1977). *Statistical power analysis for the behavioral sciences*. Rev ed. New York : Academic Press.
- Dick, W. Lou, C. and James O. C. (2005). *The systematic design of instruction*. 6th ed. Boston: Allyn and Bacon.
- Elena D. G. (2015). The development of ICT-competencies of the students at foreign language lessons as the basic for successful learning and cognitive activity.” [Online]. Available : <http://www.sciencedirect.com>
- Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E. (2010). *Multivariate data analysis a global perspective*. (7th ed.). Upper Saddle River, NJ: Prentice Hall.
- Kannarik, P. (2014). Integrating google apps for education to business English student trainees’ on-the-job training English reports. In: *The Proceedings of International e-Learning Conference 2014*, August 5-6, 2014. Retrieved from: <http://tinyurl.com/qgnoct3>.
- Komanee, S., Hoxsuwan, S., & Phusee-on, S. (2013). The contemplative education learning environment management model for undergraduate students. *The Journal of Global Business Management*, 9(3). Retrieved from: <http://tinyurl.com/ppx39w7>.



- Lara, V. (2018). Tailoring education for the 21st century: perspectives from educators. Economist Intelligence Unit. Retrieved from: <https://tinyurl.com/y8cwbte>.
- Meksophawannagul, M., & Hiranburana, K. (2013). The effectiveness of an online case-based collaborative learning (CBCL) module for a business English communication course. *International Journal of Business and Social Science*, 4(12). 128-132. Retrieved from: <http://tinyurl.com/qctvlp1>.
- Ministry of Education. (2017). Learning standards and indicators for mathematics and science learning strands and geography in social studies, religions, and cultures learning strands (Revision B.E. 2560) Under the Basic Education Core Curriculum B.E. 2551. Retrieved August 31, 2017 from [http://opec.go.th/ckfinder/userfiles/files/general/123\(2\).pdf](http://opec.go.th/ckfinder/userfiles/files/general/123(2).pdf).
- Monchai T. (2011). Courseware design and development for CAI. Bangkok: King mongkut's university of technology north bangkok.
- Nation Academic of Science. (2016). ICT competency and literacy. [Online]. Available : <http://www.nasonline.org/?referrer=https://www.google.co.th/>
- Nonglak W. (1990). A guide to writing research projects. *Journal of Educational Measurement*. 12 (35): 43-72.
- OECD (2019), PISA 2021 ICT Framework, PISA, OECD Publishing, Paris, <https://www.oecd.org/pisa/sitedocument/PISA-2021-ICT-framework.pdf>
- Office of the Education Council. (2018). Thai educational conditions for the year 2016/2017: guiding enhance Thai education For Thailand 4.0. Bangkok: Graphic Pikwhan
- Olson, C. L. (1974). Comparative robustness of six tests in multivariate analysis of variance. *Journal of the American Statistical Association*, 69(348), 894-908.doi: <https://doi.org/10.2307/2286159>
- Personnel Development Ministry of Education. (2016). The Twelfth Educational Development Plan of the Ministry of Education (2017-2021). Bangkok: Office of the Permanent Secretary to the Ministry of Education.
- Phenchan S. (2002). Research report on potential of students in Rajabhat Institute Phetchabun: Phetchabun Rajabhat Institute
- Phanich, W. (2012). Ways to build learning for students in 21st century. Bangkok, Thailand: Sodsri – Saritwong Foundation. Retrieved from: <http://tinyurl.com/zcc233j>.



- Pisa Thailand. (2018). <https://pisathailand.ipst.ac.th/news-12/>
- Pradubthong, N., Petsangsri, S., & Pimdee, P. (2018). The effects of the SPACE learning model on learning achievement and innovation & learning skills in higher education. *Mediterranean Journal of Social Sciences*, 9(4), 187-199.
- Promwong, C. (1978). Introduction to social research: Quantitative and qualitative approaches, *Psychology*, 18, 79-92. Retrieved from: <http://tinyurl.com/jdnpuvm>.
- Radicelli, et. al (2018). Smart Education: Evaluación «ex ante» previo a la implementación de una estrategia de aprendizaje ubicuo en Smart Cities. *Revista ESPACIOS*. 39 (15) . 9-23
- Reeve, E. M. (2016). 21st-century skills needed by students in technical and vocational education and training (TVET). *Asian International Journal of Social Sciences*, 16(4), 65 - 82. doi: <https://doi.org/10.29139/aijss.20160404>
- Sanith, S., Saroach, S. (2015). The Web-Based instruction model based on connectivism learning theory to enhance problem-solving skill in information and communications technology of higher education students. *FEU Academic Review Journal* .8(2). 102-112.
- Santhuenkeaw. T , Tontiwongwanich. S & Pimdee. P. (2019). Improving thai student's digital media skills: An exploratory learning model. *revistaESPACIOS*, 40(15), 21 - 34.
- Sempuech & Sukkamart. (2019). The inquiry instruction with e-learning courseware to develop problem solving skills and learning achievement on programming . *Journal of research and curriculum development*. 9(2), 246 - 261.
- Siriluk, P. & Parnichparinchai. (2014). Indicators development of student's skills in the 21st century. *Journal of Education Naresuan University*. 16(4). 155-165.
- Suapsom, & meeplad. (2017). The preparation of ict literacy skills of students in nakhon si thammarat rajabhat university. *Journal of Rangsit University: Teaching & Learning*. 11(1), 26 – 38.
- Suwanroj, T., Leekitchwatana, P., & Pimdee, P. (2019). Development of ICT Competency Domains for Undergraduate Students in Thailand. 27(2). 84-92
- Suwanroj, T., Leekitchwatana, P., & Pimdee, P. (2019). Confirmatory factor analysis of the essential digital competencies for undergraduate students in Thai higher education institutions. *Journal of Technology and Science Education*, 9(3), 340-356. doi:<http://dx.doi.org/10.3926/jotse.645>





- Tabachnick, B. G., & Fidell, L. S. (2013). Using multivariate statistics. Pearson New International Edition.
- Titiya, N. (2015). Development of information technology literacy and volunteers by using blended learning and society service project based learning. *Journal of Industrial Education*. 13(3). 59-65
- Titova.E, et. al (2018). Online complex supporting the distance education course in human anatomy for foreign pre-university medical students. *Revista ESPACIOS*. 39 (10). 34 – 44
- Toomphong & Wannasri. (2018). Needs assessment of the developing information, media and technology skills of school administrators under the office of secondary educational service area. *Journal of Graduate Studies and Social Sciences, Uttaradit Rajabhat University*. 8(2). 63-80
- United Nations Educational. (2011). Unesco Ict copetenct framework for teachers. Paris France: Unesco Regional Office for Education.
- Wichian T. (2017). The reflection on the concepts of instructional package, learning activity package and learning package. *Journal of Education Naresuan University*. 19(3), 356 - 369.
- Wiwat, M. (2018). Effects of using social network with flipped classroom to support communication skills. *Journal of Education Naresuan University*. 20(3), 162-172
- Yuhyun PC. 8 digital skills we must teach our children. World Economic Forum: WEF [internet]. 2016 [cited 17 December 2016] Available from <http://weforum.org/agenda/2016/06/8-digital-skills-we-must-teach-our-children>