Qualifications Framework of Essential Learning Outcomes for Computer Innovation and Digital Industry Professionals

Thamasan Suwanroj*, Orawan Saeung, Punnee Leekitchwatana, and Kanaporn Kaewkamjan

***Abstract*—This research aimed to study and analyze the factors of the qualification framework of essential learning outcomes for computer innovation and digital industry professionals. The factors consisted of indicators of essential competencies for undergraduates under the professional qualifications of Computer Innovation and Digital Industry Major based on the context of Nakhon Si Thammarat Rajabhat University (NSTRU). The sample group consisted of all teachers and experts in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computer, and Computer Education, covering all undergraduate programs from public institutions of higher education across Thailand. The research instrument was the questionnaire about factors of the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Major. The questionnaire used five levels of a rating scale. Content validity and reliability for the scale were 0.96–1.00, and the content validity and reliability for the factor were 0.97–0.99. Second-order confirmatory factor analysis (CFA) was employed for data analysis. The research discovered new knowledge on the list of essential competencies for undergraduates under five factors of the qualifications framework of learning outcomes with 24 indicators. These 24 indicators were separated for each factor: six for Ethical and Moral Development and Knowledge, four for Cognitive Skills, Interpersonal, and Responsibility, Numerical Analysis, and Communication and Information Technology skills, respectively.**

***Index Terms*—Qualifications framework of learning outcomes, computer innovation and digital industry professionals, indicator, Second order confirmatory factor analysis.**

I. Introduction

Thai Qualifications Framework for Higher Education (TQF: HEd) was firstly announced by the Ministry of Education in 2009. However, there has been a problem with this first TQF since 2009. The problem is that this TQF is not specific. It is just the broad framework used as a guideline to develop or improve the curriculums' details. Subsequently, other qualification frameworks for different majors have been announced for ten years (2009-2019). Still, there has been a problem. This time the problem is that the qualification frameworks do not cover all majors. This leads to other problems; for example: in developing or improving the curriculum, apart from having that TQF, the educational institutions providing bachelor's, master's, or doctoral degrees need to rely on the guideline announced by the Higher Education Commission on Practice Guidelines under Thai Qualifications Framework for Higher Education B.E. 2552 (2009) which have only five factors: 1) Ethics and Morals, 2) Knowledge, 3) Cognitive Skills, 4) Interpersonal and Responsibility Skills, and 5) Numerical Analysis, Communication, and Information Technology skills. The study of this document found that each factor does not have indicators' details or a list of essential competencies for undergraduates under the qualifications framework of learning outcomes. Therefore, it can be used only five factors of the qualifications framework for implementation [1, 2]. The indicators' details or a list of essential competencies for undergraduates under the qualifications framework of learning outcomes are not specified to have the standard and to make it concrete. A subsequent problem is evaluating the indicators' details or a list of essential competencies defined abstractly.

From the problems mentioned above, the researchers had an idea to develop the indicators' details or essential competencies under the qualifications framework of learning outcomes because this is the key to the qualification framework. The objectives of the research were to study and analyze the factors of qualifications framework of learning outcomes consisting of a list of indicators of essential competencies for undergraduates under the professional qualifications of Computer Innovation and Digital Industry Major based on the context of NSTRU. The research results identified the qualification framework of learning outcome factors and used them for practical purposes. The researchers referred to five factors of the qualifications framework mentioned above. Another essential part of this research was factor analysis of the qualification framework consisting of a list of indicators of essential competencies for undergraduates under the standard of each major to get the qualifications framework of essential professionals in the Computer Innovation and Digital Industry. This qualification framework was confirmed by using confirmatory consideration. Based on the principles of advanced statistics, construct validity was checked using CFA to be matched with actual situations based on the context. A list of 24 indicators for essential competencies, approved by checking construct validity with the technique mentioned earlier, was confirmed to assure the ability to specify the indicators' details of essential competencies under the qualifications framework. These 24 indicators were also employed as the guideline to develop the curriculum mentioned above with standard and reliability followed in the announcement of qualifications framework as stated.

The main problem and urgent need in doing this research were to build the confidence of undergraduates' users for the standard of curriculum development as well as learning and

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teaching quality in keeping with the qualifications framework of Computer Innovation and Digital Industry Major of NSTRU. The qualification framework for Computer Innovation and Digital Industry Major has not been specified yet in the announcement of the Ministry of Education for Undergraduate Qualifications of Computer Major in 2009. Only five majors have been announced: Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computer, and Computer Education. However, it can be believed that the qualifications framework and a list of all indicators for essential competencies gained from this research fit the standard. They can be compared to other curriculums and used as the standard model for curriculum development.

Moreover, these factors still have a standard not lower than those declared in the announcement of the National Qualifications Framework (NQF) in 2009. There is a solution stated in the announcement of The Higher Education Commission for Guidelines for Operation Based on the NQF in 2009, item 2.2. It mentioned, "Stick to the announcement of the Ministry of Education for the NQF in 2009 as the guidelines to develop and improve the curriculum's details in case of not having the announcement of qualifications for that major or program on the level of that qualification" [1]. The indicators' details can be specified based on the context of each university. Considering another problem, it found that the learning outcomes used from 2010 - the present are incapable of a practical purpose or actual operation. This causes an obstacle in publicizing the quality and qualified curriculums under the NQF to the Thai Qualifications Register database system (TQR). Because of this problem, it found that a list of indicators for essential competencies under the qualifications of learning outcomes specified in the curriculums since 2010 is abstract and unable to be used for evaluating the essential competencies in keeping with the evaluation principles. This causes a problem in publicizing the quality and qualified curriculums under the NQF to the database system of TQR.

Compared to the studies of Jadhav *et al*. (2020) [3], Madaminov *et al*. (2020) [4], Lin *et al*. (2017) [5], Bansal et al, (2015) [6], this research is distinctive and remarkable in the methodology of improvement for the qualification framework of essential learning outcomes for computer innovation and digital industry professionals by using the technique of confirmatory consideration. Also, the construct validity of a list of indicators for essential competencies for professionals or undergraduates was checked using different techniques. This research is also remarkable in using the advanced statistical technique, the CFA, to test the construct validity of a list of indicators of essential competencies for professionals. This technique helped reduce the number of a list of indicators for essential competencies by grouping the same factors. Also, it helped solve the problem caused by the possibility of the relation of a list of indicators for essential competencies gained by the research or the problem of Multicollinearity. Finally, the CFA brought about the structural relationship of the qualifications framework of essential professionals for Computer Innovation and Digital Industry which had the construct validity [7]. The objectives of the research were to study and analyze the factors of the qualifications framework consisting of a list of indicators of essential competencies for undergraduates followed in the qualifications of Computer Innovation and Digital Industry Major based on the context of and under the qualifications of Thailand as mentioned earlier. Five factors [1] stuck to the hypothesis that "the factors of qualifications framework required for computer innovation and digital industry professionals is validity."

II. Literature Review

Qualifications framework: Thailand started using the NQF for the first time in 2009. From 2009-the present, this has been regarded as the framework presenting the system of qualifications for the country's higher education. The framework is set to link with the strategies of educational management towards the qualifications at the international level in keeping with the National Education Act of B.E. 2552 (2009), including the qualifications of national education and qualifications. The qualification framework is mainly used to bring the policy's guidelines in improving the quality and qualifications of educational management as stated in the National Education Act. It is regarded as the national and higher education qualifications which focus on the practical operation in the educational institutions because this qualification framework has a precise method in developing the curriculums of educational institutions. Teaching strategies of teachers, as well as the students' learning, are adjusted to measure and evaluate the learning outcomes for building the confidence that undergraduates will achieve the indicators of essential competencies as the real qualifications gained from expected learning outcomes. The Ministry of Education specifies the qualifications framework consisting of five factors respectively as follows: 1) Ethics and Morals, 2) Knowledge, 3) Cognitive Skills, 4) Interpersonal and Responsibility Skills, and 5) Numerical Analysis, Communication, and Information Technology skills [1]. The qualification framework also focuses on the learning outcomes of undergraduates. It is the minimum of qualitative qualifications to assure the quality of undergraduates, communicate to the related organizations for understanding and build confidence in the process of undergraduates' production. The process starts with the production and outcomes of educational management. The expected qualification of undergraduates must be firstly specified. Then other factors related to learning and teaching in enhancing undergraduates to achieve the qualifications are considered. These two steps have to support each other coherently and systematically. Also, there is an aim to make the qualifications or degrees of Thai educational institutions approved and compared with other educational institutions both in the country and overseas. The qualifications framework helps systematically specify the qualifications in all steps by providing opportunities to the educational institutions to provide various types of curriculums and learning and teaching processes. It can also build the confidence that the final production of educational management will reflect the quality of undergraduates with their qualifications of expected learning outcomes. Undergraduates can also earn a living with pride and

happiness, with undergraduates' satisfaction. They are good people of society and help to strengthen and increase the country's development capability. The study and comparison of the details of qualifications framework on higher education levels from different countries that provide quality educational management found that the learning outcome qualifications of those countries are covered by at least five factors as well. The details are shown in Table I.

TABLE I: COMPARISON RESULT OF DETAILS FOR FACTORS OF QUALIFICATIONS OF LEARNING OUTCOME FROM COUNTRIES PROVIDING HIGH QUALITY OF EDUCATIONAL MANAGEMENT

Domains of Learning	Country				
	Finland	Switzerland	Belgium	Singapore	Netherlands
1) Ethical and Moral	✓	✓	✓	✓	✓
2) Knowledge	✓	✓	✓	✓	✓
3) Cognitive Skills	✓	✓	✓	✓	✓
4) Interpersonal Skills and responsibility	✓	✓	✓	✓	✓
5) Analytical and Communication Skills	✓	✓	✓	✓	✓

Source: (Bohlinger, 2019) [8], (Hoque, 2016) [9], (Saim *et al*, 2021) [10].

Table I shows that the qualifications framework of higher education consists of five factors: 1) Ethics and Morals, 2) Knowledge, 3) Cognitive Skills, 4) Interpersonal and Responsibility Skills, and 5) Numerical Analysis, Communication, and Information Technology skills. The learning and qualifications of learning outcomes under the Thai qualification framework focus on changing the students' behaviours based on the acquired experience during studying in the curriculum to develop learning competencies in keeping with a fundamental principle of Bloom (Bloom's taxonomy) [11]. Expected learning outcomes of undergraduates are specified to cover five factors with the details as follows: [7, 9, 12, 13]

1) **Ethics and Morals** is a habit development for students to behave well under ethics and morals as well as self and social responsibilities. Also, students can adjust their lifestyle to the value conflict, develop their habits and behave according to moral standards in personal and social behaviours.
2) **Knowledge** is an ability to understand, think and present information analysis. It is also the ability to classify facts based on theoretical principles and different processes and the ability to be a self-learner.
3) **Cognitive Skills** are the ability to analyse situations, use knowledge and understand concepts, theoretical principles, and different processes in analysing and finding solutions when facing new and unexpected situations.
4) **Interpersonal and Responsibility Skills** are the ability to work in a group, have leadership skills, take self and social responsibilities, and plan and be responsible for self-learning.
5) **Numerical Analysis, Communication and Information Technology skills** are the ability to have numerical analysis, use mathematical and statistical techniques, and communicate by speaking and writing, including information technology.

Besides the five factors of learning outcomes mentioned above, each curriculum or program can specify additional factors such as learning of the Psychomotor Domain [9, 14, 15]. Five factors previously mentioned can be set as the qualification framework. The indicators of essential competencies can be specified based on the context of educational institutions to get the model of qualification framework of essential learning outcomes for professionals. NSTRU is an example of using the result of this research, the qualification framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals.
The findings are also brought to use in the process of students' development, as shown in Fig. 1.

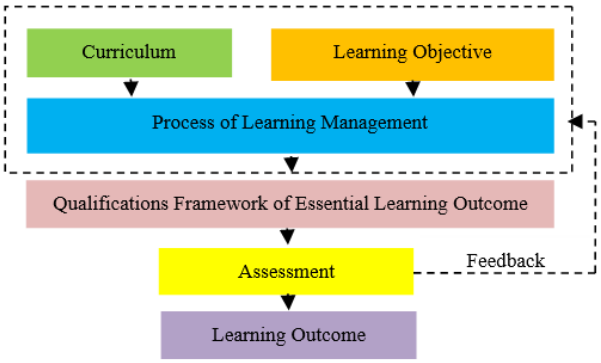


Fig. 1. Model of qualifications framework of essential learning outcomes for computer Innovation and digital industry professionals of NSTRU.

III. SCOPE OF RESEARCH

CFA of qualifications framework of learning outcomes consisted of a list of indicators of essential competencies for undergraduates followed in the qualifications of Computer Innovation and Digital Industry Major based on the context of NSTRU by mainly sticking to the factors gained from the qualifications mentioned above [1, 7, 9, 12, 15].

IV. METHOD

The flow chart below shows the methodology of this research.

A. Review Stage: The Study of Factors of Qualifications Framework for Computer Innovation and Digital Industry Professionals

Source: It was the documents related to the qualification framework for higher education. From the synthesis of the documents [1, 7, 9, 12, 15] five topics could be summarized as the conclusion by using the keyword "the qualification framework for higher education." These five topics were also selected from the contents and primary factors in at least two of three parts based on the concept of information in searching, refining, and selecting stated in the research of Kuriakose *et al*. (2018) [16], Al-Bulushi *et al*. (2018) [17] to get the details of qualification framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals.

Research Instrument: The research instrument for qualitative data collection was the recording form gained by content analysis. Creating and checking this recording form's quality were started using the five factors of qualification framework as the research framework. Then, related

documents and research were studied to acquire information and factors' details of qualification framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals. The information and details were used as the guideline to create the recording form of qualitative data gained by content analysis. This recording form was a file of frequency recording of factors. Delimitation and issue of content analysis were specified. Then the recording form of qualitative data was created and presented to nine experts who have expertise in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computer, and Computer Education. These experts were from all undergraduate programs from public institutions of higher education across the country to consider, improve and approve respectively.

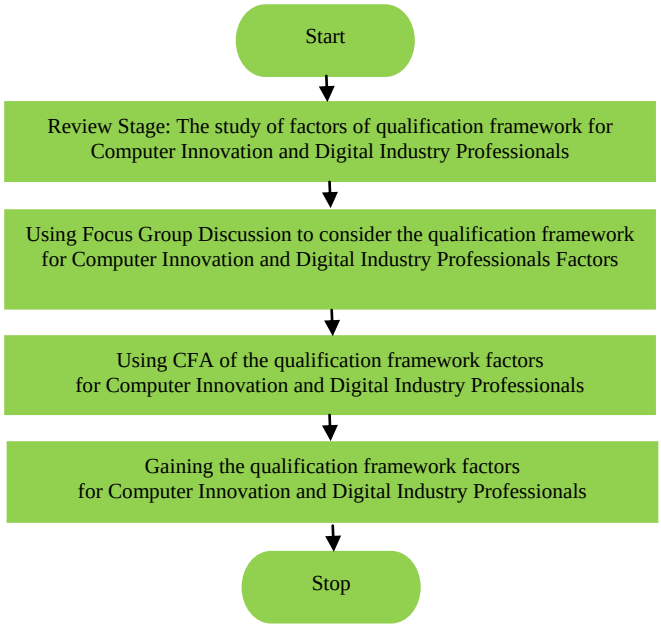


Fig. 2. The flow chart of the research methodology.

Data Collection: The data collection started by studying the qualification framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals for undergraduates from the academic documents related to the qualification framework under the conceptual framework of Office of the Higher Education Commission (2020) [1], Suwanroj *et al*. (2019) [7], Hoque (2016) [9], Almetov *et al*. (2020) [12], Qi *et al*. (2019) [15] to get the indicators of essential competencies followed in five factors stated in qualifications framework. This framework was called the "qualification framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals" and was presented to nine experts to consider and check the validity.

Data Analysis: Data were analyzed using the recording form of qualitative data synthesized from related academic documents by content and frequency analysis. Then the table was made to check the frequency of a list of indicators for essential competencies under the qualifications framework of essential learning outcomes for professionals. Next, the frequency of the data was checked. The analysis and synthesis were evaluated using the criteria of choosing 50% frequency based on the idea of Lin *et al*. (2017) [5], Keith *et al*. (2018) [18]. This step was to consider and specify the indicators of essential competencies under the factors of qualifications framework of essential learning outcomes for professionals as a preliminary outline. The indicators were used as the factors of qualifications framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals in the next phase of the research.

B. Using Focus Group Discussion to Consider the Qualifications Framework for Computer Innovation and Digital Industry Professionals Factors

A meeting for focus group discussion was held to consider the factors of indicators for essential competencies under the qualification framework of essential learning outcomes for professionals. The details of the research methodology were as follows:

Source: It was nine experts who are all teachers from public and private educational institutions and have knowledge as well as expertise not less than ten years of in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computer, and Computer Education. This group of experts was selected by using a purposive sampling method. A group of nine experts was the informants of this research, both in the first and second steps previously mentioned.

Research Instrument: Data collection was divided into two steps to validate the data. The processes of creating the research instrument in each step were as follows:

1) **1st Step:** The first instrument used for this step was the questionnaire. It was used to consider and confirm the indicators' details of essential competencies of qualifications framework of essential learning outcomes for professionals. The questionnaire was close-ended. Each question had two choices (Yes, No, 24 Items). A list of indicators of essential competencies followed in the qualifications framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals covered five factors and 24 indicators of essential competencies. Five experts checked the validity of the questionnaire content. Then the questionnaire was used to collect and compile the data before the focus group discussion.
2) **2nd Step:** The instrument used for this step was the questionnaire. It was used to confirm the details of competency indicators followed in the qualifications framework of essential learning outcomes for professionals by using open-ended questions. A list of indicators of essential competencies of 24 variables covering five factors was confirmed from the 1st step. Five experts checked the validity of the questionnaire content. Then the questionnaire was used to collect and compile the data before the focus group discussion.

Data Collection: There were 2 steps in collecting data from the group of the experts as follows:

1) **1st Step:** The research instruments were sent to the group of experts in advance to ask for their opinion, consideration, and confirmation of the details of competency indicators followed in the qualifications framework of essential learning outcomes for

professionals. Nine copies were sent back from nine experts or 100% of the group of experts.

2) **2nd Step:** Findings from step 1 were analyzed by a group of experts to find the opinions about the consideration to confirm the details of competency indicators followed in the qualifications framework of essential learning outcomes for professionals. Then the findings were presented in the focus group discussion to find a list of competency indicators followed in the qualifications framework of learning outcomes. By using focus group discussion, the group of experts considered and gave approval to the details of competency indicators and a list of 24 indicators of essential competencies and gave approval one more time to the details of indicators of essential competencies followed in the qualifications framework of essential learning outcomes.

Data Analysis: There were 2 parts as follows:

1) **Part 1:** The statistics used to analyze the data were the frequency and percentage. The criterion used to approve the consideration and confirm the factor details of the qualifications framework of essential learning outcomes for undergraduates was the opinions of the experts who answered "Yes" with 50% up [7].

2) **Part 2:** This part conducted the focus group discussion to consider and confirm the indicators' details of essential competencies followed in the qualifications framework of learning outcomes based on 24 variables by the group of experts. The open-ended questions were used in the focus group discussion. The experts met to consider, confirm and rank a list of entire indicators of essential competencies. With a unanimous resolution, the experts approved the details of a list of indicators of essential competencies followed in the qualifications framework of learning outcomes. Data (experts' opinions) were analyzed using typology and taxonomy techniques. In conclusion, for this part, a list of indicators of essential competencies approved by the unanimous resolution of the experts was regarded as the details of the qualifications framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals. The statistics used to analyze the data were the frequency and percentage.

C. CFA of the Qualifications Framework for Computer Innovation and Digital Industry Professionals Factors

Population: The research population consisted of 2,829 experts who are all teachers and have expertise in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computer, and Computer Education from public educational institutions across Thailand [7].

Sample: The sample group was a group of experts who are all teachers and have expertise in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computers, and Computer Education from public educational institutions across Thailand. For sample size determination to analyze the factors of a list of indicators of essential competencies followed in the qualifications framework, the researchers used the concept presented by Suwanroj *et al*. (2019) [7], Seo *et al*. (2021) [19]. They stated that determining the sample size depends on the number of factors the researcher wants to analyze. The sample proportion must be ten units for one variable, and the sample needs at least 100 people. This research had 24 variables of indicators of essential competencies; therefore, the minimum sample size should not be less than 240 people. However, for correctness and accuracy based on the statistical principle, the researchers used multistage sampling to determine the details of the sample of 933 people. This step followed all conditions for sample size determination, as previously mentioned.

Research Instrument: It was the questionnaire to find the opinions about the factors of the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Major. The questionnaire used five levels of the rating scale; the content validity and reliability for the scale of the research instrument were 0.96 - 1.00. The content validity and reliability for the factor were 0.97 - 0.99. Second-order CFA was used for data analysis. To test the reliability, the researchers tested the instrument with 200 experts who were not in the same sample group. However, these 200 experts have expertise in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computers, and Computer Education from public educational institutions across Thailand. Cronbach's Alpha Coefficient was used to test the quality of the research instrument for the reliability aspect. From the test, the reliability of the research instrument was between 0.96 – 0.99. The reliability of the research instrument designed for all aspects was 0.99. This showed that the research instrument had an appropriate quality to collect the data. It was a five-point Likert scale questionnaire.

5 = Want to have skills in those variables at a very high level.

4 = Want to have skills in those variables at a high level.

3 = Want to have skills in those variables at a moderate level.

2 = Want to have skills in those variables at a low level.

1 = Want to have skills in those variables at a very low level.

Data Collection: The data were collected by emailing the QR code and URL of an online questionnaire created from Google Forms to the sample group to answer the questionnaire. There were 933 responses to an online questionnaire sent back from the sample group.

Data Analysis: For the primary descriptive data, the research used descriptive statistics for data analysis. For the opinion about the factors of the qualifications framework of essential learning outcomes for undergraduates, the research used IBM SPSS Statistics 14.0 for Windows. The correlation of 24 indicators of essential competencies was brought to analyze using second-order CFA with the program of LISREL 8.72. The CFA was used to analyze the factors in which the researchers created the measurement model matching the qualifications framework. The factors of the qualification framework of essential learning outcomes were clearly known. The list of competency indicators was

approved and confirmed by the experts. For the reasons above, it was necessary to use statistical methods to prove the correctness of the measurement model and to check the construct validity. CFA is still very popular because of its high level of construct validity. Moreover, it can correctly create new research knowledge [19, 20].

V. Results

A. The Results of the Study and Factor Analysis of Qualifications Framework of Computer Innovation and Digital Industry Professionals

The research team studied the related documents in the qualification framework to gain the factors of indicators of essential competencies. Then they conducted a focus group discussion of the experts to analyze the factors of indicators of essential competencies. After this focus group, they acquired the qualifications framework of essential learning outcomes for undergraduates of Computer Innovation and Digital Industry Major of NSTRU. The conclusion showed that five factors for the indicators' details of essential competencies were followed in the qualifications framework of essential learning outcomes for undergraduates. There were 24 indicators of essential competencies. These 24 indicators with the research symbols are shown in Table II below.

TABLE II: Factor Details of a List of Indicators of Essential Competencies and the Symbols of the Framework Qualifications Framework of Essential Learning Outcomes for Undergraduates of Computer Innovation and Digital Industry Major, NSTRU

Factor	Symbol	List of Variables to Indicate Essential Competencies	Symbol
1) Ethical and Moral	EM	1) Students must have at least 80% of class attendance each semester.	EM_1
		2) Students must produce quality assignments (the level of excellent quality is 70%), and they must meet all deadlines of assignments.	EM_2
		3) Students do not copy work, literature, or other pieces of work without citing and referencing.	EM_3
		4) Students must not copy any part of other people's work.	EM_4
		5) Students must follow the university's regulations in dressing correctly every time they have classes.	EM_5
		6) Students must use the copyright programs.	EM_6
2) Knowledge	K	1) Students can tell the details of knowledge contents of the subjects which they acquire from learning in the curriculum with the correct and well-educated learning.	K_1
		2) Students can explain the details of knowledge contents of the subjects which they acquire from learning in the curriculum with the correct and well-educated learning.	K_2
		3) Students can present knowledge contents of the subjects which they acquire from learning in the curriculum with the correct and well-educated learning.	K_3
		4) Students can test the method of installation and how to use different computer programs used in the subjects which they acquire from learning in the curriculum with the correct and well-educated learning.	K_4
		5) Students can correctly create and design different pieces of work from various groups of instruments based on the context of assignments of the subjects they learn in the curriculum.	K_5
		6) Students can correctly consider and have good decision-making in using different instruments and computer programs based on the context of assignments of the subjects they learn in the curriculum.	K_6
3) Cognitive Skills	CK	1) Students can use computer instruments and essential programs in searching for digital information, evaluating values or quality of digital data.	CK_1
		2) Students can use computer instruments and essential programs to manage digital data appropriately.	CK_2
		3) Students can analyze, synthesize and settle for a synopsis from digital data.	CK_3
		4) Students can think and create pieces of work or assignments from the subjects they learn in the curriculum systematically.	CK_4
4) Interpersonal Skills and responsibility	ISR	1) Use the Thai language for communication correctly and/or classroom presentation.	ISR_1
		2) Use English language for communication correctly and/or for classroom presentation.	ISR_2
		3) Be able to finish assignments by working in a group with their classmates.	ISR_3
		4) Be able to finish assignments with quality and meet deadlines.	ISR_4
5) Analytical and Communication Skills	ACS	1) Be able to use package software in analyzing digital data.	ACS_1
		2) Be able to use the computer and internet for communication in receiving-sending digital data.	ACS_2
		3) Use peripheral equipment with the computer for communication in receiving-sending digital data.	ACS_3
		4) Use package software to analyze digital data together with the computer for communication in receiving and sending digital data.	ACS_4
		Totals of Observed variables	24

Remark: Table II is the input from the group of nine experts.

From the analysis results of a list of indicators for all essential competencies, the research concluded the details for a list of indicators of essential competencies for undergraduates of Computer Innovation and Digital Industry Major, NSTRU. The researchers used these details to develop the model diagram of the second-order CFA of the qualifications framework of essential learning outcomes for

undergraduates, as shown in Fig. 3. The research results were analyzed using descriptive statistics from the correlation and the differences between five factors from a list of 24 indicators of essential competencies gained from the sample group of 933 people. The details are shown in Table III.

Comparing the average opinion about the qualification framework of essential learning outcomes gained from 933 experts, the researchers tested the assumption of the equality of variances from two population groups using Levene's Test statistic. It found that the variances of factors of qualifications framework of essential learning outcomes for undergraduates from two population groups had no difference with statistical significance at 0.01 (F=0.11 Sig=0.90). T-test was used in this case because there was no difference in variances from 2 groups of population (t-test independent with pooled variance t-test).

The testing results of comparison on the average opinion about qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Major based on the context of NSTRU were gained from two different groups of experts: male and female. The results showed that the averages were not different with statistical significance at 0.01. It could be summarized that the opinion about the qualifications framework of essential learning outcomes for undergraduates gained from the two groups of the sample was not different. The details are shown in Table III.

TABLE III: TEST OF COMPARISON ON THE AVERAGE OF OPINION ABOUT QUALIFICATIONS FRAMEWORK OF ESSENTIAL LEARNING OUTCOMES FOR UNDERGRADUATES IN COMPUTER INNOVATION AND DIGITAL INDUSTRY MAJOR OF NSTRU GAINED FROM MALE AND FEMALE GROUPS OF EXPERTS

Group	Full Marks = 5		Levene's Test		t	df	Sig
	Mean	S	F	Sig			
Male (n_1 = 665)	4.69	0.85	0.11	0.90	0.59	78	0.28
Female (n_2 = 268)	4.73	0.91					

Remark: Table III is the input from the research sample group consisting of 933 experts.

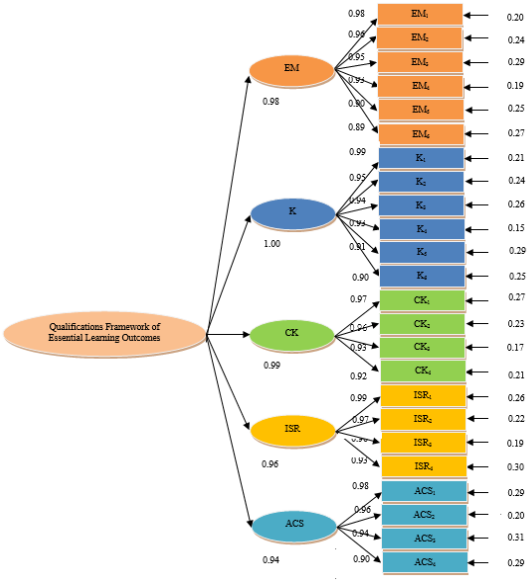
B. Results of the 2nd Order CFA in Accordance with Qualifications Framework of Essential Learning Outcomes

The model diagram of the second order CFA of qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Major is shown in Fig. 3.

From Fig. 3, the analysis result for the second order CFA factor shows that the model is relevant to the empirical data of qualifications framework of essential learning outcomes for undergraduates at the excellent level. All goodness-of-fit statistics meet the standards. The second order CFA is the analysis used to confirm two issues based on the question, "Is this relevant to the context of NSTRU?" The details were as follows:

1) **Issue 1:** This was to confirm that 24 indicators of essential competencies were regarded as the subordinate factors of 5 main factors under the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Major.

2) **Issue 2:** This was to confirm that the main factors mentioned above fit together to create the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Major.



Chi-Square = 59.73, df = 63, P- value = 0.63, RMSEA = 0.00

Fig. 3. Model diagram of the 2nd order CFA of qualifications framework of essential learning outcomes for undergraduates.

Remark: Fig. 3 is the input from the research sample group consisting of 933 experts.

Overall analysis results showed that all indicators of essential competencies were regarded as the actual subordinate factors of the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals based on the context of NSTRU according to the statistical methods.

The details of Goodness-of-fit statistics of the factor model and the empirical data are shown in the Table IV and Fig. 4.

TABLE IV: GOODNESS-OF-FIT STATISTICS OF FACTOR MODEL AND EMPIRICAL DATA

Goodness-of-fit index	Standard [7]	Value	Result of consideration	Conclusion
χ^2-test	p>0.05	0.66	Passed	Good
χ^2/df	<2	0.88	Passed	Good
GFI	≥0.95	0.97	Passed	Good
AGFI	≥0.95	0.98	Passed	Good
NFI	≥ 0.95	0.99	Passed	Good
CFI	≥ 0.95	0.97	Passed	Good
RMSEA	≤ 0.05	0.00	Passed	Good
SRMR	≤ 0.05	0.01	Passed	Good
RMR	≤ 0.05	0.01	Passed	Good

Remark: Table IV is the input from the research sample group consisting of 933 experts.

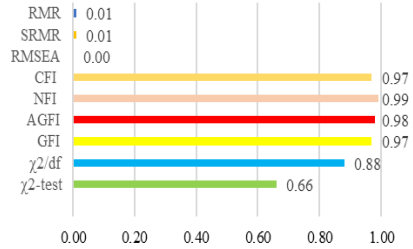


Fig. 4. Goodness-of-fit statistics of factor model and empirical data.

Remark: Fig. 4 is the input from the research sample group consisting of 933 experts.

Table IV and Fig. 4 shows that all goodness-of-fit statistics of the factor model and the empirical data meet the standards by considering χ2-test which is statistically non-significant (p=0.63), χ^2/df= 0.88, GFI = 0.97, AGFI = 0.98, NFI = 0.99, CFI = 0.97, RMSEA = 0.00, SRMR = 0.01 and RMR = 0.01. This also shows that the model from Fig. 3 matches the empirical data under the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals at a good level. Then five factors following the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals are set priority in descending order. The analysis result for the second-order CFA is used to confirm the quantitative data collected from the sample, and its details are shown in Table V and Fig. 5.

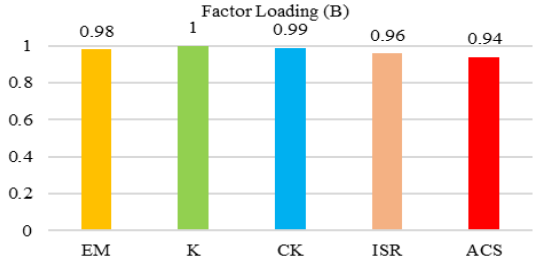
Factor loading, Covariance and Priority of Factors match the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals.

TABLE V: FACTOR LOADING, COVARIANCE AND PRIORITY OF FACTORS IN ACCORDANCE WITH THE QUALIFICATIONS FRAMEWORK OF ESSENTIAL LEARNING OUTCOMES FOR UNDERGRADUATES IN COMPUTER INNOVATION AND DIGITAL INDUSTRY PROFESSIONALS

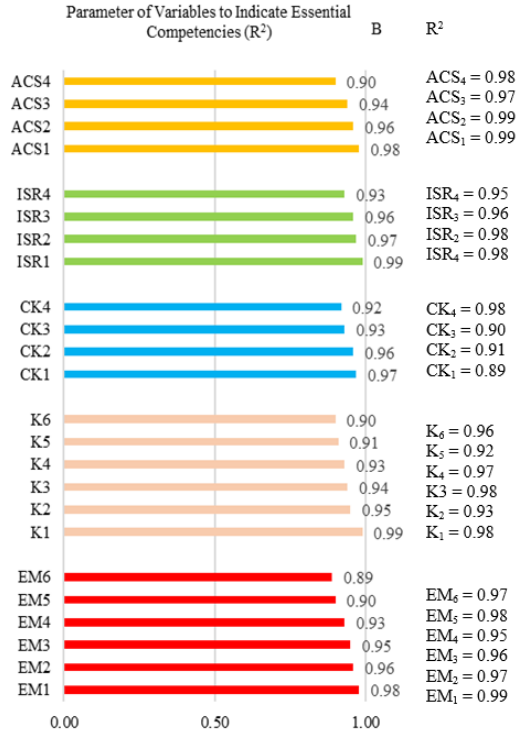
Factors	Factor loading		t	R^2	Priority
	b	S.E			
EM	0.98	0.02	29.10*	0.97	3
EM_1	0.98	0.01	29.32*	0.99*	
EM_2	0.96	0.03	28.15*	0.97*	
EM_3	0.95	0.01	26.11*	0.96*	
EM_4	0.93	0.02	28.76*	0.95*	
EM_5	0.90	0.01	27.54*	0.98*	
EM_6	0.89	0.02	27.94*	0.97*	
K	1.00	0.01	30.02*	0.99	1
K_1	0.99	0.01	30.07*	0.98*	
K_2	0.95	0.02	29.96*	0.93*	
K_3	0.94	0.01	30.04*	0.98*	
K_4	0.93	0.01	30.10*	0.97*	
K_5	0.91	0.01	29.98*	0.92*	
K_6	0.90	0.02	30.07*	0.96*	
CK	0.99	0.03	29.07	0.91	2
CK_1	0.97	0.01	28.05*	0.89*	
CK_2	0.96	0.01	29.26*	0.91*	
CK_3	0.93	0.02	29.07*	0.90*	
CK_4	0.92	0.01	29.03*	0.98*	
ISR	0.96	0.01	30.04	0.98	4
ISR_1	0.99	0.01	30.10*	0.98*	
ISR_2	0.97	0.02	29.97*	0.98*	
ISR_3	0.96	0.01	30.15*	0.96*	
ISR_4	0.93	0.01	30.07*	0.95*	
ACS	0.94	0.01	31.02	0.99	5
ACS_1	0.98	0.01	30.07*	0.99*	
ACS_2	0.96	0.01	31.05*	0.99*	
ACS_3	0.94	0.02	31.09*	0.97*	
ACS_4	0.90	0.01	30.06*	0.98*	

* p<0.01

Remark: Table V is the input from the research sample group consisting of 933 experts.



(A) Parameter of Factor Loading (B).



(B) Parameter of Variables to Indicate Essential Competencies (R^2).

Fig. 5. The factor loading parameter of qualifications framework of essential learning outcomes for undergraduates.

Remark: Fig. 5 is the input from the research sample group consisting of 933 experts.

Table V and Fig. 5 show the priority in descending order of 5 factors of qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals. The analysis result for the second-order CFA is used to confirm the quantitative data collected from the sample. The details were as follows:

1) **1st Factor:** Factor of Knowledge (K) It found that an indicator of essential competencies with the highest level of factor loading was K_1 = Students can tell the details of knowledge contents of the subjects they acquire from learning in the curriculum with the correct and well-educated learning. This was the factor with the highest factor loading of qualifications at 0.99, and covariance of the factor Knowledge was at 98%. An indicator of essential competencies with the second highest level of factor loading was K_2 = Students can explain the details of knowledge contents of the subjects they acquire from learning in the curriculum with the correct and well-educated learning. Efficiency and factor loading of qualifications of this factor was at 0.95, and the covariance of the factor Knowledge was at 93%. An indicator of essential competencies with the third highest level of factor loading was K_3 = Students can present knowledge contents of the subjects they acquire from learning in the curriculum with the correct and well-educated learning. Efficiency and factor loading of qualifications of this factor was at 0.94, and the covariance of the factor Knowledge was at 98%. An indicator of essential competencies with the fourth highest level of factor loading was K_4 = Students can test the installation method and how to use different computer programs used in the subjects

they acquire from learning in the curriculum with the correct and well-educated learning. Efficiency and factor loading of qualifications of this factor was at 0.93, and the covariance of the factor Knowledge was at 97%. An indicator of essential competencies with the fourth highest level of factor loading was K_5 = Students can correctly create and design different pieces of work from various instruments based on the context of assignments of the subjects they learn in the curriculum. Efficiency and factor loading of qualifications of this factor was at 0.91, and the covariance of the factor Knowledge was at 92%. An indicator of essential competencies with the sixth highest level of factor loading was K_6 = Students can correctly consider and have good decision-making in using different instruments and computer programs based on the context of assignments of the subjects they learn in the curriculum. Efficiency and factor loading of qualifications of this factor was at 0.90, and the covariance of the factor Knowledge was at 96%, respectively.

2) **2nd Factor***:* Factor of Cognitive Skills (CK) It was found that an indicator of essential competencies with the highest level of factor loading was CK_1 = Students can use computer instruments and essential programs to search for digital information and evaluate the values or quality of digital data. This was the factor with the highest factor loading of qualifications at 0.97, and the covariance of the factor Cognitive Skills was 89%. An indicator of essential competencies with the second highest level of factor loading was CK_2 = Students can use computer instruments and essential programs to manage digital data appropriately. Efficiency and factor loading of qualifications of this factor was at 0.96, and the covariance of the factor Cognitive Skills was at 91%. An indicator of essential competencies with the third highest level of factor loading was CK_3 = Students can analyze, synthesize and settle for a synopsis from digital data. Efficiency and factor loading of qualifications of this factor was at 0.93, and the covariance of the factor Cognitive Skills was at 90%. An indicator of essential competencies with the fourth highest level of factor loading was CK_4 = Students can systematically think and create pieces of work or assignments from the subjects they learn in the curriculum. Efficiency and factor loading of qualifications of this factor was at 0.92, and the covariance of the factor Cognitive Skills was at 98%, respectively.

3) **3rd Factor:** Factor of Ethical and Moral (EM) It found that an indicator of essential competencies with the highest level of factor loading was EM_1 = Students must have at least 80% of class attendance each semester. This was the factor with the highest factor loading of qualifications at 0.98, and covariance of the factor Ethical and Moral was at 99%. An indicator of essential competencies with the second highest level of factor loading was EM_2 = Students must produce quality assignments with good quality (level of excellent quality is 70%), and they must meet all deadlines of assignments. The efficiency and factor loading of this factor's qualifications was at 0.96, and the covariance of the factor Ethical and Moral was at 97%. An indicator of essential competencies with the third highest level of factor loading was EM_3 = Students do not copy work, literature, or other pieces of work without citing and referencing. The efficiency and factor loading of this factor's qualifications was at 0.95, and the covariance of the factor Ethical and Moral was at 96%. An indicator of essential competencies with the fourth highest level of factor loading was EM_4 = Students must not copy any part of other people's work. The efficiency and factor loading of this factor's qualifications was at 0.93, and the covariance of the factor Ethical and Moral was at 95%. An indicator of essential competencies with the fourth highest level of factor loading was EM_5 = Students must follow the university's regulations in dressing correctly every time they have classes. The efficiency and factor loading of this factor's qualifications was at 0.90, and the covariance of the factor Ethical and Moral was at 98%. An indicator of essential competencies with the sixth highest level of factor loading was EM_6 = Students must use the copyright programs. The efficiency and factor loading of this factor's qualifications was at 0.89, and the covariance of the factor Ethical and Moral was at 97%, respectively.

4) **4th Factor:** Factor of Interpersonal Skills and responsibility (ISR) It found that an indicator of essential competencies with the highest level of factor loading was ISR_1 = Use the Thai language for communication correctly and/or for classroom presentation. This was the factor with the highest factor loading of qualifications at 0.99, and the covariance of the factor Interpersonal Skills and responsibility was 98%. An indicator of essential competencies with the second highest level of factor loading was ISR_2 = Use English for communication correctly and/or for classroom presentation. The efficiency and factor loading of this factor's qualifications was at 0.97, and the covariance of the factor Interpersonal Skills and responsibility was 98%. An indicator of essential competencies with the third highest level of factor loading was ISR_3 = Be able to finish assignments by working in a group with classmates. The efficiency and factor loading of this factor's qualifications was at 0.96, and the covariance of the factor interpersonal skills and responsibility was at 96%. An indicator of essential competencies with the fourth highest level of factor loading was ISR_4 = Be able to finish assignments with quality and meet deadlines. The efficiency and factor loading of this factor's qualifications was at 0.93, and the covariance of the factor Interpersonal Skills and responsibility was at 95%, respectively.

5) **5th Factor:** Factor of Analytical and Communication Skills (ACS) It found that an indicator of essential competencies with the highest level of factor loading was ACS_1 = Be able to use package software in analyzing digital data. This was the factor with the highest factor loading of

qualifications at 0.98, and the covariance of the factor Analytical and Communication Skills was at 99%. An indicator of essential competencies with the second highest level of factor loading was ACS_2 = Be able to use the computer and internet to communicate sending digital data. The efficiency and factor loading of this factor's qualifications was at 0.96, and the covariance of the factor Analytical and Communication Skills was at 99%. An indicator of essential competencies with the third highest level of factor loading was ACS_3 = Use peripheral equipment with the computer to communicate and send digital data. The efficiency and factor loading of this factor's qualifications was at 0.94, and the covariance of the factor Analytical and Communication Skills was at 97%. An indicator of essential competencies with the fourth highest level of factor loading was ACS_4 = Use package software to analyze digital data together with the computer for communication in receiving and sending digital data. The efficiency and factor loading of this factor's qualifications was at 0.90, and the covariance of the factor Analytical and Communication Skills was at 98%, respectively.

Factor Validity and Average Variance Extracted (AVE) of factors of the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals.

TABLE VI: FACTOR VALIDITY AND AVERAGE VARIANCE EXTRACTED (AVE) OF FACTORS OF THE QUALIFICATIONS FRAMEWORK OF ESSENTIAL LEARNING OUTCOMES FOR UNDERGRADUATES IN COMPUTER INNOVATION AND DIGITAL INDUSTRY PROFESSIONALS

Priority	Validity (ρ_c)		AVE (ρ_v)	
	Value	Consideration result	Value	Consideration result
1. EM	0.97	High validity	0.96	High explanation
2. K	0.98	High validity	0.98	High explanation
3. CK	0.97	High validity	0.95	High explanation
4. ISR	0.95	High validity	0.94	High explanation
5. ACS	0.96	High validity	0.97	High explanation

Validity (ρ_c) = Standard >0.60, AVE (ρ_v) = Standard >0.50

Remark: Table VI is the input from the research sample group consisting of 933 experts.

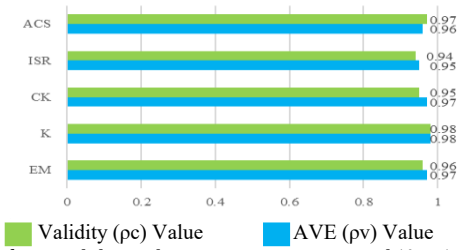


Fig. 6. The factor validity and average variance extracted (AVE) of factors of the qualifications framework of essential learning outcomes for Undergraduates in Computer Innovation and Digital Industry professionals.

Remark: Fig. 6 is the input from the research sample group consisting of 933 experts.

Table VI and Fig. 6 show that five factors of the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals have high validity (more than .60) based on the concept of Suwanroj *et al*. (2019) [7], Seo *et al*. (2021) [19]. It means that the model's factors have high validity when considering the factor loading and the common factor of a list of indicators of essential competencies. The main factors can be used to explain the variance of indicators of essential competencies in the factor with a high level (more than .50) which is also relevant to the concept of Suwanroj *et al*. (2019) [7], Seo *et al*. (2021) [19]. Thus, these five factors can be considered appropriate to use as the qualifications framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Major based on the context of NSTRU because of its validity in keeping with the hypothesis previously mentioned.

VI. DISCUSSION

From the results, there were two main issues to discuss based on the hypothesis that "factors of the qualifications framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals based on the context of NSTRU have validity." The details of the discussion were as follows:

1) **1st Issue:** The result and analysis of the factors of the qualification framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals were gained by focus group discussion of the experts. The second order CFA of the qualifications framework of essential learning outcomes for undergraduates from a list of indicators of essential competencies showed that 24 indicators were regarded as the subordinates of the five primary factors under the qualifications framework of essential learning outcomes for undergraduates. The matching between the model and the empirical data based on the context of NSTRU, collected by asking opinions from the experts of Thai educational institutions, influenced all goodness of fit statistics to pass a criterion. These all showed that the model of the qualifications framework of essential learning outcomes for undergraduates was useful and matched the empirical data based on the context of NSTRU from the expert's point of view. The qualifications framework of essential learning outcomes for undergraduates consisted of five factors. A list of all indicators considered and confirmed by using CFA can be used as the qualification framework for essential learning outcomes for undergraduates. Moreover, the model and the empirical data based on the context of NSTRU were fit because all indicators of essential competencies and the factors used to analyze were studied from the related documents and research previously mentioned [9, 15]. Moreover, the factors were discussed by the focus group discussion of the experts to consider and confirm for improving this model to be the efficient qualification framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals based on the context of NSTRU. This model can be used in the development process of undergraduate curriculums to improve learners' competencies for the ability to head to learning in the digital age, focusing on digital power with maximum efficiency. Also, it can be used for

workforce development to meet the digital industrial sector. These are in keeping with the concept of Suwanroj *et al*. (2019) [7]. They found that the necessary digital competencies are the critical and essential fundamentals for the learners in creating or continuing knowledge, making them the essential competencies in the digital age. These competencies are based on ethical, moral, knowledge, cognitive skills, interpersonal skills and responsibility, and analytical and communication skills, which cover the fundamental factors under the context of NSTRU and the needs of the learners. Moreover, it is in keeping with the concept of Suwanroj *et al*. (2019) [7], Hoque (2016) [9], Almetov *et al*. (2020) [12], Qi *et al*. (2019) [15]. They studied and researched the concept of the qualifications framework of essential learning outcomes for undergraduates. The concept focused on learners' abilities to create essential competencies from the knowledge, including publicizing, expanding, and exchanging knowledge with instructors and experts through digital technology under the qualifications framework of essential learning outcomes for undergraduates, which is essential in developing the learners' competencies.

2) **2nd Issue:** The result of the second-order CFA of the qualification framework of essential learning outcomes for undergraduates in Computer Innovation and Digital Industry Professionals from the list of 24 indicators confirmed by the experts fit the conditions of sample size determination based on the concept of Suwanroj *et al*. (2019) [7], Seo *et al*. (2021) [19]. They researched the qualifications framework of essential learning outcomes for undergraduates. This concept of sample size determination was used to apply for developing the qualifications framework of essential learning outcomes for undergraduates, which was in keeping with the concepts of Videnovik *et al*. (2018) [20], Arguedas *et al*. (2016) [21], Suwanroj *et al*. (2022) [22] who studied the qualifications framework of learning outcomes covering the factors of ethical and moral, knowledge, cognitive skills, interpersonal skills and responsibility, analytical and communication skills. All main factors under the qualifications framework of essential learning outcomes for undergraduates will be used to specify the qualifications of learning outcomes of the curriculums and learning and teaching process. This is the maximum benefit to instructors and NSTRU to use this framework for developing the competencies of undergraduates by having knowledge creation skills following the context of the learners in the digital age and to be able to continually apply knowledge for improving professional competencies.

VII. Contribution to Knowledge

From the development of the qualification framework of essential learning outcomes for Computer Innovation and Digital Industry Professionals using five factors and a list of indicators of essential competencies, it can be summarized that the benefits gained from this research under the context of NSTRU are as follows:

Higher educational institutions in Thailand providing bachelor's, master's, and doctoral degrees can employ the CFA and construct validity testing. They can apply the principles of advanced statistics with the CFA to test the construct validity of the indicators for essential competencies of the existing curriculums or curriculums in the development process under Thai Qualifications Framework for Higher Education B.E. 2552 (2009). This technique can be used to check whether the indicators match the actual conditions based on the context of each university or not. It is also used to build undergraduates' identities and institutions' curriculums. If educational institutions need more factors to build expertise for undergraduates and identities of institutions' curriculums, they can add more essential factors such as professional skills. They can specify a list of additional indicators for essential competencies. However, a list of additional indicators must be concrete, measured, and evaluated.

For the contexts of higher educational institutions in foreign countries providing bachelor's, master's, and doctoral degrees, they can also apply the techniques mentioned above under their contexts.

Higher education institutions that already have a qualification framework of essential learning outcomes for professionals can use the confirmatory principle and check the construct validity of the existing qualifications framework of essential learning outcomes. They can employ the technique from this research to check that they match the actual conditions to build undergraduates' identities and institutions' curriculums.

Although this research was studied in Thai educational institutions, the researchers believe that the method gained from the research has validity and is relevant to the context. It can build confidence because the qualification framework of learning outcomes has construct validity and can be used at the policy level. Therefore, it indicates that the qualification framework of learning outcomes can be applied to all curriculums in Thailand and foreign countries, which are different based on the cultural contexts in learning. Learning styles are all based on the factors of five aspects consisting of 1) Ethics and Morals, 2) Knowledge, 3) Cognitive Skills, 4) Interpersonal and Responsibility Skills, and 5) Numerical Analysis, Communication and Information Technology skills. Other essential factors can be added to fit the context. However, a list of additional indicators must be concrete, measured, and evaluated.

From the benefits above, the qualification framework of learning outcomes for professionals can be used to specify the strategies of management and development or improvement of institutions' curriculums to focus on the efficient learning development of the learners and appropriate with the learning in the digital age.

VIII. Conclusion

From the development of the qualifications framework of essential learning outcomes for Computer Innovation and

Digital Industry Professionals of NSTRU, the model of the qualifications framework of essential learning outcomes for undergraduates was designed to align with the empirical data. This means that the qualifications framework of learning outcomes factors consisted of five factors from a list of 24 indicators of essential competencies. Five factors included 1) Ethics and Morals with six indicators, 2) Knowledge with six indicators, 3) Cognitive Skills with four indicators, 4) Interpersonal and Responsibility Skills with four indicators, and 5) Numerical Analysis, Communication and Information Technology skills with four indicators. The findings of this research are essential and beneficial because they can be developed to be the curriculum and strategy of learning management for undergraduates in the next phase of the research. The researchers believe that the model fits the context and can be used for curriculum development and learning and teaching management in keeping with the professional qualifications by meeting the needs of the labor market in the digital industrial sector.

For higher educational institutions in Thailand and foreign countries, if they would like to build students' identities or curriculums, they should start with developing indicators for essential competencies under the qualifications framework of learning outcomes for professionals based on the context of each institution. However, a list of indicators of essential competencies must be concrete, measured, and evaluated to have the most efficient way to develop or improve the curriculums.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Thamasan Suwanroj conducted the research, analyzed the data, and wrote the paper; Orawan Saeung the research consulting; Kanaporn Kaewkamjan and Punnee Leekitchwatana checked academic writing; all authors had approved the final version.

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