# The Development of Professional Competency Test in Knowledge and Cognitive Skill for Computer Innovation and Digital Industry

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

***Abstract*—This research aimed to 1) analyze the content of professional competencies, 2) create the professional competency test, and 3) check the quality of the professional competency test. The operation method was composed of three steps: 1) five experts (set 1) analyzed the qualitative data of the professional competencies, 2) five experts (set 2) built the professional competency test, and 3) experts (set 3) checked the quality of the professional competency test, and then two trials of the test were performed. The research showed that 1) the content analysis of professional competencies found ten indicators: six for knowledge and four for cognitive skills, including 100 issues of the required measurement list. A test with 100 items covered the course descriptions of seventeen subjects in five curriculum groups. 2) The creation result found the professional competency test, five multiple-choice questions. The respondents got one point when they answered correctly and no point when they answered incorrectly. The test comprised 100 items in two aspects: 57 items for knowledge and 43 for cognitive skills. 3) The result of the quality check revealed that the professional competency test was good. It had a good level of content validity (IOC = 0.80-1.00). Its difficulty was appropriate ($p$ = 0.25-0.78). The discrimination was good ($r$ = 0.44-0.96). There was validity with a good level of internal consistency ($\alpha$ = 0.87), and it had good construct validity ($\chi^2$- Sig = 0.25, RMSEA = 0.03, RMR = 0.02 and AGFI = 0.97), ($\rho c$ = 0.97-0.98). This test can be used as a quality tool to measure the professional competency test in knowledge and cognitive skills for Computer Innovation and Digital Industry.**

***Index Terms*—Test, professional competency test in knowledge and cognitive skills, knowledge and cognitive skills, qualification framework of learning outcomes.**

## I. Introduction

Students' competencies are the central issue of the desired outcomes related to students at all levels of Thai education. They were specified in the 2018 National Education Standard and approved by the cabinet on October 2, 2018. The cabinet states that government sectors and public departments relating to educational management must bring the National Education Qualifications to determine educational institutions' educational qualifications and curriculum in each level and type of education. Moreover, educational institutions must encourage, supervise, and check the evaluation and educational quality assessment [1], [2].

The announcement of the Ministry of Education about the Higher Education Qualifications for higher education in 2018 specified that educational institutions need to have a curriculum and provide the learning to emphasize students' development. There must be the administration under the obligations and visions of each educational institution and a quality assessment system to follow up, check, evaluate, and improve educational management at the curriculum, faculty, and institution levels with effectiveness and efficiency. Moreover, supervision is required to manage the education and operation following obligations under the regulations of the Ministry. The educational quality assessment must be done continually in keeping with the National Higher Education Qualifications, Thai Qualifications Framework for Higher Education, and other qualifications specified by the Ministry of Education [1], [2].

Nakhon Si Thammarat Rajabhat University (NSTRU) is a public educational institution established to develop the locality, focus on academic services, and inherit and maintain art and culture. NSTRU provides bachelor's, master's, doctorate, and graduate diploma curriculums. One of the bachelor's degrees is the Bachelor of Science, Major in Computer Innovation and Digital Industry. This major is vital for the social and industrial sectors, the important sectors to strengthen the country, as it produces workforce graduates in the digital field. Thus, the graduate production system of this curriculum must follow the Professional Qualification Framework specified in the curriculum, and the major must to build confidence in the curriculum's production to organizations: graduate users. However, the university specifies to evaluate the professional competencies of the students under the Thai Qualifications Framework for Higher Education in 2009, which consists of five competency domains: 1) ethics and morals, 2) knowledge, 3) cognitive skills, 4) interpersonal skills and responsibility, and 5) numerical analytical, communication and information technology skills [3], [4].

As the instructors in this curriculum, the research team sees the importance of evaluating students' competencies, particularly knowledge and cognitive skills. The university usually operates the competency evaluation for the fourth-year students, the final year before graduating. It is the preparation of the students before they enter the establishment. However, not many appropriate instruments could pass the quality check in measuring competencies. The research team wanted to use the instrument for data collection to assess the competency accurately and reliably. Therefore, the research team was interested in developing a high-quality professional competency instrument for knowledge and cognitive skills, which resulted in setting the objectives of the research as follows:

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1) analyze the professional competency content in the knowledge and cognitive skill domains under the Qualification Framework of Learning Outcomes for undergraduates in the Bachelor of Science, Major in Computer Innovation and Digital Industry,
2) create the professional competency test in the knowledge and cognitive skill domains under the Qualification Framework of Learning Outcomes for undergraduates in the Bachelor of Science, Major in Computer Innovation and Digital Industry, and
3) check the quality of the professional competency test in the knowledge and cognitive skill aspects under the Qualification Framework of Learning Outcomes for undergraduates in the Bachelor of Science, Major in Computer Innovation and Digital Industry.

However, there must be a framework of the professional competencies with validity to measure the competencies. The research team chose the professional competency framework in content and cognitive skill domains under the Qualification Framework of Learning Outcomes of the Bachelor of Science, Major in Computer Innovation and Digital Industry, studied by Suwanroj *et al.* [3]. He found that the professional competency in the knowledge domain consisted of six indicators; the cognitive skills comprised four indicators, ten totaling. Nevertheless, these indicators were like the sub-elements of the central element in the knowledge and cognitive skill domains. However, the content of different subjects in five subject groups of the curriculum has not been detailed. Thus, an analysis of the content of professional competencies in the areas of knowledge and cognitive skills related to the content of 17 subjects in five groups was essential. With this analysis, the research gained the details of the necessary things needed to measure. However, firstly there must be an analysis to determine the weight of importance of the list needed to measure. Then drafted the test and checked the quality of the test later [3], [4].

The quality check of this test was particular. Besides checking by using formal analysis: content validity, difficulty, discrimination, and reliability, the research team also brought advanced analysis: Second-Order Confirmatory Factor Analysis (2nd CFA) to analyze the quality of construct validity for the professional competency measurement model and construct reliability of latent variables in the model. Therefore, this test was distinctive in the quality analysis compared to the average test.

From the analysis process of the professional competency content, the creation of the test, and the quality check of the test, the research team obtained the professional competency test in the knowledge and cognitive skill domains for undergraduates in the Computer Innovation and Digital Industry Major. The test had a suitable quality, appropriate for measuring the students' professional competencies and giving the information with suitable validity and reliability to adequately evaluate the students' professional competencies.

## II. Literature Review

### A. *Strategies for Professional Competency Measurement*

The research team employed different measurement tools to measure the professional competencies to meet graduates' Qualification Framework of Learning Outcomes. For example, at the undergraduate level, there are at least five dimensions of professional competencies in computer innovation and digital industry among the learning areas, namely 1) ethics and morals, 2) knowledge, 3) cognitive skill, 4) interpersonal skills and responsibility, and 5) numerical analytical, communication and information technology skills [3]-[6]. The professional competency measurement tools can be divided into five strategies as follows:

1) **Using the questionnaire:** The questionnaire is a series of questions written in a statement, or it can be images used as questions. The respondents answer the questions by a statement or by making marks under specified conditions. The data used to test professional competencies through questionnaires include various types such as facts, knowledge, opinions, and practical skills.
2) **Using the test:** The test is the question series to answer by writing, speaking, and practicing in different ways that can be measured following the skills and brought to analysis. Data measured using the professional competency test includes variable data in the cognitive, affective, and psychomotor domains. The professional competency test can be classified using different criteria such as the level of the quality check, ways to answer, specified time, and variable name.
3) **Using the attitude test form:** The attitude test form is a set of questions on the emotion or affective response of the person to something, in positive or negative ways. There will be the determination of the answer level in each session continually. Each session has an equal unit, and the respondents choose to answer following their real emotions. The level separation includes odd and even levels. Odd sessions can be separated into five or seven levels. On the other hand, even sessions can be separated into four or six levels. The research can use as appropriate. The characteristics of the question for the attitude test are diversified. However, there are three well-known tests in general: Thurstone's attitude test, Osgood's attitude test, and Likert's attitude test.
4) **Using an interview:** The interview is the converse used as a tool for data collection. It has the same objective as the questionnaire, so many people call the interview an oral questionnaire. However, they have different methods. In the interview, an interviewer asks by speaking, and the interviewee answers by speaking as well. During this question and answer, the interviewer is the person to record the answer. For the questionnaire, the respondent answers the questions in the questionnaire form. The interview can be divided by the criteria: the question structure and the number of interviewees.
5) **Using an observation:** this is a method used to collect the professional competency test data using the observer's senses. An observer is a person recording the sound with the recorder or recording the events with the camera or video camera. Observation is suitable for the study of phenomena and behavior leading to professional competency expressions. The observation can be classified based on the structure of observation things and

the participation of the observer.

However, before using these five strategies of professional competency measurement, there must be a study of each measurement tool's good and bad points for the suitable application. There must be a quality test of the mentioned tools before bringing them to measure the professional competencies to ensure high quality. The quality of the measurement tools includes several ways. This research summarized the quality check in four main points: validity, reliability, difficulty, and discrimination, as shown in Table I.

TABLE I: WAYS TO CONSIDER THE QUALITY CHECK OF THE PROFESSIONAL COMPETENCY TEST

| Types of Tools | Essential Quality Required to Check | | | |
|---|---|---|---|---|
| | Validity | Reliability | Difficulty | Discrimination |
| 1. Questionnaire | ✓ | ✓ | - | - |
| 2. Test | ✓ | ✓ | ✓ | ✓ |
| 3. Attitude Test Form | ✓ | ✓ | - | - |
| 4. Interview | ✓ | ✓ | - | - |
| 5. Observation | ✓ | ✓ | - | - |

*Source*: (Leekitchwatana, 2015) [5]

### *B. Dimension of Professional Competencies in Computer Innovation and Digital Industry in Thailand*

The Professional competencies in Computer Innovation and Digital Industry in Thailand consist of five categories (Office of the Higher Education Commission, 2020) [4]. The researchers studied and compared the features of the dimensions of professional competencies in computer innovation and digital industry from Finland, Switzerland, Belgium, Singapore, and the Netherlands. All of these countries have high-quality educational management (Rahmawati et al, 2019) [6], Hoque, 2016] [7]. The study discovered five dimensions as follows:

1) **Ethics and Morals:** These are the ways students improve their behavior under ethics and morals, including the responsibility for themselves and the public. They can also adjust their lifestyle in a conflict of values. They have behavior development and behave under the morals both in personal and social ways.
2) **Knowledge:** This is an ability in understanding, thinking, and presenting the data as well as fact analysis and classification in the theoretical principles and processes, including and self-learning ability.
3) **Cognitive Skill:** This is an ability to analyze situations, apply knowledge, and understand concepts and processes in thinking and analyzing, including problem-solving when facing new and unexpected situations.
4) **Interpersonal Skills and Responsibility:** These are the ability to work as a team, to be a leader, to have responsibility for themselves and society, including the ability to plan and be responsible for self-learning.
5) **Numerical Analytical, Communication, and Information Technology Skills:** These are the ability to apply numerical analytical, to use mathematical and statistical techniques, to communicate by speaking and writing, including using information technology.

Aside from the five dimensions of professional competencies in Computer Innovation and Digital Industry mentioned above, each educational institution can specify supplementary learning outcomes, for example, in psychomotor or work skill dimensions (Rahmawati *et al*., 2019) [6], (Hoque, 2016) [7]. These five skill dimensions can be integrated with the strategies of professional competency measurement by determining them as the essential competency indicators in the context of each educational institute (Starr *et al*., 2008) [8]. This concept was also relevant to the concepts presented by Suwanroj *et al*.(2019) [3] and (Rahmawati *et al*., 2019) [6].

In conclusion, the researchers aimed to point out that the previously mentioned concepts were developed to test professional competence in knowledge and cognitive skills for computer innovation and digital industry. These strategies were integrated with the dimensions of professional competence in computer innovation and digital industry in Thailand to achieve the quality of professional competence test for knowledge and cognitive skills for computer innovation and digital industry. In this research, the test for the quality of professional competencies in knowledge and cognitive skills for the computer innovation and digital industry was called "the professional competence test".

## III. CONCEPTUAL FRAMEWORK

The model (Fig. 1) below shows the conceptual framework model of this research.

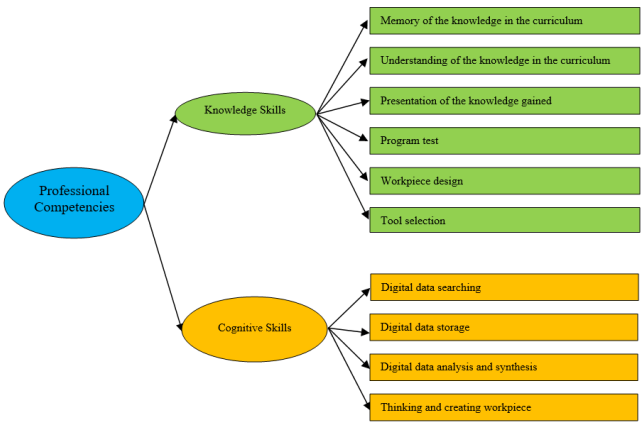



Fig. 1. Conceptual framework of content structure for professional competencies used in the research.

## IV. METHOD

The flow chart (Fig. 2) below shows the methodology of this research.

The research operation was composed of 3 parts: the analysis of professional competency content, the creation of the professional competency test, and the quality check of the professional competency test. The details are as follows:

### *Part 1: The Analysis of Professional Competency Content*

This analysis integrated the professional competency indicators in knowledge and cognitive skill under the qualification framework of learning outcomes for undergraduates to the subject content and course description of seventeen subjects in five subject groups of the Bachelor of Science, Major in Computer Innovation and Digital Industrial.

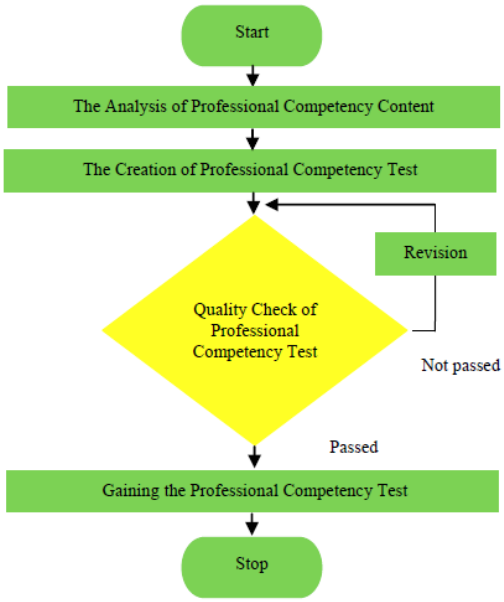



Fig. 2. The flow chart of the research methodology.

To operate this part, the research team used the group discussion of five experts (set 1). The experts included 1) instructors in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computer, and Computer Education from public educational institutions providing the bachelor's degree level, and 2) experts in research and educational evaluation.

The essential sources of the document used for the analysis of professional competency content were 1) ten professional competency indicators in knowledge and cognitive skill following the qualification framework of learning outcomes for undergraduates presented by Suwanroj *et al.* [3] and 2) subject content and course description of seventeen subjects in five subject groups of the Bachelor of Science, Major in Computer Innovation and Digital Industrial.

The expert team gathered to consider and integrate ten professional competency indicators—six for knowledge and four for cognitive skill—into the subject content and course description of 17 subjects in five subject groups of the Bachelor of Science, Major in Computer Innovation and Digital Industrial. The importance of each professional competency indicator for each subject (curriculum mapping) was divided into two levels: major and minor responsibilities. The "major responsibility" indicators were the list that was tested by the measurement test created as a part of the professional competency test. The analysis results were in the form of the subject content, and the number of tests used to measure the professional competencies. The period of operation was during February - March 2019.

Tables II and III show the list of indicators and 17 subjects in five groups used to analyze the professional competency content.

*Part 2: The Creation of Professional Competency Test*

This part was to draft the professional competency test in knowledge and cognitive skill. The researchers chose five multiple-choice questions. The respondents gained one point when they answered correctly and no point when they answered incorrectly. The test comprised 100 items: 57 items for knowledge and 43 for cognitive skills. The test was created under the content structure and the number of test items to measure the professional competencies resulting from the experts' operation (set 1) from part 1.

A team of five experts (set 2) responsible for creating the test was composed of 1) instructors in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computer, and Computer Education from public educational institutions providing the bachelor's degree level, 2) representatives of the organizations who hire the students, and 3) the experts in educational research and evaluation. The operation period was from April - May 2019.

TABLE II: THE LIST OF PROFESSIONAL COMPETENCY INDICATORS IN KNOWLEDGE AND COGNITIVE SKILL

| Professional Competency | Indicator | Symbol |
|---|---|---|
| Knowledge Skills (K) | **1) The memory of knowledge in the curriculum:** students can tell the subject details and knowledge gained from the curriculum's learning with proper ways of learning and studying. | $K_1$ |
| | **2) The understanding of knowledge in the curriculum:** students can explain the knowledge and content of the subject gained from the curriculum's learning with proper ways of learning and study | $K_2$ |
| | **3) The presentation of knowledge:** students can present the knowledge and content of the subject gained from the curriculum's learning with proper ways of learning and study. | $K_3$ |
| | **4) Program test:** students can test the installation and use of computer programs used in the subject gained from the curriculum's learning with proper ways of learning and studying. | $K_4$ |
| | **5) Workpiece design:** students can create and design their workpieces from different instruments or computer programs correctly under the work context assigned in the subject gained from the learning in the curriculum. | $K_5$ |
| | **6) Tool selection:** students can consider and decide to use tools and computer programs correctly under the work context assigned in the subject gained from the learning in the curriculum. | $K_6$ |
| Cognitive Skills (C) | **1) Digital data searching:** students can use computer tools and programs necessary to search and evaluate the digital data's values or quality. | $C_1$ |
| | **2) Digital data storage:** students can use computer instruments and programs necessary to manage digital data appropriately. | $C_2$ |
| | **3) Digital data analysis and synthesis:** students can analyze, synthesize, and summarize key points from the digital data. | $C_3$ |
| | **4) Thinking and workpiece creation:** students can think and create their workpieces or assignment in the subject gained from systematically learning in the curriculum. | $C_4$ |
| **Total: 2 Domains** | **10 Indicators** | |

*Source*: (Suwanroj *et al.*, 2019) [3]

TABLE III: SEVENTEEN SUBJECTS IN FIVE SUBJECT GROUPS OF THE BACHELOR OF SCIENCE, MAJOR IN COMPUTER INNOVATION AND DIGITAL INDUSTRIAL

| Subject Group | Subject | Symbol |
|---|---|---|
| 1. Organizational Issues and Information Systems (OIIS) | (1) Cognitive Database System | IDS |
| | (2) Digital Competencies for Digital Manpower | DCDM |
| | (3) Principles of Human-Computer Interactions | PHCI |
| 2. Applied Technology (AT) | (1) Computer Graphic | CG |
| | (2) Digital Content Management System | DCMS |
| | (3) Digital Animation Technology | DAT |
| | (4) Interactive Digital Media Technology | IDMT |
| | (5) Digital Learning Platform | DLP |
| | (6) Digital Commerce Management | DCM |
| 3. Technology and Software Method (TSM) | (1) Digital Repository Management Technology | DRMT |
| | (2) Software Engineering for Digital Information Management | SEDIM |
| | (3) Information Systems Analysis and Design | ISAD |
| | (4) Microcomputer Maintenance and Program Installation | MMPI |
| 4. System infrastructure (SI) | (1) Information Technology for Digital Information Management | ITDIM |
| | (2) Internet of Everything | IoE |
| 5. Digital Industry (DI) | (1) Digital Information Management System | DIMS |
| | (2) Information Graphic and Digital Media | IGDM |
| **Total: 5 Subject Groups** | **17 Subjects** | |

*Source:* (Office of the Higher Education Commission, 2020) [4]

*Part 3: Quality Check of Professional Competency Test*

This part was the quality check of the draft of the professional competency test in knowledge and cognitive skill resulting from the operation of the experts (set 2) from part 2.

The operation was composed of 3 minor steps: the proposal of the test to the experts to check content validity, the first trial to check the difficulty; discrimination; and reliability, including the second trial to check the construct validity and construct reliability. The details were as follows:

*Step 3.1: The Proposal of The Test to The experts to Check Content Validity*

This step proposed a professional competency test draft in knowledge and cognitive skill to five experts (set 3). These five experts included 1) instructors in Computer Science, Computer Engineering, Software Engineering, Information Technology, Business Computer, and Computer Education from public educational institutions providing the bachelor's degree level, and 2) experts in research and educational evaluation. They were responsible for checking the content validity of the test in each item, analyzing the data by finding Item Objective Congruence (IOC), and comparing it to the 0.5 criteria. The operation of this step was in June 2019.

*Step 3.2: The First Trial to Check the Difficulty, Discrimination, and Reliability*

This step brought the professional competency test in knowledge and cognitive skill with content validity to trial with 30 students in the fourth year of Computer Innovation and Digital Industry Major, NSTRU, in semester 1 of the academic year 2019. These 30 students passed the professional competency test. The trial aimed to check the quality in difficulty, discrimination, reliability, and internal consistency. The researchers analyzed the score to find the difficulty and discrimination of each item. Next, considered and selected under the difficulty criteria from 0.2-0.8 and discrimination between 0.2-1.00. These criteria were from the concepts presented by Suwanroj *et al.* [3], Leekitchwatana [5] and Rahmawati *et al*. [6]. Then, the researchers brought the score from the items that passed the criteria to analyze the reliability of the professional competency test using Cronbach's alpha coefficient (α). The operation of this step was in July 2019.

*Step 3.3: The Second Trial to Check the Construct Validity and Construct Reliability*

After passing the quality check in content validity, difficulty, discrimination of each item, reliability, and internal consistency, this step brought the professional competency test in knowledge and cognitive skill to trial with 70 students in the fourth year of the Computer Innovation and Digital Industry Major, NSTRU, in semester 1 of the academic year 2019. It aimed to check the test's construct validity and each aspect's construct validity. The researchers brought the score to analyze the construct validity by 2nd CFA using LISREL 8.72 program. Then, compared to the statistical criteria of Goodness of Fit for the measurement model and empirical data. The researchers brought the analysis results to calculate the construct reliability (ρc) and compared the criteria. The operation of this step was in August 2019.

## V. RESULTS

The research presented the results based on the objectives with the details as follows:

### *A. The Analysis Results of Professional Competency Content*

The analysis results of professional competency content in knowledge and cognitive skill by five experts (set 1) in Step 1 were in content structure and the number of professional competency test items as shown in Table IV.

From Table IV, the experts (set 1) analyzed the content of professional competency in knowledge and cognitive skill by using the list of indicators under the Qualification Framework of Learning Outcomes for Undergraduates. There were ten indicators: six for knowledge (K) and four for cognitive skill (C). These indicators were integrated into seventeen subjects in five subject groups of the Bachelor of Science, Major in Computer Innovation and Digital Industry.

By considering each subject's content and course description, the experts specified the indicators' weight to two levels: primary responsibility and minor responsibility. Then, they specified the indicators that were the "primary responsibility" of each subject were the list needed to measure. This indicator list was used to create the test items matching the content structure and the number of test items, 100.

TABLE IV: CONTENT STRUCTURES AND THE NUMBER OF TEST ITEMS USED TO MEASURE PROFESSIONAL COMPETENCIES

| Subject Group | Competency/ Indicator / Subject | Competency | | | | | | | | | | The Number of Test Items | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Knowledge Skills (K) | | | | | | Cognitive Skills (C) | | | | K+C | Total |
| | | $K_1$ | $K_2$ | $K_3$ | $K_4$ | $K_5$ | $K_6$ | $C_1$ | $C_2$ | $C_3$ | $C_4$ | | |
| 1. OIIS | (1) IDS | • | • | • | O | O | O | • | • | • | O | 3+3=6 | 18 |
| | (2) DCDM | O | • | • | • | O | O | • | O | • | • | 3+3=6 | |
| | (3) PHCI | O | O | • | • | • | • | O | • | • | O | 4+2=6 | |
| 2. AT | (1) CG | O | O | • | • | • | O | O | O | • | • | 3+2=5 | 36 |
| | (2) DCMS | • | • | • | O | • | O | • | • | O | O | 4+2=6 | |
| | (3) DAT | O | • | • | • | • | O | O | • | • | • | 4+3=7 | |
| | (4) IDMT | O | O | • | • | O | • | O | O | • | • | 3+2=5 | |
| | (5) DLP | O | • | • | • | O | O | • | • | O | • | 3+3=6 | |
| | (6) DCM | O | • | • | • | • | O | O | • | • | • | 4+3=7 | |
| 3. TSM | (1) DRMT | • | • | • | O | O | O | O | • | O | • | 3+2=5 | 23 |
| | (2) SEDIM | O | • | O | • | • | O | • | • | • | O | 3+3=6 | |
| | (3) ISAD | O | O | • | • | • | O | O | • | • | O | 3+2=5 | |
| | (4) MMPI | O | O | • | • | • | • | O | • | • | • | 4+3=7 | |
| 4. SI | (1) ITDIM | O | • | • | • | O | O | • | O | • | O | 3+2=5 | 11 |
| | (2) IoE | O | O | • | • | • | O | O | • | • | • | 3+3=6 | |
| 5. DI | (1) DIMS | O | O | • | • | O | • | • | O | O | • | 3+2=5 | 12 |
| | (2) IGDM | • | O | • | • | • | O | O | • | • | • | 4+3=7 | |
| | **Total** | | • | • | • | • | • | • | • | • | • | **57+43** | **100** |

*Remark* • = Major Responsibility, O = Minor Responsibility

In conclusion, there were 100 items in the professional competency test. The test items were divided into five groups in keeping with the subject group and subject content: 18 items for Group 1 Organizational Issues and Information Systems (OIIS); 36 items for Group 2 Applied Technology (AT); 23 items for Group 3 Technology and Software Method (TSM); 11 items for Group 4 System Infrastructure (SI); and 12 items for Group 5 Digital Industry (DI).

### *B. The Creation Result of Professional Competency Test*

The creation result gained from five experts (set 2) in Step 2 was the professional competency test in knowledge and cognitive skill. The test was five multiple-choice questions. The respondents got one point when they answered correctly and no point when they answered incorrectly. The test comprised 100 items covering the content structure of the professional competency of seventeen subjects in five subject groups. The test items were classified into two domains: 57 items for knowledge skills and 43 items for cognitive skills, as shown in Table IV.

### *C. The Quality Check Result of Professional Competency Test*

The researchers employed the criteria presented by Suwanroj *et al.* [3], Leekitchwatana, [5] and Rahmawati *et al.* [6] for the quality check result of the professional competency test in knowledge and cognitive skills. The results were as follows:

1) The content validity of each item: five experts considered and analyzed the data to find the index of Item Objective Congruence (IOC). The result showed that all items had content validity with the IOC between 0.80-1.00. With this value, the test passed the criterion, which was set not lower than 0.50.
2) The difficulty and discrimination of each item: the result showed that all items in the test had appropriate difficulty between 0.25-0.78, which passed the criterion 0.20-0.80. Also, all items had the appropriate discrimination between 0.44-0.96, which passed the criterion 0.20-1.00.
3) The reliability and internal consistency of the test: it showed that after using the alpha coefficient (α) of Cronbach, the reliability coefficient was 0.87. When separating into 2 domains, the reliability coefficient of the knowledge domain was 0.80, and the reliability coefficient of the cognitive skill was 0.97. For the indicator aspect, the reliability coefficient of 10 indicators was 0.80-0.97, higher than 0.80, the criterion specified.
4) The construct validity: after using 2nd CFA, the research found the model to measure the professional competencies. The model consisted of 2 main elements: knowledge and cognitive skill. There were 6 indicators of professional competencies for knowledge and 4 indicators for cognitive skill. Details were shown in Fig. 3 and Table V-VI.

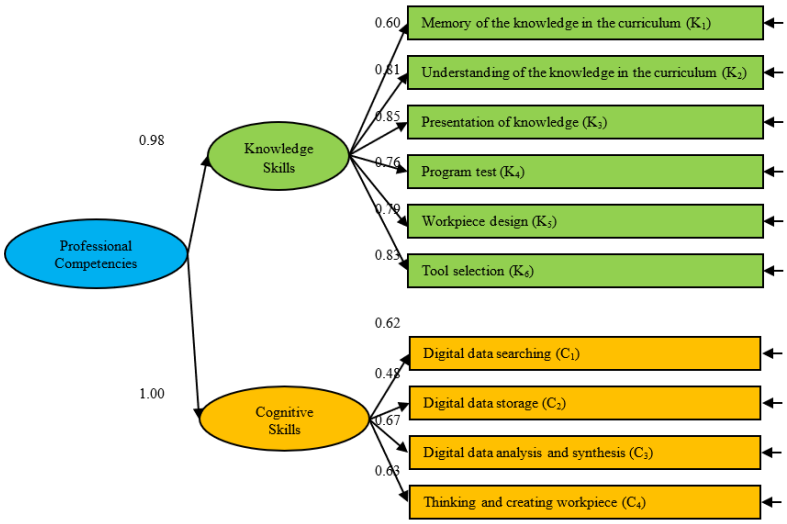
Fig. 3 shows that the professional competencies comprise 2 main domains: cognitive skill (C) (1.00) and knowledge (K) (0.98), sorting by the importance of weight values following the standard elements in descending order.

The knowledge domain consists of six minor elements. When sorting by the importance of weight values following the standard elements in descending order, the research finds:

**The presentation of knowledge ($K_3$):** students can present the knowledge and content of the subject gained from the curriculum's learning with proper ways of learning and study (0.85).

**Tool selection ($K_6$):** students can consider and decide to use tools and computer programs correctly under the work

context assigned in the subject gained from the learning in the curriculum (0.83).




Chi Square = 9.97, df = 9, P value = 0.25, RMSEA = 0.031

Fig. 3. 2nd CFA model of professional competency measurement.

*Remark:* Fig. 3 is the input from the Second Trial to Check the Construct Validity and Construct Reliability (Step 3.3).

**The understanding of knowledge in the curriculum ($K_2$):** students can explain the knowledge and content of the subject gained from the curriculum's learning with proper ways of learning and study (0.81).

**Workpiece design ($K_5$):** students can create and design their workpieces from different instruments or computer programs correctly under the work context assigned in the subject gained from the learning in the curriculum (0.79).

**Program test ($K_4$):** students can test the installation and use of computer programs used in the subject gained from the curriculum's learning with proper ways of learning and study (0.76).

**The memory of knowledge in the curriculum ($K_1$):** students can tell the subject details and knowledge gained from the curriculum's learning with proper ways of learning and study (0.60).

The cognitive skill domain consists of 4 minor elements. When sorting by the importance of weight values following the standard elements in descending order, the research finds:

**Digital data analysis and synthesis ($C_3$):** students can analyze, synthesize, and summarize key points from the digital data (0.67).

**Thinking and workpiece creation ($C_4$):** students can think and create their workpieces or assignment in the subject gained from systematically learning in the curriculum (0.63).

**Digital data searching ($C_1$)**: students can use computer tools and programs necessary to search and evaluate the digital data's values or quality (0.62).

**Digital data storage ($C_2$):** students can use computer instruments and programs necessary to manage the digital data appropriately (0.48).

Table V shows that the professional competency test has a good level of construct validity because the model is relevant to the empirical data on a good standard.

Table VI reveals that the two domains in the professional competency test have a good level of construct validity because the coefficient reliability is of a good standard.

TABLE V: STATISTICS TO MEASURE GOODNESS OF FIT INDEX OF PROFESSIONAL COMPETENCY MEASUREMENT MODEL

| Goodness of Fit Index | Good Criterion | Value gained | Consideration Result | Conclusion |
|---|---|---|---|---|
| $\chi^2$- Sig (p) | >0.05 | 0.25 | passed | good |
| RMSEA | <0.05 | 0.03 | passed | good |
| SRMR | <0.05 | 0.02 | passed | good |
| AGFI | >0.90 | 0.97 | passed | good |

*Remark:* The criteria was from the concepts presented by Suwanroj *et al*, (2019) [3], Leekitchwatana, (2015) [5] and Rahmawati *et al*, (2019 [6].

TABLE VI: CONSTRUCT RELIABILITY OF PROFESSIONAL COMPETENCY TEST IN EACH DOMAIN

| Domain (Latent Variable) | Construct Reliability ($\rho_c$) | | Consideration Result | Conclusion |
|---|---|---|---|---|
| | Good Standard | Value Gained | | |
| Knowledge Skills (K) | >0.60 | 0.98 | passed | good |
| Cognitive Skill (C) | >0.60 | 0.97 | passed | good |

*Remark:* The criteria was from the concepts presented by Suwanroj *et al*, (2019) [3], Leekitchwatana, (2015) [5] and Rahmawati *et al*, (2019 [6].

In conclusion, the quality of the professional competency test in knowledge and cognitive skill was in the qualified standard. (The criteria were from the concepts presented by Suwanroj *et al.* [3], Leekitchwatana, [5] and Rahmawati *et al.* [6].) Its content validity was on a reasonable level. The difficulty was appropriate. The discrimination had a reasonable level, as well as a good value of reliability for internal consistency. The construct validity and construct reliability were acceptable. These results showed that the professional competency test was a viable tool to measure the professional competencies in knowledge and cognitive skill of undergraduates, Major in Computer Innovation and Digital Industry.

## VI. DISCUSSION

The results of this research show essential points that can be discussed in three issues based on the research objectives.

The details of the result discussion are as follows:

### A. First Issue: The Analysis of Professional Competency Content

1) The list of ten professional competency indicators used as the framework in creating the professional competency test in two domains were from the concepts presented by Suwanroj *et al.* [3]. When considering the list of professional competency indicators, it was found that they were from the focus group discussion of the experts (set 1). The experts considered together and set the details covering all domains under the criteria of the Office of the Higher Education Commission [4]. The research used these criteria as the qualification framework for learning outcomes for the Computer Innovation and Digital Industry undergraduate program at Nakhon Si Thammarat Rajabhat University. Due to being the first study and the pilot in two domains—knowledge and cognitive skills—this professional competency test development had the professional competencies' content entirely followed in the qualification framework of learning outcomes. Moreover, the group of experts (set 1) suggests that the professional competency test, five-multiple choice questions, is practical because it is appropriate and relevant to the knowledge and cognitive skill domains following the concept of Bloom's taxonomy revisited [8] which aims to study and measure the behavior in five levels: 1) understanding 2) utilization 3) analysis 4) synthesis/creativity, and 5) evaluation.
2) The researchers analyzed the content and course description to create the test's framework based on the list of ten professional competency indicators in two domains, knowledge and cognitive skills. The content and course descriptions consisted of five subject groups: group 1-Organizational Issues and Information Systems gained from three subjects: IDS, DCDM, and PHCI, group 2-Applied Technology gained from six subjects: CG, DCMS, DAT, IDMT, DLP, and DCM, group 3-Technology and Software Method gained from 4 subjects: DRMT, SEDIM, ISAD, and MMPI, group 4-System infrastructure gained from two subjects: ITDIM and IoE, and group 5-Digital Industry gained from two subjects: DIMS and IGDM. The researchers used the analysis results of the professional competency content following the competency variables and the subjects under the qualification framework of learning outcomes for undergraduates, Major in Computer Innovation and Digital Industry, NSTRU to find the primary and minor responsibilities based on the curriculum mapping gained from the criteria of Office of the Higher Education Commission [4]. It was in keeping with the concepts of Rahmawati *et al.* [6] and Hoque [7]. They analyzed the content and course description to create the test's framework by classifying each subject's primary and minor responsibilities from the curriculum mapping.

### B. Second Issue: The Creation Result of Professional Competency Test

The experts (set 2) created the professional competency test concerning the list of professional competency indicators and the analysis of the content and course descriptions gained from the Bachelor of Science Major in Computer Innovation and Digital Industry, NSTRU. The test included 100 items covering two domains: knowledge and cognitive skills under the Office of the Higher Education Commission (2020) [4]. All 100 items of the professional competency test aligned with the qualification framework of learning outcomes for undergraduates, program in Computer Innovation and Digital Industry, NSTRU. These 100 items came from five subject groupings, as mentioned in the first issue (2). The researchers used the criteria emphasizing the primary and minor responsibilities based on the curriculum mapping from the Office of the Higher Education Commission (2020) [4]. It adhered to the ideas of Rahmawati *et al.* 2019 [6] and Hoque (2016) [7]. They analyzed the content and course description to create the test's framework by classifying each subject's primary and minor responsibilities from the curriculum mapping.

### C. Third Issue: The Quality Check Result of Professional Competency Test

1) The research checked the content validity of the professional competency test in each item by using the Index of Consistency (IOC) gained from the experts (set 3). The result revealed that the IOC of all 100 items had quality following the specified criteria under the concepts of Leekitchwatana [5] and Hsu *et al.* [9]. They said that the requirements of the content validity in each item by finding the IOC must be $\geq 0.50$. Therefore this professional competency test had content validity in each item. Also, Hsu *et al.* [9] said that the table of curriculum analysis must be applied as the criteria to consider content validity because it is the precise plan used for the guideline to create the test that can cover the required contents. It was also relevant to the concepts presented by Lamshoeft *et al.* [10] and Perez-Richet *et al.* [11]. They stated that checking the content validity by the content experts with the consideration of the IOC 0.50 shows that the questions can be measured by matching with the things that the researchers want to measure and be able to select those questions to use. Content validity is an essential characteristic of the qualified professional proficiency test. The researchers focused on the test quality in each item and mainly considered content validity. This method was relevant to the study of Hsu *et al.* [9], who wanted to check the content validity. It was also in keeping with Leekitchwatana [5] presented in the book Research Methods in Education, which said there must be a content validity check to create the professional competency test. Furthermore, if the questions from the test can be precisely measured and cover things that the researchers want to measure, the professional competency test created has content validity.
2) The difficulty check and discrimination results in each item showed that all 100 items had difficulty and discrimination that passed the criteria. It was relevant to the concepts presented by Leekitchwatana [5], and Hsu *et al.* [9], who say that the criteria of each item's quality in difficulty and discrimination is 0.20 – 0.80. Moreover, it is necessary to thoroughly check each item's quality in the professional competency test following the specified

framework in creating the questions of the professional competency test.

3) The quality results in reliability with the internal consistency using Cronbach's alpha coefficient showed that this professional competency test had the reliability coefficient for an entire issue. It could be separated into two domains: knowledge and cognitive skills. Ten indicators of professional competency had a reliability coefficient higher than the criterion. It was relevant to the concepts presented by Leekitchwatana [5], and Hsu *et al*. [9]. They said that a reliable criterion with the internal consistency of the professional competency test for the entire issue using Cronbach's alpha coefficient is ≥0.80. Thus, this professional competency test had reliability with the internal consistency for the entire issue. It was the measurement of internal stability to find the reliability of the test by using the test a single time. The research used test-retest and parallel or alternate test forms because it was more convenient than repeating the same sample group [10], [11]. Moreover, the reliability estimation of the professional competency test for the entire issue was higher than the criterion specified by the researchers [5], [9]. It was also in line with the concept of Bax *et al.* [12], who said that the popular rule to find the reliability for the entire issue should be ≥0.70 depending on the research objectives. Leekitchwatana [5] states that in creating the professional competency test, the reliability with the internal consistency for the entire issue should be ≥0.80.
4) The quality check results mentioned above showed that the professional competency test created had quality in the satisfied level. However, the researchers aimed to insist on the validity more strongly following the concept of Keith *et al.* [13], who gives importance to the measurement ability to be accurate in line with the descriptions specified as the structure. Thus, the researchers decided to apply the concepts of Leekitchwatana [5], Keith *et al.* [14], Kuzminska *et al.* [15] and Ly *et al*. [16] to check the construct validity of the professional competency test for the entire issue. The 2nd CFA was used with the empirical data gained from the students' test results in making the professional competency test using LISREL 8.72. The results discovered that the professional competency test had the construct validity in the satisfied level because the measurement model fit with the empirical data. It could strongly confirm the validity quality of this test.
5) The validity check results in each aspect revealed that the construct validity of the professional competency test in knowledge and cognitive skill domains was qualified compared to the criterion 0.60 following the concept presented by Suwanroj *et al.* [3].

The benefits of this research's findings based on the three discussion issues are as follows:

1) Before developing the professional competency test: It is essential to check the competency measurement tools to ensure their high quality. However, the professional competency test can be measured to find the quality differently. This research presented three practical ways for interested people, 1) content validity of the professional competency test in each item using the Index of Consistency (IOC), 2) the difficulty check and discrimination results in each item, and 3) the reliability coefficient with the internal consistency for an entire issue.
2) The development of professional competency test:

Undergraduates in the Computer Innovation and Digital Industry Major at NSTRU have gradually improved their learning outcomes. By building motivation practically, the students could know their scores immediately after the professional competency test. If the students failed the test, they could see the areas where they needed to improve their knowledge and cognitive skills. The test is then repeated until they pass or meet the requirement. With this method, the student's professional competencies in the Computer Innovation and Digital Industry match the establishment's core criteria, giving the students a reasonable chance of finding a position in the industrial sector in the future.

In conclusion, the mentioned professional competency test had a good quality. It could be used as a tool to measure the competencies of undergraduates as the users desire. The test was the five multiple-choice questions. It included 100 items: 57 items to measure the knowledge domain and 43 items to measure the cognitive skill domain. These 100 items were gained from the ten indicators for professional competencies. They covered the content and course descriptions of seventeen subjects in five subject groups of the Bachelor of Science, Computer Innovation and Digital Industry Major.

## VII. Contribution to Knowledge

The development of this professional competency test gave importance to three main points: the analysis of professional competency content, the creation result of the professional competency test, and the quality check result. It could be said that this development process aimed to acquire a quality professional competency test. Moreover, the test results using the professional competency test could reflect the competencies of each student. It can be used to prepare the students before entering the establishments promptly. However, students with low professional competency levels will be developed promptly as individuals before entering the establishments. This individual development aims to reduce the problems that students can graduate, but they cannot work to meet the establishment's needs.

## VIII. Conclusion and Suggestions for Further Studies

The development of this professional competency test is the initiation to improve the competency measurement tool for the students. The development chose to start with two domains from five domains: knowledge and cognitive skills under the qualification framework of learning outcomes for undergraduates of Computer Innovation and Digital Industry Major, NSTRU. The research has gained the professional competency test, which has the quality and effectiveness in keeping with real situations. The professional competency test that was developed and composed of 100 items can measure the professional competencies in knowledge and cognitive skill. Based on the specified qualification

framework of learning outcomes, it is also very suitable for the undergraduate context in Computer Innovation and Digital Industry Major, NSTRU. The researchers propose the suggestions in two main issues as follows:

### *A. First Issue: Suggestions to Apply this Professional Competency Test*

1) The professional competency test measures the professional competencies in knowledge and cognitive skills under the qualification framework. The curriculum administrative committees and instructors can use the results from this research to set the plan to develop the professional competencies for each student.
2) The users should consider other diagnostic results and apply this professional competency test, for example, practical tests, demonstrations, and experiments. This concurrent consideration aims to increase the accuracy in evaluating professional competencies in a different dimension.

### *B. Second Issue: Suggestions for Further Studies*

The professional competency should be improved in three other domains: ethics and morals, interpersonal skills and responsibility, and numerical, analytical, communication, and information technology skills. The researchers should use different instruments suitable for the contexts, such as the practical tests using Scoring Rubric, questionnaire, attitude test, interview, and observation. The purpose of using different instruments is to test the professional competencies in all domains under the qualification framework of learning outcomes for undergraduates of Computer Innovation and Digital Industry Major, NSTRU.

## 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.

## REFERENCES


[1] Ministry of Education. (2019). *National Education Standards B.E.* [Online]. Available: https://eduservice

[2] The Secretariat of the Cabinet. (2018). *Higher Education Standards B.E. 2561*. [Online]. Available: http://www.ratchakitcha.soc.go.th/DATA/PDF/2561/E/199/T19.PDF

[3] T. Suwanroj, P. Leekitchwatana, and P. Pimdee, "Confirmatory factor analysis of the essential digital competencies for undergraduate students in Thai higher education," *Journal of Technology and Science Education*, vol. 9, no. 3, pp. 340-356, 2019.

[4] Office of the Higher Education Commission. (2020). *Thai Qualifications Framework for Higher Education*. [Online]. Available: http://www.mua.go.th/users/tqf-hed/news/news6.php

[5] P. Leekitchwatana, *Research methods in Education*, 7th ed., Min Service Supply, Bangkok: King Mongkut's Institute of Technology Ladkrabang, 2015.

[6] R. Rahmawati, F. Lestari, and R. Umam, "Analysis of the effectiveness of learning in the use of learning modules against student learning outcomes," *Desimal: Journal Matematika*, vol. 2, no. 3, pp. 233-240, 2019.

[7] M. E. Hoque, "Three domains of learning: Cognitive, affective and psychomotor," *The Journal of EFL Education and Research*, vol. 2, no. 2, pp. 45-52. 2016.

[8] C. W. Starr, B. Manaris, and R. H. Stalvey, "Bloom's taxonomy revisited: specifying assessable learning objectives in computer science," *ACM SIGCSE Bulletin*, vol. 40, no. 1, pp. 261-265, 2008.

[9] T. Suwanroj, and S. Orawan, "New normal appropriate learning model: 2NAL model during COVID-19 pandemic for undergraduates of Thai educational institutions," *Journal of Engineering Education Transformations*, vol. 35, no. 4, pp. 31-41, 2022.

[10] F. Y. Hsu, H. M. Lee, T. H. Chang, and Y. T. Sung, "Automated estimation of item difficulty for multiple-choice tests: An application of word embedding techniques," *Information Processing & Management*, vol. 54, no. 6, pp. 969-984. 2018.

[11] M. Lamshoeft, Z. Gao, H. Resseler, C. Schriever, R. Sur, P. Sweeney, and M. U. Reitz, "Evaluation of a novel test design to determine uptake of chemicals by plant roots," *Science of the Total Environment*, vol. 61, no. 3, pp. 10-19. 2018.

[12] E. Perez-Richet, and V. Skreta, "Test design under falsification," Work Pap. Sci. Po. Paris Access provided by University of Chicago Libraries, 2018.

[13] S. Bax and S. Chan, "Using eye-tracking research to investigate language test validity and design," *System*, vol. 83, pp. 64-78, 2019.

[14] T. Z. Keith and M. R. Reynolds, "Using confirmatory factor analysis to aid in understanding the constructs measured by intelligence tests," *Contemporary Intellectual Assessment: Theories, Tests, and Issues*, vol. 9, no. 2, pp. 853–900, 2018.

[15] O. Kuzminska, M. Mazorchuk, N. Morze, V. Pavlenko, and A. Prokhorov, "Digital competency of the students and teachers in Ukraine: Measurement, analysis, development prospects," in *Proc. ICTERI Workshops*, 2018, vol. 8, no, 9, pp. 366-379.

[16] A. Ly, M. Marsman, and E. J. Wagenmakers, "Analytic posteriors for Pearson's correlation coefficient," *Statistica Neerlandica*, vol. 72, no. 1. pp. 4-13, 2018.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