

INTERNATIONAL EDUCATIONAL TECHNOLOGY CONFERENCE
IETC2013

Development of ICT Competency Standard Using the Delphi Technique

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Abstract

The purpose of the paper is to discuss the application of the Delphi technique in the research design of developing a valid and reliable ICT (Information & Communication Technology) competency standard for teachers. Much investment has been placed on organizing ICT training programmes for in-service teachers but the effects of teaching and learning practices in the classroom have not achieved expected outcomes. In addition, allegations from teachers highlighted that the training programmes are inadequate to completely meet the needs of ICT competencies. Hence, an ICT competency standard is necessary and timely to be developed to serve as a guide for organizing ICT training programmes. The Delphi technique is a research approach used to obtain a consensus opinion from experts using a series of questionnaires. This study was carried out with the purpose to obtain a consensus opinion from the experts on the types of important ICT competencies to be mastered by secondary school Science and Mathematics teachers, and ultimately develop the ICT competency standard for Malaysian Science and Mathematics teachers. The developed competency standard using the Delphi technique is valid and reliable.

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Selection and peer-review under responsibility of The Association of Science, Education and Technology-TASET, Sakarya Universitesi, Turkey.

Keywords: ICT competency; Delphi technique; Science and Mathematics

1. Introduction

ICT (Information & Communication Technology) is proven of being able to provide new learning opportunities among students by making learning fun and simplifying the process of constructing new

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knowledge (Dooly, 2009). In addition, teacher's quality is another main determinant factor in the learning of students (Ololube, 2006). Therefore, school teachers should equip themselves with ICT knowledge and skills to design new learning environment which is termed as ICT-rich learning environment. Various types of professional development programmes relating to ICT implementation have been organised for in-service teachers with the objective to upgrade ICT competencies among teachers, and subsequently bringing change to their teaching and learning practices, such as integrating ICT in classroom teaching and learning effectively (Borko, 2004). Some examples of ICT training programmes organised for teachers are Intel Teach to the Future project (Toh et al., 2006), smart teacher training courses, 14-week professional development programme, and one-year expert certification training course (Asariah, 2009).

Are the aforementioned programmes effective? To answer this question, some past research were studied and it is found that most of the ICT training programmes did not achieve the expected outcomes set by the organisers, and moreover the needs of the participating teachers were left unfulfilled (Wan Zah et al., 2009; Fong et al., 2009; Toh et al., 2006). In other words, after teachers return to schools from the training programmes, there are not much changes of behaviour in their teaching practices when being observed. The past research findings support Cuban's claim (2000) that much investment had been placed on organising ICT training programmes but only minimal usage and changes were implemented. What is the reason behind?

The fact to be emphasised here is that most of the ICT courses offered in the ICT training programmes lack of uniformity and the curricula were designed according to the organisers without following any ICT competency standards, such as International Society for Technology in Education (ISTE) National Educational Technology Standards for Teachers (ISTE 2000; ISTE 2008), European Computer Driving License (ECDL, 2007), European Pedagogical ICT License (EPICT) (Hojsholt-Poulsen, 2005) or UNESCO ICT Competency Standards for Teachers (UNESCO, 2008). It is clear that practices in the past did not manage to solve problems faced by teachers. Therefore, corrective actions are needed urgently.

In view of this phenomenon, this study was conducted to identify the types of important ICT competencies required to be mastered by Malaysian teachers. This study was carried out using the modified Delphi technique to ascertain elements needed in the content of ICT competency standard. This paper explains the research design used in the study in developing a valid and reliable ICT competency standard for teachers.

2. Research Design

The research design used to develop ICT competency standard for Science and Mathematics teachers is shown in Figure 1. It encompasses three stages, which are the stage of designing research instrument, the stage of validating instrument and the stage of developing ICT competency standard.

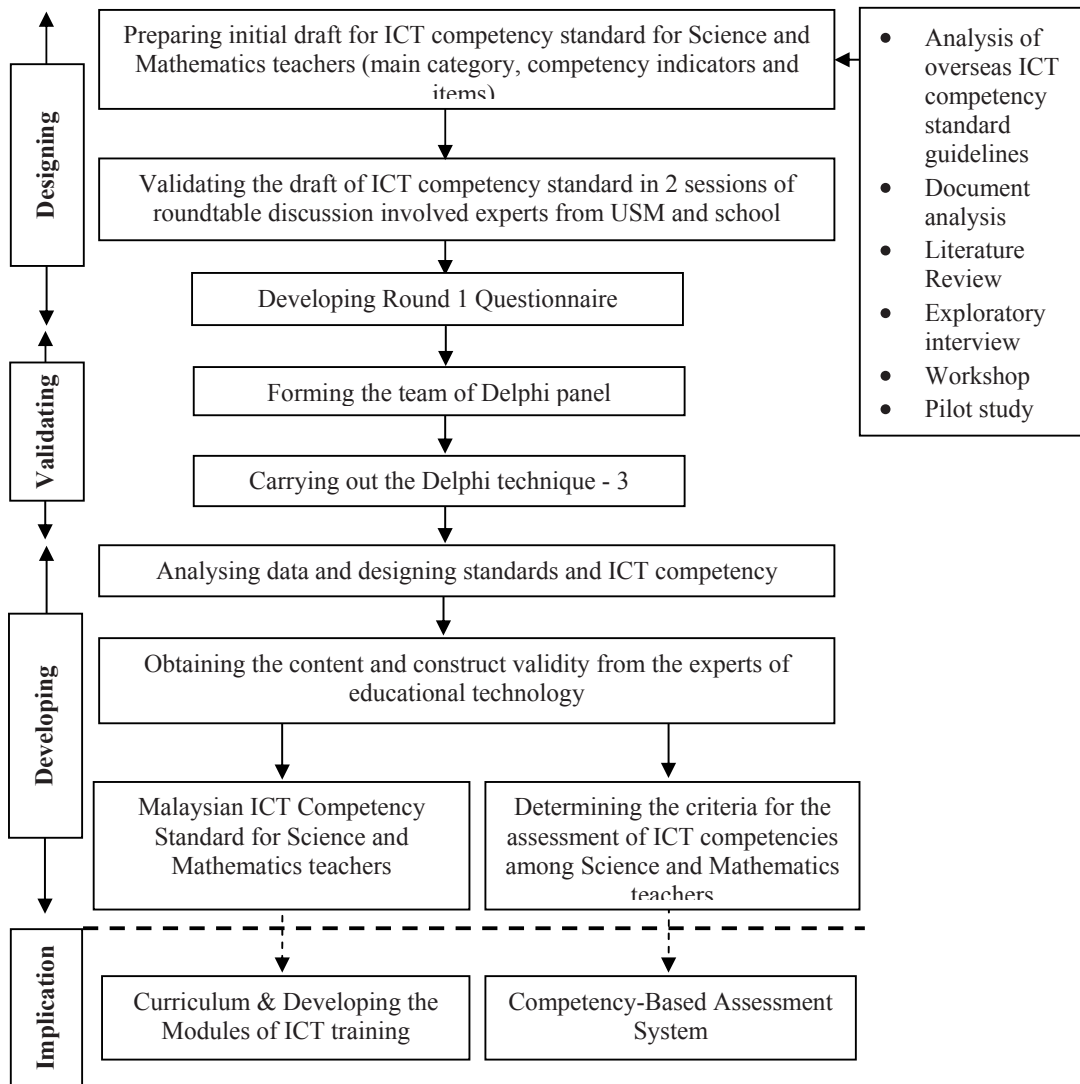


Figure 1: Research Design of Developing ICT Competency Standard

The Delphi technique is defined as a communication structure used to discuss and assess an issue critically (Linstone & Turoff, 1975). It is a qualitative method introduced as a way to allow a group of experts to discuss and make decision on policy without having to meet face-to-face (Goodman, 1987). According to Lang (1998), the Delphi technique has already become a research methodology in helping researchers to formulate plans for the future. The rationale of using the Delphi technique is its cost and time effectiveness in achieving desired results (Helmer, 1983). When conducting this study, it involved iterative distribution of questionnaires to collect opinions from a selected group consisted of experts. This

technique is employed with the purpose to identify consensus opinions relating to a specific topic (Talbot, 1995). Although opinions of this expert group which gathered collectively seem to be subjective, they are considered more reliable and the results are more objective compared to views gathered solely from an individual (Helmer, 1983).

The Delphi technique is designed to optimise the use of group opinion and minimise the quality of conflict interaction within group (Lang, 1998). Therefore, the following four basic characteristics need to be fulfilled if the researcher intends to use this approach, which are:

1. Structured questioning in which questionnaires are used. With this method, moderator is able to control the whole research process and foster more concrete results.
2. Meaningful interaction of questionnaires is performed numerous rounds to allow panelists to re-evaluate their responses.
3. Controlled feedback in which it is achieved by giving overall group response to the panelists in rounds (except Round 1). This means that all the responses of the panel group are considered on the subsequent rounds of assessment.
4. Anonymity is an important characteristic because every panelist has the freedom to express his/her views without feeling pressured from other more powerful group (Rowe & Wright, 1999).

The Delphi technique has already been applied to solve problems in education field, for instance, it was used to determine research areas in distance education (Zawacki-Richter, 2009), to determine secondary school future curriculum (Saedah & Azdalila, 2008), to design m-learning curriculum (Ahmad Sobri, 2009), and to determine university teachers' ICT competencies in online learning (Espasa, Guasch, & Alvarez, 2009) and so on.

3. Designing Main Category, Indicators and Items

The structure of ICT competency standard employed in this study follows the standard structure of ISTE National Educational Standards for Teachers (2000; 2008). It comprises the following sections:

1. Main Category – It encompasses general aspects of the teachers' knowledge and skills pertaining to the teachers' job specifications.
2. Indicators – It illustrates the desired quality of a professional teacher.
3. Items – It is used as the assessment criteria to obtain evidence of applying the knowledge and skills in actual practice.

3.1 The Main Category of ICT Competency Standard

Referring to the structure of ICT competency standard, the first question "What are the main categories of ICT competencies to be included in the teachers' ICT competency standard?" was asked. Analysis was performed on eight sets of existing ICT competency standard guidelines for teachers. These include European Computer Driving Licence (ECDL) (ECDL, 2007), European Pedagogical ICT License (EPICT) (Hojsholt-Poulsen, 2005), Computer Proficiency for Teachers developed by the Ministerial Advisory Council on the Quality of Teaching (MACQT, 1997), Minimum Standards for Teachers-Learning Technology (Education Queensland, 1997), and Queensland ICT Continua (Education Queensland, 2003); International Society for Technology in Education (ISTE) National Educational Technology Standards for Teachers (ISTE NETS-T 2000; ISTE NETS-T 2008) and UNESCO ICT Competency for Teachers (UNESCO, 2008). Based on the results of comparing the eight sets of ICT competency guidelines, approximately ten main categories were listed (Ch'ng et al., 2008a).

Subsequently, document analysis was conducted as a step to determine the important categories in the context of a nation, and in this paper Malaysia is referred specifically. The documents that were

investigated include Smart School Flagship Applications: The Malaysian Smart School A Conceptual Blueprint (Smart School Project Team, 1997), Education Development 2001-2010: Integrated Planning for Generating Education Excellence (Malaysian Ministry of Education, 2001), Formulation of the National Education Blueprint, 2006-2010 (Malaysian Ministry of Education, 2006), ICT Literacy for Secondary School Guideline (Malaysian Ministry of Education, 2007) and so on.

Therefore, the researcher decided to focus the scope of this study on six main categories in designing the draft of ICT competency standard for teachers, they include: (1) Knowledge in ICT Operation, (2) Planning and Designing Learning Environment, (3) Smart Pedagogy, (4) Assessment and Evaluation, (5) Lifelong Learning, Practice and Productivity, and (6) Social, Moral Values and Issues.

3.2 Important ICT Competency Indicators

The subsequent steps include performing literature review on the findings of local research, exploratory interview and comparing technique toward the ISTE 2000 standard guide to outline the statements for ICT competency indicator division.

3.2.1 Literature Review

Past research done in Malaysia such as Fong & Ng (2005), Toh et al. (2006), Chong, Sharaf, & Jacob (2005), Kamisah, Lilia & Subahan (2006), Mas Nida, Moses & Wong (2009), Fong et al. (2009) and so on, were studied to obtain ideas about the types of knowledge and ICT skills that are already mastered, yet to be mastered or needed to be mastered among the in-service teachers. These form an important benchmark for the teachers' ICT competencies.

3.2.2 Exploratory Interview

Exploratory interviews were conducted among school teachers to obtain information about the teachers' experiences in implementing ICT at school level, without the intention to make any comparison. The findings of the exploratory interviews (refer to Ch'ng et al., 2008b) are advantageous as they help in developing competency statements and important items which are used to reflect the actual needs, the barriers and the usage of ICT in schools among teachers.

3.2.3 Comparing The Standard Guides

Based on the information gathered from literature review and exploratory interviews, there are 24 subcategories suggested to be identified as the ICT competency indicators for this study. Comparing technique together with the existing ICT standard guidelines are used as the basis to classify subcategory group.

Then, the process of outlining specific statements for each competency indicator is initiated. The models of competency standards of ISTE NETS for Teachers (2000) and ISTE NETS for Teachers (2008) were selected to use as the fundamental framework to outline the statements of competency standard indicators. The formulation of the statement of competency indicators was administered using the methods of comparing and modifying upon the use of terminology, word or sentence structure to conform to the needs and suitability.

3.3 The Measurement Items of ICT Competency Standard

There were four workshops organised to write and classify items gathered from literature review. The research instrument was designed based on the constructs of ICT competencies (main category and competency indicator). There were 20 research assistants consisted of ICT experts, lecturers and Science and Mathematics teachers participated in these workshops. The research instrument referred were obtained from the past research such as Norizan (2003), Scheffler & Logan (1999), McCoy (2001), Dakich (2005), Fong & Ng (2005), Namlu & Odabasi (2007). With this method, different types of sample items were collected and reviewed for the development of ICT competency items. The outcomes of this series of workshops resulted in the drafting of a list of measurement items.

4. Pilot Study

Pilot study was carried out among school teachers. The objective of the pilot study is to identify the weaknesses of the instrument. Thirty Science and Mathematics teachers were selected randomly. A set of instrument for the pilot study was developed. The questionnaires prepared include open questions and likert scale questions. The questionnaires were printed and there were three sections in the questionnaires, which were:(1) 6 main categories, (2) competency indicators and (3) ICT competency items. Respondents were invited to assess the suitability of main categories and statements of ICT competency indicators to convert into ICT competency standard for teachers. The items were in the form of open questions whereby the respondents were required to write their views and comments about the statements contained in the questionnaires. The respondents' comments in the pilot study were taken into account for modifying and eliminating the list of items to ultimately develop the Delphi technique research instrument.

5. Validating Instrument

Subsequently, two sessions of round-table discussion were arranged to obtain validation from the experts in respect of determining categories, ICT competency indicators and items which were outlined earlier. The participants for the round-table discussion were invited using snowball sampling where all the participants were invited by the researcher's supervisor with reference to their expertise. The participants consisted of ten lecturers from local university with expertise in educational technology, Science education, Mathematics education, distance education and psychology education. Besides that, another four in-service secondary school teachers from the field of Information Technology, Science and Mathematics were invited for the round-table discussion. This process is important to confirm the validity of the items with regard to the constructs. At this stage, one set of the drafts of ICT competency was reviewed. It consisted of 6 main categories and 24 competency indicators.

6. Developing Round 1 Questionnaires

The content of the draft of ICT competency standard together with the measurement items produced through the qualitative research procedure were used to develop Round 1 questionnaires. This approach is regarded rational, intuitive or theory-based. Items used in Round 1 questionnaires were generated from the concepts of theory which were identified following several procedures discussed earlier.

7. Forming The Delphi Panel Group

According to Adler & Ziglio (1996), the members of the Delphi panel should meet four conditions as stated below:

1. possess extensive knowledge and experience in the research problem,
2. are committed to involve,
3. have spare time to participate in the research process of the Delphi technique,
4. possess effective communication skills.

For this study, the criteria set for selecting the Delphi panel were all local educators with extensive experience and expertise in using ICT in the classroom. The snowball sampling technique was used to identify individuals who were qualified to be invited and appointed as the Delphi panel of this study (Skulmoski, Hartman & Krahn, 2007).

In fact, there is flexibility in determining the sample size of the Delphi panel. According to Skulmoski, Hartman & Krahn (2007), the number of panel in the past research range from approximately 4 to 171 “experts”. However, Dalkey (1975), finds that 15 experts and above can maximise reliability and minimise group error on the degree of consensus.

As exemplified in this study, there were 33 experts appointed as the Delphi panel. They were local university lecturers in the field of education and educational technology; university/college lecturers in the field of Science and Mathematics, university/college lecturers from other fields but with extensive experience in using ICT to execute professional tasks and they were ICT daily users to support teaching and learning practices; and also school teachers who used ICT in classroom at least three times per week. In addition, the selected candidates affirmed their full commitment to this study using the Delphi technique.

8. Procedure of Modified Delphi Technique

Immediately after forming the Delphi panel, every member of the Delphi panel was contacted whether face-to-face, or via telephone and email. The panelists were given brief explanation regarding the research objectives and the expectation from them. This included giving access link to the research instrument website. In actuality, the expert panel has the flexibility to give their responses online or using printed questionnaires or using questionnaires in the form of MSWord attached in the email. The Delphi panel was given seven days to answer the questionnaires for Round 1. Two days before the due date of giving Round 1 response, a reminder email was sent by the researcher to remind the panel members about their incomplete tasks. However, the duration was extended for another three days to wait for the responses from the panel members who were unable to return the questionnaires in time.

All the data collected in Round 1, was analysed and adopted to develop questionnaires for Round 2. New items were included in the Round 2 questionnaires based on the suggestions given by the experts in Round 1. Face validity and content validity were checked by the researcher’s supervisor.

Delphi Round 2 questionnaires were prepared in two forms: in MS Word file and printed questionnaires. Delphi panel individual feedback together with the data analysis of group feedback were prepared by the researcher in Round 2 questionnaires. They were then printed and distributed or emailed. Panel could refer to the comments of other panel, and the group median value, inter quartile range and personal rating in Round 1. They then justified whether the values in the earlier round were significant or some modification needed to be made upon their respective ratings in this Delphi round. All the panel members were given five days to respond. Two days before the due date of giving Round 2 response, a reminder email was sent by the researcher to remind the panel members about their incomplete tasks.

However, the duration was extended for another three days to wait for the responses from the panel members who were unable to return the questionnaires in time.

Delphi Round 3 questionnaires were prepared in two forms: in MS Word file and printed questionnaires. The format was similar to Round 2 questionnaires, except the number of items in this round was limited to only eight items. Face validity and content validity were checked by the researcher's supervisor. All the panel members were given seven days to respond in view of three public holidays fell within the period.

As the example of this study, three rounds of the Delphi technique were practised. Round 1 was performed to collect additional input and comments from the expert panel about the initial list of ICT competencies compiled through qualitative research method such as document analysis results, literature review, exploratory interview, pilot study and round-table discussion. Round 2 was executed to obtain validation for items in Round 1 and to obtain consensus from the experts, and to distribute new items and suggested ideas from the panel in Round 1 for the first time. Considering all the items in Round 2 had reached consensus, the implementation of Round 3 was merely to validate the panel's responses on the additional items (contained in Round 2 questionnaires). In Round 3, it was found that consensus from the experts was achieved for all the items and hence the Delphi round stopped (Delbecq, Van de Ven, & Gustafson, 1975).

9. Delphi Data Analysis

Immediately after forming the Delphi panel, every member of the Delphi panel was contacted whether face-to-face, or via telephone and email. The panelists were given brief explanation regarding the research objectives and the expectation from them. This included giving access link to the research instrument website. In actuality, the expert panel has the flexibility to give their responses online or using printed questionnaires or using questionnaires in the form of MSWord attached in the email. The Delphi panel was given seven days to answer the questionnaires for Round 1. Two days before the due date of giving Round 1 response, a reminder email was sent by the researcher to remind the panel members about their incomplete tasks. However, the duration was extended for another three days to wait for the responses from the panel members who were unable to return the questionnaires in time. All the feedback and comments collected in three Delphi rounds were recorded. The quantitative data was analysed using Statistical Package for Social Sciences (SPSS) v. 16 and MS Excel.

The degree of importance and consensus are justified after each Delphi round before making interpretation. The group response median value and the inter quartile range distribution are usually referred as the reference for the degree of importance and consensus in the past research (Norizan, 2003; Saedah & Azdalida, 2008; Ahmad Sobri, 2009). For the example of this study, the analysis of consensus data of the experts was done based on median, inter quartile range and quartile deviation on Round 1 data, Round 2 data and Round 3 data.

After the median value, inter quartile range and quartile deviation are identified, the subsequent analysis technique is classifying items according to the consensus level and importance level. For this study, the consensus level is divided into three levels (high, medium and no consensus) and importance level is divided into two levels (very high and low). To determine the consensus level which are: high (if quartile deviation is less than or equal to 0.5), medium (if quartile deviation is in between 0.5 and 1) and no consensus (if quartile deviation is more than 1); and the importance level which are: very high (in which the median value is 4 and above) and low (in which the median value is less than 3.5). For this study, items which obtained very high importance level and also high consensus level were used to develop ICT competency standard and ICT competency assessment criteria.

10. Reliability and Consistency of Experts' Responses

Young (2007) suggests that researcher can evaluate the consensus obtained in Round 1 and Round 2 to present to the panel as a measurement of reliability. If after Round 2, it is found that consensus has been achieved, it can then be assumed that researcher has done well on the summary of panel's feedback gathered in Round 1. With this method, researcher has concrete reason to support the assumption that the acceptable one reliability degree is fulfilled (Fish & Busby, 2005).

Consistency refers to the stability of response. For this study, the response pattern of local Delphi experts was observed in the perspective of response consistency between rounds. This is important for acceptable data reference quality or reliability. In the research of Ahmad Sobri (2009), the Wilcoxon Match-pairs Signed-ranks test was used to identify the consistency of experts' responses between rounds. This test was also used in this study for data between Rounds 1 and 2, Rounds 2 and 3.

11. Results and Discussion

The Delphi results of the study are presented in Table 1 and Table 2. Table 1 presents indicator statements found to be rated high importance and achieved high consensus level. These are items that achieved quartile deviation (Q.D) value of less or equal to 0.5 with median of 4 and above.

Table 1. Delphi Results: Indicators with High Importance Rating and High Consensus Level

Indicator	Median	Q1	Q3	IQR	QD
1: KNOWLEDGE IN ICT OPERATIONS					
1A – Show understanding and application basic ICT-related concepts and skills.	4	4	5	1	0.5
1B - Demonstrate constant development and enhancement in the latest ICT-related knowledge and skills.	4	4	4	0	0
2: PLANNING AND DESIGNING LEARNING ENVIRONMENT					
2A - Design and prepare suitable and relevant ICT-integrated lessons to cater to students’ diverse needs.	4	4	5	1	0.5
2C - Select and evaluate appropriate curriculum materials.	4	4	5	1	0.5
2D - Plan the usage and management of curriculum materials in lesson activities.	4	4	5	1	0.5
2E - Plan strategies to integrate ICT in lesson activities and manage student learning.	4	4	5	1	0.5
3: SMART PEDAGOGY					
3A - Use ICT assisted instruction to enhance students’ meaningful learning.	4	4	5	1	0.5
4: ASSESSMENT AND EVALUATION					
4A – Apply ICT in assessing student learning of subject matter using a variety of assessment techniques.	4	3	4	1	0.5
4C – Apply evaluation criteria to assess students learning, communication, and productivity.	4	3	4	1	0.5
5: LIFELONG PROFESSIONAL LEARNING, PRACTICE AND PRODUCTIVITY					
5A - Use ICT to engage in ongoing professional development and lifelong learning.	4	4	5	1	0.5
5B - Continuous evaluation and reflection on the use of ICT that supports meaningful learning.	4	3.5	4.5	1	0.5
5C – Apply ICT for “just in-time learning” (JIT) to enhance productivity.	4	3	4	1	0.5
5D - Use ICT to communicate and collaborate with colleagues, parents, and other communities to nurture student learning.	4	4	5	1	0.5
6: SOCIAL AND MORAL VALUES AND ISSUES					
6A - Understand the moral and ethical issues concerning the usage of ICT.	4	4	5	1	0.5
6B - Inculcate and practice moral values regarding ICT application.	4	4	5	1	0.5
6D - Promote and support safe and healthy use of ICT tools.	4	4	5	1	0.5
6E - Provide all students with fair equitable access to ICT resources.	4	4	5	1	0.5

A total of 17 indicators achieved high importance rating and high consensus level. It was found that all indicators that were proposed under 2 main categories: (i) knowledge in ICT operations, and (ii) Lifelong Professional Learning, Practice, and Productivity are regarded as important competencies for Science and Mathematics teachers.

Based on the number of indicators listed according to each main category in Table 1, the findings show that the emphasis is toward competencies related to the three main categories such as Planning and Designing Learning Environment (4 indicators), Lifelong Professional Learning, Practice, and Productivity (4 indicators), and Social, Moral Values and Issues (4 indicators). This followed by main category related to *Assessment and Evaluation* (2 indicators), except for category *Smart Pedagogy* which was rated 1 indicator for high importance and high consensus level.

Table 2 presents the items that achieved high importance rating with moderate consensus level. These items achieved quartile deviation values of more than 0.5 and equal to 1 with a median of 4 and above.

Table 2. Delphi Results: Items with High Importance Rating and Moderate Consensus Level

Indicator	Median	Q1	Q3	IQR	QD
2: PLANNING AND DESIGNING LEARNING ENVIRONMENT					
2B – Refer to contemporary ICT-related educational research in the preparation of lesson plans.	4	3	4.5	1.5	0.75
3: SMART PEDAGOGY					
3B - Employ ICT to support students' diverse needs in self-paced, self- assessed, and self-directed strategies.	4	3	5	2	1
3C – Apply ICT to develop critical and creative thinking skills.	4	3	5	2	1
3D - Manage student learning activities in an ICT instructed environment.	4	3	5	2	1
3E - Integrate ICT in various instructional strategies.	4	3	5	2	1
4: ASSESSMENT AND EVALUATION					
4B - Apply ICT to generate data on students' achievement, to interpret results and communicate findings; so as to improve instructional practice and to maximize students' learning.	4	3	5	2	1
6: SOCIAL AND MORAL VALUES AND ISSUES					
6C - Identify and discuss the impact of ICT on the society.	4	3	5	2	1

It was found that there are 7 indicators which achieved high importance rating with moderate consensus level. All these indicators are listed under 4 main categories such as Planning and Designing Learning Environment (1 indicator), Smart Pedagogy (4 indicators), Assessment and Evaluation (1 indicator), and Social and Moral Values and Issues (1 indicator).

The expert panel of this study agreed that teachers should be competent to refer to research in relation to ICT-based education for their lesson plan preparation, but this has only achieved moderate level of consensus based on the analysis report of the expert consensus views. It was explained that the reason behind this circumstance is due to this practice increases teachers' burdens when writing lesson plans.

Nonetheless, the expert panel acknowledged that it is important for teachers to possess the competency as the research findings are a good source for innovative ideas to ease the process of integrating ICT in teaching and learning activities.

The expert panel of this study affirmed that teachers should be competent in using ICT to support self-paced, self-directed, self-assessed learning among students and to inculcate independent learning, but this has only achieved moderate level of consensus based on the analysis report of the expert consensus views. It was explained that the huge student number per class is an additional burden for teachers. Nonetheless, the expert panel acknowledged that it is important for teachers to possess this competency.

It is interesting to note that though the expert panel agreed “*Apply ICT to develop critical and creative thinking skills*” is an important competency indicator, this has only achieved moderate level of consensus based on the analysis report of the expert consensus views. To view from different perspective, the expert panel of this study has exhibited high level of consensus that this competency is very important to be considered as a criterion in assessing teachers’ ICT competencies.

It is also interesting to note that though the expert panel agreed on the importance of teachers should be competent in using ICT to generate student performance data, interpret students’ results, communicate analysis and findings to improve students’ learning, this has only achieved moderate level of consensus based on the analysis report of the expert consensus views. There were opinions highlighted that the tasks should be taken over by Learning Management System (LMS), but the present system at school level is unable to generate student performance data automatically. Teachers still have to record the test marks by hand and prepare the report cards for parent signatures. Also, there were opinions indicated that this competency is only relevant if schools are equipped with LMS. Looking at the existing situation, this competency is not needed at present time.

From another aspect, the expert panel agreed that teachers should be competent in managing learning activities in ICT (3D) teaching environment and integrating ICT with different teaching strategies (3E). Teachers should also be competent in discussing the impacts of ICT toward society in the classroom (6C), but based on the analysis report of the expert consensus views all these three indicators have only achieved moderate level of consensus.

For the purpose of this study, these indicators were not considered in the development of ICT competency standard for Science and Mathematics teachers.

Based on the findings of this study, there was no item that achieved quartile deviation of more than 1 or the value of median which is less than 4. In other words, no items was rated not important or no consensus.

Only statements which achieved high consensus level and high rating were used in the establishment of the ICT competency standard for this study. After analyzing all the 24 indicators proposed in the preliminary research, the researchers are able to identified high importance with high consensus statements to be used in developing the ICT competency standard.

12. Limitations of the Study

The appointed Delphi panel experts for this study comprised of local Malaysian academics only. The number of Delphi rounds used for this study is only three rounds. Every round of the Delphi strategy is limited to only seven to ten days duration for responses from the experts. The results of this study cannot be generalized among all Science and Mathematics teachers in other nations.

13. Conclusion

This paper presents the research method from preparing the initial draft of ICT competency standard for Science and Mathematics teachers to the development process of the Delphi research technique instrument. It includes competency statements such as main category, competency indicators and items represent skills and competencies. Document analysis, exploratory interview, literature review and pilot study are all done for the purpose. Modification of the initial draft of competency statements is completed based on the round-table discussion. The draft of ICT competency standard and measurement items are finalized and the validity is obtained through the Delphi technique. Data is then analyzed to check for the consistency of experts' responses between rounds. Instrument developed from the Delphi technique research findings is also examined and it obtains validation from the experts in educational technology for the content validity and construct validity. The research procedure using the Delphi technique is rigorous and hence the developed research product is valid and reliable. This paper has provided a clear discussion on all aspects such as selection of expert panel, development of Delphi questionnaires and data analysis technique used to identify types of important ICT competencies to be mastered by school teachers. After the analysis of data using the Delphi technique, a set of ICT competency standard for teachers is developed together with a list of ICT competency assessment criteria for the Ministry of Education, organizers of ICT training programs and Science and Mathematics teachers.

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