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A Real-Time Web-Based Delphi Study on ICT Integration Framework in Basic Education

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Abstract. Strategies for ICT integration in the basic education sector have substantial educational and economic consequences. Many government efforts and private initiatives have been deployed, but the impact of ICT use remains difficult to measure and is open to much reasonable debate because the data to support these are still limited[10]. UNESCO 2003[12] has provided a matrix of performance indicators to measure the impact of ICT use in education. However, currently there is no framework that synthesizes the said matrix to help evaluate and assist the ICT integration of each school. Therefore, creating an ICT integration framework, while taking into account the expert opinions of all the stakeholders, is of great considerable interest. We asked 26 experts from the academe, industry, and government to anonymously participate in a "Delphi Conference" or real-time web-based Delphi with two aims: 1) determine the relative importance of the five (5) main indicators as established by UNESCO 2003 (Delphi I), 2) to determine the scale of importance of each sub-indicators along the stages of ICT integration (Delphi II). Delphi I consisted of three (3) rounds while Delphi II had two (2) rounds. Answers were compiled automatically and visualizations of the distribution among subgroups and among indicators were shown after each round. Eighteen experts, which consisted of 5 experts from the Academe, 6 experts from the Industry, and 7 experts from the Government, completed the study. Average Measure Intra-class Correlation Coefficients (ICC) were computed for each round (ICCs) using the two-way random ANOVA model and with absolute agreement as individual rater variability type. A consensus emerged at Round 2 of Delphi I with ICC=0.7 and at Round 2 of Delphi II with ICC=0.8. In particular, in Delphi I, indicator 1(ICT-Based Policy and Strategy) has the highest standard deviation, 6.51, while indicator 5 (Student Learning and Outcomes) has the lowest deviation at 4.42. This study has applied the Delphi technique to come up with the ICT integration framework which will be used to evaluate the ICT integration of each school, district, and division. A national survey is proposed to be conducted using the framework.

Keywords: ICT integration in education; Delphi technique; intra-class correlation coefficients;

1. Introduction

ICT integration is a response to an emerging shift of global economy from industry-based to knowledge-based[6, 1]. There is a need then that the future workforce is prepared to be globally competitive in a knowledge-based economy by increasing their skills and capacity [11]. Many government efforts and private initiatives tried to address ICT integration in the school level by carving out policies and strategies, providing computers and Internet access, giving trainings to teachers, or by adopting an ICT-based curriculum [16, 4]. However, it appears that ICT integration is still a challenge that remains to be addressed [10, 13]. This study uses the UNESCO 2003[12] performance matrix in evaluating the impact of ICT use in education to create an ICT integration framework that will be used to evaluate and assist ICT integration in schools.

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2. The UNESCO Performance Indicators for ICT in Education

The UNESCO 2003 [12], through a consultative workshop, established a set of performance indicators on the impact of ICT use in education. The five (5) indicators are: 1) ICT-Based Policy and Strategy, 2) ICT Infrastructure and Access, 3) ICT-Based Curriculum, 4) Teaching Professionals Use and Teaching, and 5) Student Learning and Outcomes. Each indicator has a number of sub-indicators which reflects the aspects to be considered. Furthermore, each sub-indicator has an actual number of measurable entities. Table 1 shows the list.

TABLE 1. Number of Indicators, Sub-indicators and Measures

Main Indicator	Number of Sub-indicators	Number of Measures
1	3	8
2	3	15
3	3	3
4	6	7
5	5	5

3. ICT Integration Frameworks

One existing tool that can help assess ICT integration is the CEO STaR Chart[2], which "is a guide, not a definitive measure, of a school's effectiveness in integrating technology into the teaching and learning process." It identifies and defines four school profiles ranging from the school with "Early Technology" to the "Target Technology" school that fully integrates technology throughout the curriculum. It has four (4) main indicators: hardware and connectivity, professional development, digital content, and student achievement and assessment. Another framework is the UNESCO 2003[12], which has 5 main indicators and a comprehensive list of sub-indicators (the set of indicators adopted in this study), however, it did not define stages of ICT integration. UNESCO 2008[11] also established competency standards for teachers. It contains 6 main indicators: policy and vision, pedagogy, ICT, organization and administration, teacher professional development, curriculum and assessment; and 3 stages: technology literacy, knowledge deepening, knowledge creation. These stages were adopted in this study.

We make use of the UNESCO 2003 indicators and identify three stages of ICT integration (adopted from UNESCO 2008), which are: ICT Literacy-Driven, ICT Knowledge Application-Driven, and ICT Knowledge Creation-Driven. This completes the framework needed to specify development pathways to guide and assist each school through the different stages and various contexts of the ICT integration process as recommended by [16].

4. Overview of the Delphi Technique

The history of the Delphi technique started in Rand Corporation in the 1950s as a way to get an "expert opinion to the selection, from the point of view of a Soviet strategic planner, of an optimal U. S. industrial target system and to the estimation of the number of A-bombs required to reduce the munitions output by a prescribed amount"[8]. Since then, this method has been used widely in situations "when accurate information is unavailable or expensive to obtain, or evaluation models require subjective inputs to the point where they become the dominating parameters"[8].

Linstone, et al[8] defines Delphi as a "method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem." Some sample researches are in the development of curriculum [7, 17, 14], and determining research priorities [14] among others.

Strictly there are two forms of the Delphi method: 1) conventional Delphi which uses paper and pencil/electronic email just like any traditional surveys, and 2) real-time Delphi sometimes called "Delphi Conference" which automates compilation of group results in each round. This latter approach has the advantage of eliminating the delay caused in summarizing each round of Delphi, thereby turning the process into a real-time communications system [8]. A usual Delphi process involves these four (4) phases: 1) exploration of the subject, 2) reaching an understanding of how the group views the issue, 3) explore

disagreement, and 4) feedback for consideration. This is done while preserving anonymity throughout the whole iterative process.

In this study we implement a real-time and web-based Delphi. This saves time and enables immediate interaction among the experts.

5. Methodology

5.1. Selection of Participants

A crucial element in the Delphi method is the selection of experts for the study conducted since the results depend not on statistical power as in the case of traditional surveys [9]. Pawlowski, et. al.[9] suggested a process in the selection of the participants, which this study has adopted. Since education is a joint effort of three major stakeholders, namely: academe, government, and industry; hence, we invited experts from each sector. It is also important that each sector will have an equal number of representatives in the final expert panel. We asked 26 identified experts in all sectors. The invitations were then sent through electronic mail or fax. Phone calls were made to ascertain that they received the invitations and to ask their confirmation. This was done a month before the actual Delphi study.

Of the 26 identified experts, 18 of them were able to make it on the actual Delphi study. Of this final list, five (5) come from the academe, six (6) come from the industry, and seven (7) from the government sector. This size of the Delphi panel is enough to come up with reliable results [9].

Since this is an on-site and web-based Delphi, experts were invited to a specific place one afternoon where they gather and exchange their comments and votes online.

5.2. Delphi Rounds

This study makes use of two Delphi sub-studies to come up with a detailed framework.

The objective of the first Delphi sub-study (Delphi I) is to distribute 100% to the five (5) main indicators of the UNESCO 2003[12]. The percentage given to each indicator reflects its relative importance in the whole framework according to each expert. The answers of all experts were averaged to get the final percentage for each indicator after the group has come to a consensus.

The objective of the second Delphi sub-study (Delphi II) is to identify the relative importance of sub-indicators in each stage of ICT integration. The experts rate the importance of the sub-indicator, indicate the percentage, or select the appropriate threshold requirement at each stage.

Delphi I consisted of three (3) rounds while Delphi II consisted of only two (2) rounds. On the first round, the participants were presented with the indicators or sub-indicators which they were to rate. For Delphi I, they can put their comments on why they choose that certain percentage distribution among the indicators. On the 2nd and 3rd rounds, the following elements were shown to the participant: his/her previous answer, the group answer (average), comments of each expert (in the case of Delphi I). For the Delphi I, other data visualizations were also shown in order to aid their decision such as percentage distribution among sectors, box plots to show distribution of individual answers, and juxtaposed group and the expert's answer.

5.3. Defining Consensus

The main question in Delphi studies is: How do you know if the group has already arrived at a consensus? Most of the researches[14],[15] use quantitative and statistical measures such as mean, median, mode, standard deviation, skewness index, interquartile range, and rank. Depending on the area of research, usually researchers define their own consensus criteria such as: items that did not receive "strongly disagree" from any member of the panel [7], when at least 75% of the participants rate any competency or course item as Very Important (4) or Important (3) on a four-point scale[3].

This study uses Intra-class Correlation Coefficients (ICC) [5] particularly the two-way random average class measures ICC (2, k) together with the other statistical measures: mean, standard deviation and median. The concise formulation of ICC (2,k) is given as[5]:

$$ICC(2,k) = \frac{BMS - EMS}{BMS + (JMS - EMS)/n}$$

,where n targets are rated by k judges. BMS refers to between-targets mean square, EMS refers to error mean square and JMS refers to judges mean square.

Intraclass Correlation literature suggests different thresholds according to the need of the research but most are in the range of 0.7 to 0.9. In this study, we used 0.7 as the consensus threshold.

5.4. The Delphi Web Application

This section describes and discusses the functions the Delphi web application provides.

The first function is the account security through the use of passwords. This feature is necessary in Delphi method to preserve anonymity among the participant-experts. Each participant was provided with a six-letter password with the first three letters indicating their subgroup and the rest a random combination of letters (e.g. “acdmeu”, “gvtpba”, “induxy”).

The second function provided by the application is the use of comment system for the participants to support their choice in each round with an explanation. This feature distinguishes this Delphi implementation from a survey because the former’s iterative nature is intended to go deep into the reasons of the participants’ choices while making anonymous interaction possible among participants.

The third function concerns the controlled feedback to the participants as included in any Delphi implementation. In this study, all the feedbacks were displayed in the form of group averages, subgroup percentages, and percentage distributions among indicators along with the comments. We made use of the Google visualization libraries to create the dynamic charts.

The user interface was constructed using the jQuery UI library which provided Ajax facility. The whole application was developed in PHP and the database in MySQL. An administration system was also developed for the control of the Delphi rounds. Audit trail was implemented in the database for each round of the Delphi sub-studies to monitor every change made by the participants within a round and their final answers in each round.

6. Results and Discussion

This section is divided into two Delphi sub-studies but they form the one ICT integration framework with differences only in the level of detail.

6.1. Delphi I

There were three rounds in this Delphi sub-study. The question pertains to the percentage distribution to the 5 main indicators cited by UNESCO 2003. The goal of the participants is to distribute the 100% among these five (5) indicators based on their expert opinion. Table 2 shows the statistical summary over three rounds.

TABLE 2. Statistical Measures of Delphi I in 3 Rounds

Indicator	Mean			SD			Median		
	1	2	3	1	2	3	1	2	3
1	18	19	20	6.99	6.51	6.11	20	20	20
2	24	24	24	5.46	5.33	5.06	25	25	25
3	18	17	18	5.66	4.93	4.83	20	20	20
4	21	20	19	6.13	5.35	4.77	20	20	20
5	19	20	19	5.06	4.42	4.66	20	20	20

Among the three rounds, Round 2 has the highest ICC value=0.7, which lies in the threshold boundary, meaning it is the round where the consensus emerged among the participants as shown in Table 3.

TABLE 3. ICC Values in each round

Round	1	2	3
ICC	0.6	0.7	0.6

The standard deviation of Round 2 shows that the experts vary in their answers mostly in the first indicator: ICT-Based Policy and Strategy while they vary least with one another on the last indicator: Student Learning and Outcomes. It is also noticeable from Table 2 that the median values stayed the same for all indicators in all rounds.

Figure 1 shows the actual distribution of answers in the form of a box plot, showing the 5 quartiles (i.e. 0th, 25th, 50th, 75th, 100th). The large standard deviation of the ICT Policy indicator is visually evident in the box plot. The extreme values were considered outliers (i.e. 0 and 50) and were excluded in the ICC computation. Figure 2 shows the average percentage of subgroups in each indicator which reflects the internal consensus among them.

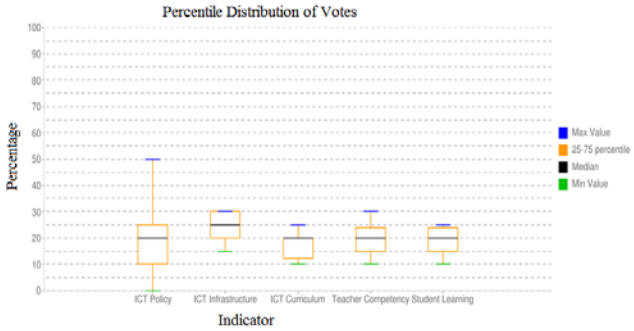

FIGURE 1. Box Plot Distribution of Votes in Delphi I Round 2

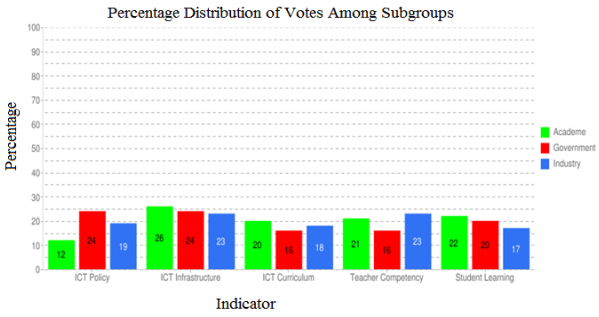

FIGURE 2. Percentage Distribution of Votes among Subgroups in Delphi I Round 2

The vote percentage distribution is explained in their comments. The academe subgroup sees ICT infrastructure as the primary mover in the ICT integration process while the curriculum, teacher competency, and student learning were seen as more of variable indicators. The low percentage they gave to the ICT Policy is also observable. The government subgroup, however, places ICT Policy as equally important with the ICT infrastructure. One of the comments said that the other indicators will necessary follow once the ICT Policy is in place. The industry subgroup places emphasis on the concerted effort among stakeholders. It recognizes the importance of the ICT infrastructure and Teacher Competency over others. One comment said that bigger emphasis should be focused on the mentioned two because they form the building blocks for the other indicators (e.g. Student Learning hinges on Teacher Competency and ICT Infrastructure).

6.2. Delphi II

This Delphi sub-study is intended to refine the expectations at each stage of the ICT integration process. Each indicator has sub-indicators which narrow down specific aspects to be considered. The participants answered different type of questions ranging from scale of importance, percentage allocation, absolute values, and ideal frequencies. The consensus emerged in Round 2 with ICC=0.8, while in Round 1 the ICC value only reached 0.4. The outliers were handled accordingly. Following the logic of increasing sophistication across the stages, answers with the inverted pattern were replaced with the value in the highest stage. If the percentage of teachers with pre-service training is expected to increase from stage 1 to stage 3, then if answers were instead going down from 40% , 30%, 20% from stage 1 to stage 3, respectively, then the stage 1 and 2 answers were replaced with 20%. This may have resulted from an unguided criterion. Nevertheless, with this method of handling outliers we have preserved the intention of the experts.

7. Conclusion and Recommendations

This study has applied the Delphi technique to come up with an ICT integration framework. The experts reached a consensus for the whole ICT integration framework with ICC= 0.7 in Round 2 of Delphi I and ICC=0.8 in Round 2 of Delphi II, respectively. A pilot survey will have to be conducted to test the framework and an implementation model will have to be crafted for the pilot schools. A national survey is proposed to be conducted using the framework. This can be used to evaluate the ICT integration of each school, district, and division.

8. Acknowledgements

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