Integrating ICT in Engineering Education in Universities: Teacher's knowledge Perspective in Bangladesh

BY

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DECLARATION

This is to certify that the work presented in this thesis is the outcome of the investigation carried out by Mugigayi Fahadi under the supervision of Dr. Md Shahadat Hossain Khan in the Department of Technical and Vocational Education (TVE), Islamic University of Technology (IUT). Gazipur, Bangladesh. It is hereby declared that this thesis/report or part of it has not been submitted elsewhere for the award of any Degree or Diploma.

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DEDICATION

I dedicated this work to Allah (S.W.A) without whose support I would have been nowhere and then to my son, parents, brothers, sisters and friends for their concern and backing throughout. May the almighty Allah count the support they have been rendering to me upon their heavenly treasures, AMEEN!

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ACRONYMS

ABBREVIATION	ACRONYM
ICT	Information and Communication Technology
TPACK	Technology Pedagogy and Content Knowledge
TK	Technology Knowledge
PK	Pedagogy Knowledge
CK	Content Knowledge
PCK	Pedagogy Content Knowledge
TPK	Technology Pedagogy Knowledge
TCK	Technology Content Knowledge
TVE	Technical and Vocational Education
CSE	Computer Science and Engineering
EEE	Electrical and Electronic Engineering
CEE	Civil and Environmental Engineering
MCE	Mechanical and Chemical Engineering
BTM	Business and Technology Management
IPE	Industrial and Production Engineering
TE	Textile Engineering
SPSS	Statistical Package for the Social Sciences
MOOCS	Massive open online courses
LMS	Learning Management Systems
DB	Digital Bangladesh
EE	Engineering Education

ABSTRACT
Governments, Non-Government Organizations and Universities have heavily invested and advocated for use of Information and Communication Technologies (ICTs) in Higher Institutes of Learning (Universities). However, there is inadequate evidence that shows that ICTs have been integrated effectively in the teaching and learning process. This study (thesis) investigates the Knowledge attributes that a University Teacher need for effective use of ICTs in their Content and Pedagogy practice in Bangladesh Engineering Universities. The Technological Pedagogical and Content Knowledge (TPACK) framework has been frequently used for this purpose in lower levels of education (Primary and secondary) but it's application in Engineering Education at tertiary education level has been limited. The objectives of the study are to confirm whether TPACK framework can be applied in engineering education at Universities, analyze the knowledge competencies needed by a university teacher in order to use ICTs in educational context and study key attributes of teachers for effective integration and use of ICTs in Engineering Education. A self-assessment tool was administered to 136 teachers in Engineering field teaching two Engineering Universities. The results of the study confirm the applicability of the framework and reveals significant differences in technology and conventional knowledge regarding academic discipline of the teacher and significant difference in technology enhanced teaching in regard to the age group to which the teacher belongs. The study thus contributes to the knowledge discipline regarding use of technology to enhance teaching and education.

1 Chapter One: Introduction

1.1 Background

Deployment of technology to support learning has exponentially increased in recent years (Casey, Goodyear, & Armour, 2017). For over 25 years, Information Communication Technology(ICT) in higher education has been promoted as having the potential to transform teaching and learning (Englund, Olofsson, & Price, 2017). Many universities around the global have embraced ICT as a key component to enhance teaching and learning (Cubeles & Riu, 2018; Kirkup & Kirkwood, 2005) and to offer diverse learning experiences through different technologies, such as Learning Management Systems (LMS) used to organize course content and to provide many learning opportunities (Ain, Kaur, & Waheed, 2016), flexible course deliveries: Massive open online courses (MOOCs) (Yuan, Powell, & CETIS, 2013), Virtual labs (Abdulwahed & Nagy, 2011) that allow simulations of a physical experiment, Serious games (SGs) that engage and retain learners' attention (Callaghan, Savin-Baden, McShane, & Eguiluz, 2017). Thus, ICT provides new and simplified ways of representing and delivering teaching and learning in higher education.

Despite the above benefits offered to higher education, there is little evidence of effective integration/use of ICT in teaching and learning process. Successful integration occurs when teachers focus their attention on the actual teaching and learning experiences, opportunities provided by ICT rather than the technology resource (Cubeles & Riu, 2018; Hue & Ab Jalil, 2013). In order to tackle the above challenge, firstly, there is need for both preservice and in-service training of teachers with current trending technologies, and secondly, need to have a conceptual framework that can help a teacher acquire the knowledge, competences and skills necessary for effective integration/use of ICT in teaching and learning. Any debate about effective integration/use of ICT in teaching and learning should focus on the role of a teacher given the argument that he/she has a significant impact (influence) on learners and their learning (Hargreaves & Fullan, 2012; Hattie, 2012) thus it is important that teachers are at the forefront of reform efforts to improve technology enhanced teaching and learning.

Clark (1995) stated that "Teachers are the human point of contact with learners, all other influences on the quality of learners are mediated by who the teacher is and what the teacher does" p.3. In this era where the content and methods in which it's delivered to learners is drastically shifting from the traditional ways towards digitalization of the content and presented in an electronic form raises the need to evaluate the knowledge required by the teachers to effectively integrate ICT into their teaching practice due to the position and role that they play in the learners' learning.

While Technology is celebrated for its astonishing and abounding creativity, it has been argued that innovation in its use in education has been stagnated (Fullan, 2013). He further points out that few teachers are able to incorporate ICT into pedagogical context in purposeful ways that enhance their teaching practice. Sipilä (2014) experimented that almost half of teachers feel under prepared to use ICTs infrastructure to support their teaching and learning methodologies while (Kretschmann, 2015) carried out a small scale study in German involving teachers of Physical and Health Education and results revealed that teachers are resistant and struggle to integrate ICTs in pedagogically sound ways. Therefore, it is necessary to understand, i) the different forms of knowledge that a teacher has to possess in order to use ICT resources in a way that promotes and simplifies teaching and learning. ii) how these different forms of knowledge interact to achieve technology enhanced teaching and learning.

In 2017 alone, 178,220 high school students in science stream graduated (Database, 2019) while the higher education system only accepts 10,000 students in undergraduate engineering programs in Bangladesh (Chowdhury, Alam, Biswas, Islam, & Islam, 2013). Government has since 2011 spearheaded a major drive/vision called Digital Bangladesh (DB) where it presented four pillars of Vision DB(Islam & Grönlund, 2011). The four pillars are:

1. Developing Human Resource to be ready for the 21st Century.
2. Connecting the citizens.
3. Automating government administration and services to the citizens.
4. Making private sector more productive and competitive through use of ICT(Karim, 2010).

With effective integration of ICT in engineering education in Bangladesh Universities, Teachers can create innovative and engaging methods of teaching and learning so that teachers can find better and simpler ways of delivering knowledge to the ever increasing number of students.

Although most institutions of higher learning in Bangladesh are far away from implementing ICT into their teaching and learning context, there are a significant number of institutes in big cities that have ICT facilities although they have not effectively integrated them due to lack of proper vision and plan (Khan, Hasan, & Clement, 2012). This integration is associated to the actions taken at school level in general, pre-requisite requirement of the academic staff (teachers) like their attitudes towards use of ICT in education context and their role in effective integration of ICT in educational environment in particular.

The purpose of this study was to analyze the relationship between variables of university teachers and their degree of technological pedagogical content knowledge (TPACK). In order to achieve this purpose, the following research questions were addressed:

1. What kind of knowledge domains does an engineering university teacher need to possess in order to effectively achieve Technology enhanced teaching?
2. What is the relationship between a teacher's attributes and his degree of TPACK knowledge?
3. is the TPACK framework applicable in engineering education in Bangladesh universities?

2 Chapter Two: Literature Review

2.1 Related Literature

Science and Engineering Education (EE) is known to enable economies progress in this era of globalization without having natural resources of their own. Chowdhury and Alam (2012) argues that EE is more for developing countries than developed countries as the former cannot break the vicious cycles of poverty if its population is not educated in science, engineering and technology. He further states that they should invest heavily in technical and engineering education in order to progress socio-economically.

Globalization and mobility has created unique opportunities for flow and exchange of Technology, Knowledge, Trade etc. thus EE has become part of this globalization as engineering graduates from one country can find employment in another country. This globalization has created the need for quality assurance and standardization (Chowdhury et al., 2013).

(McGaw, 2008) argues that “change on a global scale is required to equip students of today with the skills they need to succeed in the workforce of tomorrow” (p. 1). This further emphasis on the global convergence of labour markets therefore giving rise to the need of developing policies, expectations and standards for using technology as a tool to prepare future workforce capable of satisfying the 21^{st} C labour demands. Therefore, TPACK framework is the total package for teaching in the 21^{st} C. However, most of the curricular used in teaching Engineering in higher institutes of learning was developed in 20^{th} Century using (Shulman, 1987) PCK framework without consideration of technology knowledge which is necessary attribute of a professional teacher teaching EE in the 21^{st} C (Finger, Jamieson-Proctor, & Albion, 2010).

In developing countries, teachers hardly cover the syllabus as outlined in the curriculum (Glewwe & Muralidharan, 2016). This may be due to a number of factors that are common in the higher education context of developing countries like low rates of actual attendance masked by high rates of enrollment. (Glewwe & Muralidharan) points out that greater use of technology in education context is necessary to improve effectiveness of pedagogy thus rapid improvement in education outcomes. However, introduction of technology into education context is not a matter of mere adding technology domain into the existing pedagogy and content model. It requires creative strategies (Mishra & Koehler, 2006) of combining the three base knowledge domains by the teacher hence, there is no single universal technology solution that works for every teacher, subject and teaching and learning situation (Lye, 2013). Therefore, there is need to understand which kind of knowledge a teacher needs to effectively use technology in his teaching and learning practice, how the different knowledge domains interact and finally how the different attributes of a teacher affect his or her degree of TPACK knowledge.

Research has identified a number of strategies that can successfully contribute to developing the competences teachers need to integrate ICTs in teaching and learning (Tondeur et al., 2012). However, the ways in which these strategies may ultimately contribute to ICTs integration in higher education remain highly under explored (Tondeur, Pareja Roblin, van Braak, Voogt, & Prestridge, 2017). Many new teachers use technology as a preparation tool with only a few using technology as a pedagogical tool while experienced teachers have more time and resources to explore the educational value of ICTs and apply it to their already developed pedagogical knowledge (Tondeur et al., 2017). He further, noted that ICTs should be infused into the entire higher education curriculum so that teachers understand the educational reason and value of ICTs thus experience how ICTs support their teaching and learning.

2.2 The TPACK Framework and application in higher education Context.

Since the inception of the TPACK notation by M. Koehler, Mishra, Yahya, and Yadav (2004) in the bid to find ways of integrating technology in educational processes, much of the focus of the framework was directed towards primary and secondary education. However, due to the potentials that the framework offers, researchers picked interest in further applying the framework to higher institutes of learning. Cubeles and Riu (2018) extended the application of the model to the university setting and provided insights into different variables that affect TPACK knowledge of a university professor.

To develop the TPACK framework, M. Koehler et al. (2004) expanded on (Shulman, 1987) theory of Pedagogical Content Knowledge (PCK) by introducing Technology Knowledge into the framework. (Shulman, 1987) framework illustrated different knowledge base that an individual teacher has to possess in order to be able to effectively teach and the interdependence between the knowledge bases. The PCK framework suggests that teachers should not only understand the pedagogical knowledge and cram subject matter or content, but also should have skills and strategies that he or she can use to transform understanding, desired attitudes or values into pedagogical representation and actions on both students and the content, meaning the interaction between pedagogy and the curriculum. Based on this foundation, M. J. Koehler and Mishra (2005) developed TPACK framework to explain the knowledge that a teacher needs to possess in order to introduce technology into his or her teaching practice. Therefore, the importance of the framework lies in the interaction and interdependence of the three base knowledge constructs i.e. Content knowledge (CK), Technological knowledge (TK) and Pedagogical Knowledge (PK). Thus, to create a teaching dispersion approach and educational knowledge pool, teachers need more than the three base knowledge constructs. They have to visualize and understand how the three base knowledge constructs interact with each other to give rise to more three secondary knowledge constructs i.e. Technology pedagogy knowledge (TPK), Technology content knowledge (TCK) and Pedagogy content knowledge (PCK) and last knowledge construct as a result of the three secondary knowledge interactions Technology, Pedagogy, Content Knowledge (TPCK). Hence the seven knowledge constructs of TPACK framework (M. J. Koehler, Mishra, & Cain, 2013) as illustrated below.

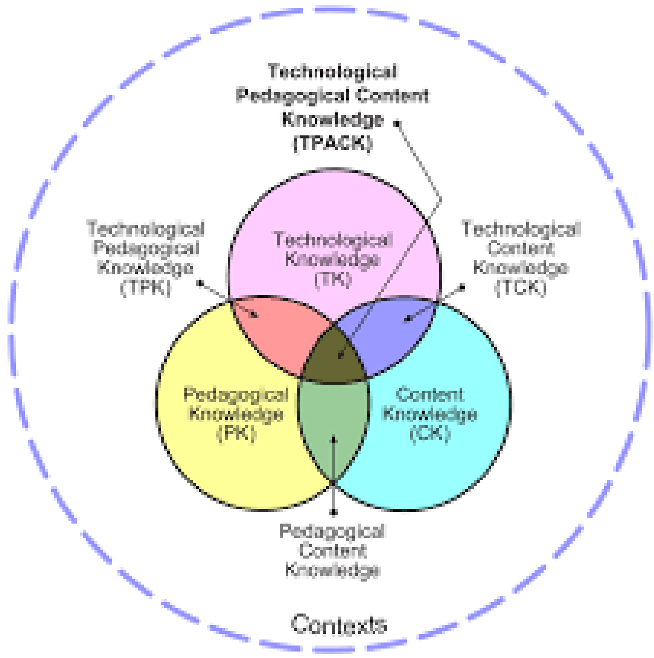

Figure 2-1. Graphical representation of TPACK Framework and its Knowledge Constructs. Adapted from (Mishra & Koehler, 2008) p.3

Knowledge of specific hardware and software is needed to enable a teacher understand the options from which he/she may select and perform them efficiently (Technical knowledge) for specific domain in the curriculum (Technological content knowledge). Knowledge of the features of ICT- rich learning resources is important because it allows the teacher to distinguish the qualities and affordance of specific tools in light of pedagogical (Technological pedagogical knowledge) and domain specific learning (Technological content knowledge) goals. Knowledge of how to use technology rich curricular resources is necessary for teachers to be able to employ ICT in pedagogically meaningful ways to achieve learning in specific content areas (Technology Pedagogy Content Knowledge, TPACK) (Voogt & McKenney, 2017). TPACK is essential for enabling teachers to integrate ICT in their teaching practice as it enables them to select and use hardware and software, identify the affordance of specific features and use the tools in pedagogically appropriate and effective ways.

The adoption of ICTs by teachers is however a complex process influenced by many factors both extrinsic and intrinsic (Price, 2013). For effective integration of ICT, Teachers need to bridge the gap between knowledge of pedagogical practice, Technical skills and content knowledge (M. Koehler & Mishra, 2009; M. J. Koehler et al., 2013). A search in academic repository on studies involving integration of ICT in higher education and TPACK in particular reveal that “Limited research is available in a higher education context” (Rienties, Brouwer, & Lygo-Baker, 2013, p. 124). Some of the available studies point out lack of universal satisfaction in regard to integrating new technologies into higher education (Reyes Jr, Reading, Doyle, & Gregory, 2017). Other significant findings on TPACK in higher education highlights the independence of technology knowledge (TK) and technology enhanced teaching (TPACK) (Benson & Ward, 2013; Blackburn, 2014; Cubeles & Riu, 2018) and a strong association between pedagogy content knowledge (PCK) and technology enhanced teaching (TPACK) (Alzahrani & Cheon, 2015). To study the role of a teacher in integrating technology in teaching and learning practice, only a couple of studies have been carried out despite the difference in teaching context and professional goals set by the university teachers different from secondary and primary teachers (Alvarez, Guasch, & Espasa, 2009; Reyes Jr et al., 2017). Kinchin, Lygo-Baker, and Hay (2008) points out that university teachers “academics are required to consult discipline-specific literature on teaching and learning, focusing reflection on specific areas of one’s practice, focusing teaching on students and learning and publishing results of teaching initiatives through peer review mechanisms” (p92).

Therefore, University teachers face a lot more challenges when integrating technology into their teaching practice (Reyes Jr et al., 2017) as they have to adapt new teaching approaches and content to fit available technology resources while upholding discipline-specific literature style and culture. Cubeles and Riu (2018) investigated the knowledge required by professors to integrate ICTs in Spanish Universities and recommended future research to be carried out in different geographical areas.

The focus of this research is another set of studies which analyses and evaluate the variables of a university teacher and his/her knowledge in respect to TPACK framework (Alzahrani & Cheon, 2015; Blackburn, 2014; Cubeles & Riu, 2018). Most results in this study field show that the level of TPACK knowledge of a teacher is not affected by his/her field of specialization (Alzahrani & Cheon, 2015; Lye, 2013). When age group to which a given teacher belongs is analyzed, results found show that TPACK knowledge of a teacher is not affected by the age group to which he/she belong (Cubeles & Riu, 2018) although some studies found contradictory findings when age group and TPACK constructs were analyzed (Alzahrani & Cheon, 2015; Blackburn, 2014) . Therefore, our research questions are:

1. What kind of knowledge domains does an engineering university teacher need to possess in order to effectively achieve Technology enhanced teaching?
2. What is the relationship between a teacher's attributes and his degree of TPACK knowledge?
3. is the TPACK framework applicable in engineering education in Bangladesh universities?

A critical factor in the successful integration of ICTs in higher education is the knowledge of the teacher to know why, when and how best to implement ICTs in his teaching practice (Krumsvik, 2014). Very little attention is specifically given to the knowledge that teachers need to effectively integrate ICTs in their teaching and learning (Voogt & McKenney, 2017). Therefore, even when ICT applications have proved effective in isolation, it does not imply that the same effects are realized in natural educational environments. Empowering teachers for effective integration of ICTs implies that teachers need to understand how to shape instructional practices in which technological, content and pedagogical knowledge are embedded.

3 Chapter Three: Methodology

3.1 Research Design

This study was a quantitative type of research and a descriptive survey method was used to investigate the knowledge required by university teachers in order to incorporate ICTs into their teaching practices. A questionnaire is considered an appropriate tool as recommended by Johnson in (Johnson & Christensen, 2008). Similarly (Bernard & Bernard, 2012; W Lawrence Neuman, 2014; William Lawrence Neuman & Kreuger, 2003) recommended that in a descriptive survey involving beliefs, it is appropriate to use questionnaire for data collection, because it allows the respondents to easily express their perception.

3.2 Research participants

In this research study, a purposive sampling was used to select two Engineering Institutes of choice Islamic University of Technology (IUT) and Dhaka University of engineering and Technology (DUET)and 110 teachers from each of the selected Institutes to make a sample of 220. Cubeles and Riu (2018) carried out a similar research where the sample size was 114 participants therefore, the sample of 220 is acceptable. The selection process of the participants and their participation in this study required the approval of all institutes involved. Each of the participants was given a questionnaire, participant information statement form (appendix -C) and ample time to respond to the questionnaire voluntarily. These questionnaires were filled while teachers were not teaching in order not to disrupt their regular teaching activities and some received it from their emails. All the participants' information was reserved as confidential and remained anonymous.

3.3 The research tools

A questionnaire adapted and modified from (Chen & Jang, 2014; Schmidt et al., 2009) was used for collecting data from the target population. The questionnaire was divided into two parts with closed-ended questions; the first section involved questions on the demographic data, background characteristics; the second section includes statements about Technology Knowledge (TK) - 7 items, Pedagogy Knowledge (PK) - 6 items, Content Knowledge (CK) - 3 items, Pedagogy Content Knowledge (PCK) - 4 items, Technology Content Knowledge (TCK) -3 items, Technology Pedagogy Knowledge(TPK) - 4 items, and Technology

Pedagogy Content Knowledge (TPCK) - 4 items that comprised total 31 items (Appendix - A) . The responses were on a Likert type scale, ranging from 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

3.4 Data collection procedure

The questionnaire was designed using an online tool called Google forms. The researchers shared a link to the google form with the respondents via email addresses obtained from university computer centers with authorization from the academic registrars' office. However, it's important to note that an equal amount of printed questionnaires was availed to respondents so that they could choose the means that were more favorable to them. Along with that, the data collection process followed ethical requirements of the Islamic University of Technology (IUT) and Dhaka University of engineering and Technology (DUET). Being an online form, all responses were received in real time upon the completion of the form by the respondents. A number of studies have used online questionnaires to collect data which have yielded good results (Habibi et al., 2015; Lakhal, Khechine, & Pascot, 2013).

In the study, a total number of 220 questionnaires were emailed and distributed among respondents from Islamic University of Technology (IUT) and Dhaka University of engineering and Technology (DUET)A total of 136 (61.8%) fully completed questionnaires were returned, of which 46 (33.8%) filled using the offline tool (Hard copy) of the questionnaire and 90 (66.1%) filled using the web tool (Google forms) as illustrated in a table below:

Table 3-1. Questionnaire Return Rate

Number issued out	Number returned	Percentage
220	136	61.8%

The table shows that the response rate was 61.8% of the targeted respondents. The researcher is confident that the views expressed in the report is a representative of the target population(Tse, 1998).

4 Chapter Four: Results

4.1 Introduction

The data collected by the questionnaire was managed and analyzed using IBM **Statistical Package for the Social Sciences** (SPSS) version 20 for windows. Separate tables and graphs were prepared for different parts of the questionnaire and each table and graph was followed by their own interpretation. A quantitative approach using different statistical methods was used for analyzing the data collected from the structured questionnaire. An Exploratory Factor Analysis (EFA) was carried out to decide the final number of factors and Cronbach Alpha test was carried out to evaluate the reliability of the entire questionnaire and each TPACK Domain. The matrix of correlations with Pearson's correlation coefficient (r) was used to analyze the degree of association between different domains of the TPACK model.

4.2 Response to Demographic data

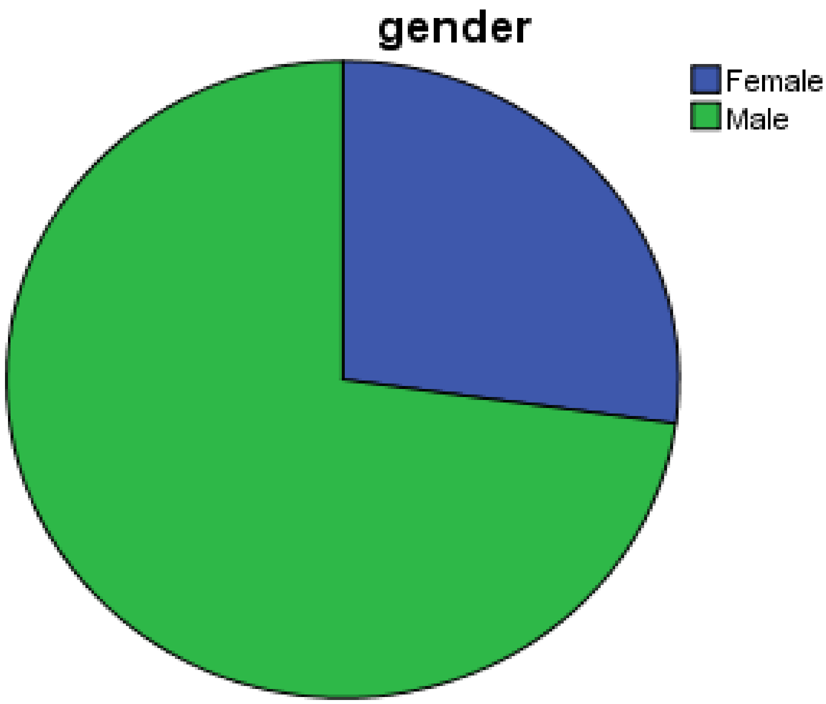

Figure 4-1 Pie Chart showing Gender

The table 4.1 represents the Gender demographic information of the university teachers. Out of 136 respondents, 99 (72.8%) were males and 37 (27.2%) females.

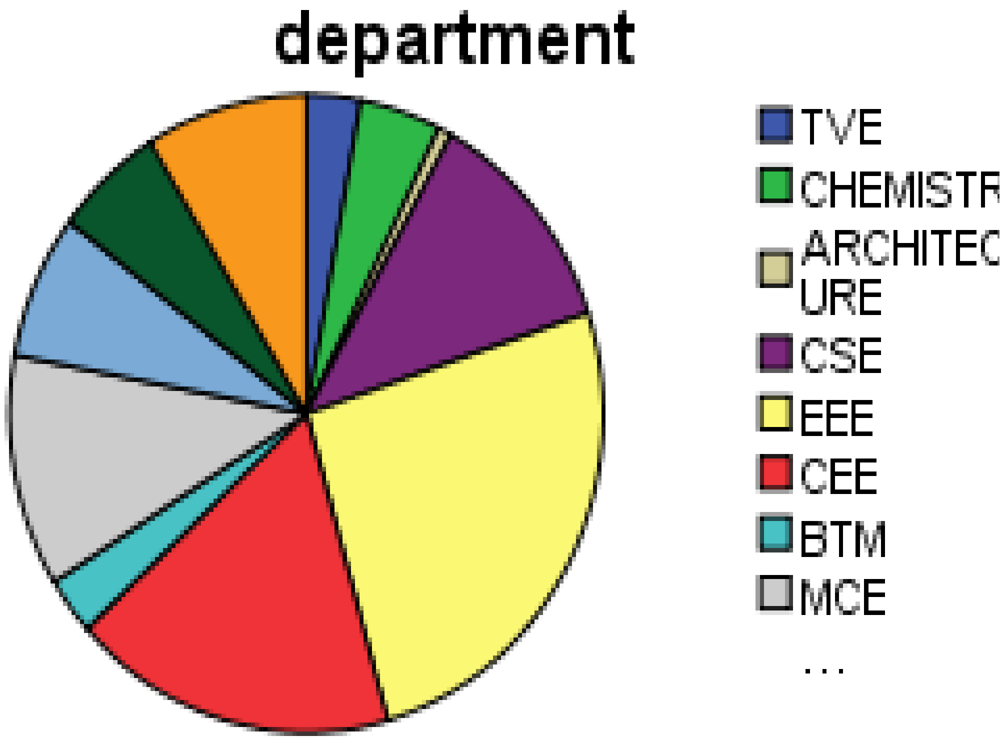

Figure 4-2 Pie Chart Showing departments

Table 4.2 shows the distribution of respondents in terms of department. 2.9% TVE, 4.4% Chemistry, 0.7% Architecture, 11.8% CSE, 25.7% EEE, 17.6% CEE, 2.9% BTM, 11.8% MCE, 7.4% IPE, 5.9% Textile Eng, 8.8% Physics.

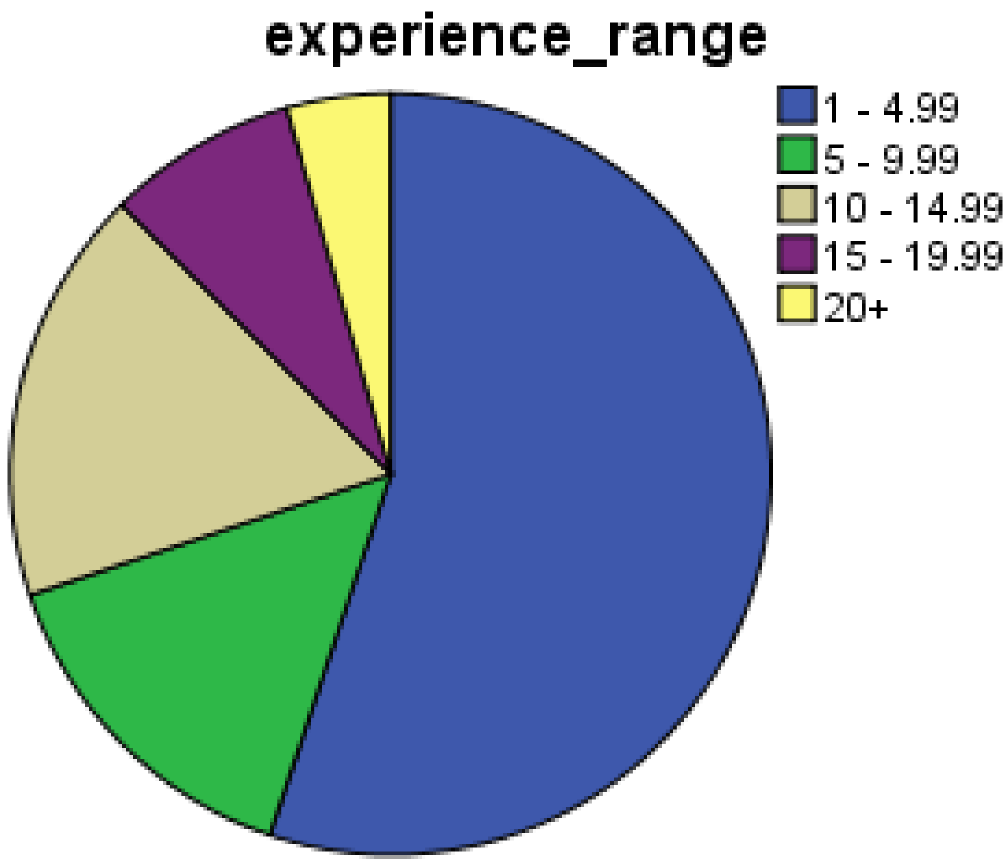

Figure 4-3 Pie Chart Showing Experience of Teachers

Table 4.3 shows the distribution of respondents by years of experience in teaching profession. Over half of the respondents (55.1%) have a teaching experience ranging from 1-4.99 years. 14.7% of respondents are having teaching experience from 5 – 9.99 years, 17.6% are having 10 – 14.99 years of experience, 8.1% of respondents have a teaching experience ranging from 15 – 19.99) years, and lastly 4.4% of respondents have a teaching experience of over 20 years.

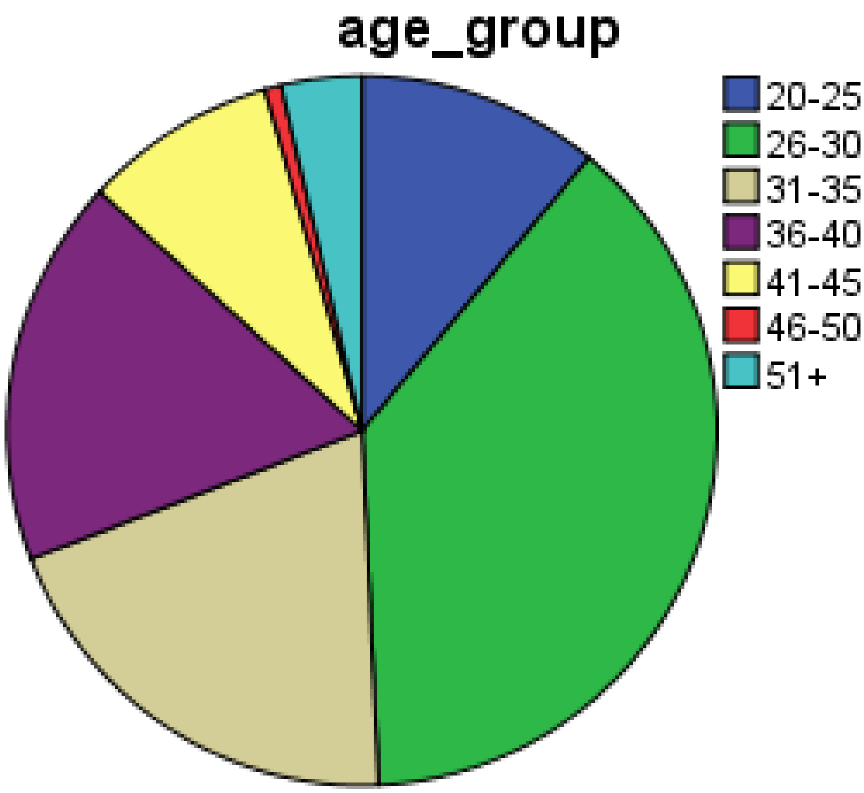

Figure 4-4 Pie Chart Showing Age Groups

Table 4.4 shows that 11.0% of respondents are in age group of 20-25, 38.2% are in the age group of 26-30, 19.9% are in the age group of 31-35, 17.6% are in the age group of 36-40, 8.8% are in the age group of 41-45, 0.7% are in the age group of 46-50, and lastly 3.7% are over 50 years.

Table 4-1 : Summary of descriptive statistics for domains

Domain	Number of items	Mean	SD	Cronbach's Alpha
Technology (TK)	7	4.25	0.82	.833
Pedagogy (PK)	6	4.17	0.77	.821
Content (CK)	3	4.32	0.77	.782
Pedagogy Content (PCK)	4	4.16	0.74	.823
Technology Content (TCK)	3	4.04	0.83	.830
Technology pedagogy (TPK)	4	4.10	0.83	.836
Technology Pedagogy Content (TPACK)	4	4.14	0.81	.851
Overall Reliability	31	4.17	0.80	.950

Cronbach's Alpha test was used to analyze the reliability of the survey tool. Table 4-5 shows an overall reliability score of .950, However, for individual domain reliability test scores are: 0.833 for TK, 0.821 for PK, 0.782 for CK, 0.830 for TCK, 0.823 for PCK, 0.836 for TPK, and 0.851 for TPCK. The above degree of reliability is considered adequate as all values are between .7 and .95 (Lance, Butts, & Michels, 2006) and closely similar to those that were obtained while validating the original tool by (Schmidt et al., 2009) which was between 0.75 and 0.92.

Table 4-2 : Pearson correlation coefficients.

	TK	PK	CK	PCK	TCK	TPK	TPCK
TK	1						
PK	.553**	1					
CK	.368**	.521**	1				
PCK	.473**	.687**	.616**	1			
TCK	.498**	.389**	.571**	.526**	1		
TPK	.432**	.552**	.532**	.593**	.519**	1	
TPCK	.457**	.541**	.533**	.606**	.523**	.746**	1

**. Correlation is significant at the 0.01 level (2-tailed).

To analyze the relationship between different constructs, (Cohen, West, & Aiken, 2014) we used Pearson's correlation coefficient (r) to generate the matrix of correlation as shown in table 4-6. The test is significant as shown in table 4-6, which shows a strong (greater than .5) positive correlation in several domains.

Table 4-3: Loadings of TPACK Factors with Corresponding Communalities.

	1	2	3	Communalities
TPCK2	.736			.572
TPCK4	.734			.569
TPK1	.733			.613
TPK2	.719			.484
TPCK3	.718			.568
TPK4	.677			.408
TCK2	.663			.460
TPK3	.658			.494
CK3	.636			.478
TCK1	.623			.513
CK2	.594			.517
TPCK1	.581			.493
PCK3	.551			.567
PCK4	.541			.516
CK1	.409			.212
PK6	.408			.329
TK6		.818		.694
TK4		.775		.553
TK1		.684		.491
TK5		.639		.503
TK7		.622		.454
TK3		.452		.373
TK2				
PK2			.723	.496
PK5			.707	.471
PK3			.637	.515
PK1			.572	.471
PK4			.549	.460
PCK2			.498	.536
PCK1			.400	.440

To validate the application of the TPACK model in Engineering Education at Universities in Bangladesh, we calculated the correlation among different subscales (domains) after which we performed an exploratory factor analysis. This analysis was made with the matrix of correlations obtained (Table 4-6). The sample size in our research (N = 136) follows a ratio of 1 variable per 4.4 respondents. Priori analysis could classify the sample size as low (Black, Babin, & Anderson, 2010) , the number of variables per factor (more than six) and the high communality obtained allow us to consider posteriori that the sample size was appropriate to apply this analysis (Henson & Roberts, 2006). Using Jackson (1993) rule which states that factors with Eigen values greater than 1 should be accepted to identify a number of factors and their constitution based on the data analysis, the test was carried out initially with the Eigen-value of 1 and 7 factors were extracted with an explained variance of 64.5%. using the scree plot, the factors were fixed to 3 and we later applied Promax oblique rotation and obtained a 48.4% explained variance. Table 4-7 shows the weights of the items in the questionnaire construct by construct on application of rotation. In the table, the results with a weight lower than .4 have been removed due to their low significance in relation to the size of the sample. As shown, factor analysis identifies three inter-related constructs. The first construct is related to Technology enhanced teaching (TPK, TCK and TPCK), Content (CK) and traces of pedagogy knowledge (PK). The second construct is directly related to Technology (TK) and lastly the third construct is related to traditional teaching without technology (PK and PCK). These results were compared to previous studies carried out in higher education. In relation to the study where the researchers adapted the questionnaire Chen and Jang (2014), Our findings fit three out of four of their constructs. CK loads together with technology enhanced teaching which is probably due to adapting of content and pedagogical approaches when introducing ICT into education field (M. J. Koehler & Mishra, 2005). The results from table 4-7 show that the seven domains of TPACK framework may practically not exist as participants acknowledged existence of basically three factors: firstly, technology knowledge, secondly, traditional teaching without technology and lastly, technology enhanced teaching knowledge. These findings are similar to those that (Archambault & Barnett, 2010) found when they explored the nature of factors making up the TPACK model. Using the responses given, participants showed a strong connection among technology content knowledge, technology pedagogy knowledge and technological pedagogical content knowledge. They also reported a connection between content knowledge and pedagogy knowledge as noted by interconnection of responses to pedagogy knowledge, content knowledge and pedagogy content knowledge statement. Furthermore, it's important to note that respondents did not differentiate to which construct the statements belonged. Instead, statements to technology enhanced teaching (TPK, TCK, TPCK AND CK) loaded together. Respondents were able to differentiate technology knowledge items where no reference was made to pedagogy or content was used. The loading of technology enhanced teaching (TPK, TCK and TPCK) and Content knowledge (CK) can be attributed to the continued introduction of technology resources like projectors and computers within the classroom environment leading to adaption of content to available technologies.

Table 4-4. Descriptive scores of TPACK Domains

Variables	Mean	SD	Median	Mode
TK	4.13	.597	4.17	4.50
PK/PCK	4.18	.495	4.29	4.29
TPCK/TPK/TCK/CK	4.21	.499	4.25	4.44

Table 4-8 shows the mode, median, standard deviation and the average obtained for three factors calculated as the average of each sub-domain (subscale). The factor with highest mean is technology enhanced teaching (TPCK/TPK/TCK/CK) closely followed by traditional teaching (PK/PCK) and Technology (TK). Although it is important to note that all the means are strong (above 4.0) which shows a positive general perception of teachers in TPACK knowledge.

After analyzing all the responses, the averages of different factors were compared to find out whether there was a significant difference in respect to teacher's grouping in terms of age, teaching experience and field of study.

Table 4-5. Analysis of Age Groups of different teachers

	Levene	**Mean by group**							ANOVA	
Factor	p	20-25	26-30	31-35	36-40	41-45	46-50	51+	F	p
TK	.133	4.0444	4.0609	4.3086	4.2083	4.0694	4.3333	3.9000	.794	.576
PK/PCK	.354	4.0667	4.1236	4.2804	4.1845	4.2262	5.0000	4.3429	.994	.432
TPCK/TPK/TCK/CK	.370	3.8667	4.1719	4.3773	4.2161	4.2500	4.8125	4.3625	2.172	.050

In reference to differences which may arise due to different age groups of teachers, the result in table 4-9 show significant differences in the technology enhanced teaching (TPCK/TPK/TCK/CK) of the teacher, but no significant differences in the other two TPACK factors (TK and PK/PCK) for any age group. Meaning the perception of teachers on use of technology enhanced teaching in educational process is affected by the age group to which he/she belongs.

Table 4-6. Analysis of experience of different teachers

	Levene	**Mean by group**					ANOVA	
Factor	p	1 - 4.99	5 - 9.99	10 - 14.99	15 - 19.99	20+	F	p
TK	.365	4.093	4.233	4.229	4.076	3.972	.505	.732
PK/PCK	.818	4.143	4.336	4.071	4.273	4.452	1.460	.218
TPCK/TPK/TCK/CK	.118	4.149	4.266	4.245	4.267	4.438	.706	.589

In reference to the number of years a teacher has spent in the teaching profession, table 4-10 shows that there are no significant differences in the three TPACK factors in relationship to the number of years that a teacher has taught. i.e. the self-perception of a teacher on use of technology in teaching seems not to be affected by the level of experience of the teacher in the teaching profession.

Table 4-7. Analysis of different fields of study for teachers.

	Levene	**Mean by group**											ANOVA	
Factor	p	TVE	CHE	ARC	CSE	EEE	CEE	BTM	MCE	IPE	T.E	PHY	F	p
TK	.000	3.83	4.33	4.17	4.34	4.34	3.98	3.33	4.04	3.68	4.56	4.00	3.20	.001
PK/PCK	.000	3.64	4.55	3.43	4.04	4.27	4.20	4.54	4.04	4.01	4.34	4.24	1.95	.045
TPCK/TPK/ TCK/CK	.000	3.66	4.26	4.38	4.01	4.29	4.22	4.42	4.18	4.06	4.41	4.28	1.19	.305

In reference to the discipline (specialization) taught by the university teacher, results in table 4-11 show significant differences in two factors, i.e. PK/PCK and TK of the teacher but no significant difference in technology enhanced teaching (TPCK/TPK/TCK/CK). This gives us two possible conclusions about the self-perception of a teacher on the use of technology in respect to their area of specialization. first, the results show no significant difference in self-perception of a teacher in technology enhanced teaching domain regardless of the teacher's specialization. This maybe be due to the nature of universities i.e. engineering. second, the results show a significant difference in self-perception of a teacher in TPACK domains related to technological and conventional teaching knowledge.

5 Chapter Five: Findings

5.1 Discussion

This study is focused on the applicability of the framework specifically to engineering education in Bangladesh universities and to further provide more insight into different variables of university teachers and how they affect their TPACK knowledge.

The reliability scores obtained after adapting and modifying of the questionnaire further confirm the applicability of the framework in engineering education environment because the scores are similar to those correlations published in application of the TPACK model in higher education (Cubeles & Riu, 2018). However, the model faces the same challenges that Cubeles and Riu (2018) faced when they tried to separate the model into individual constructs. Similar difficulties were found in studies involving high school, in-service and pre-service teachers (Chen & Jang, 2014).

The general results obtained after extracting the three sub-domains (subscales) indicate a strong perception of general knowledge in TPACK constructs. The highest mean (average) value is that of technology enhanced teaching knowledge followed by traditional (conventional) teaching knowledge and lastly technology knowledge. These results partially contradict other studies conducted at higher institute level (Blackburn, 2014; Cubeles & Riu, 2018) where conventional knowledge of teaching had the highest average followed by technology enhanced teaching and finally technology knowledge. As conclusion in regard to the perception of the university teacher's TPACK knowledge, this study illustrates that they perceive the three necessary knowledge as extracted by the factor analysis that is to say: Technology knowledge, conventional knowledge of teaching and finally technology enhanced teaching. Hence major emphasis should be on ways teachers can combine the different knowledge constructs in order to experience educational reason and value of ICT in pedagogically appropriate and effective ways.

This categorization enabled the researcher to develop explanations for relationships found between the teacher's traits (attributes) and TPACK.

In reference to the variables of the university teacher and age group in particular, the researchers only found significant differences in the teacher's self-perception in respect to technology enhanced teaching knowledge, but not in technology knowledge aspect or traditional (conventional) way of teaching domains between different age groups. These results coincides with a study conducted by Alzahrani and Cheon (2015) where a significant correlation was found between the respondents' age group and technology enhanced teaching (TPCK and TPK), and are partially similar to those obtained by Cubeles and Riu (2018) , Marcelo-García, Yot-Domínguez, and Mayor-Ruiz (2015) both from Spanish universities and with those obtained in the united states by Blackburn (2014) where no significant difference was found in teachers' self-perception of TPACK constructs related to technological knowledge and conventional teaching knowledge. This finding can be explained by Benson and Ward (2013) where they found out that high values of Technology knowledge (TK) does not necessarily translate into high levels of Technology enhanced teaching (TPCK) but higher knowledge levels in conventional practice (PCK) usually contributes to increase a teacher's technology enhanced teaching knowledge because it guides a teacher in making decisions in their teaching. Younger teachers posed high TK but with lower PCK which translates to lower TPCK and older teachers posed lower TK but higher PCK which translated into high TPCK. This coincides with results found in a study carried out in Saudi Arabia by Alzahrani and Cheon (2015) but partially contradicts the results found in previous study on age groups (Blackburn, 2014; Cubeles & Riu, 2018) where no significant differences in perception of the constructs of the framework among teachers of different age groups were found.

The researchers also found significant differences in the teachers' self-perception of technological knowledge aspect and conventional way of teaching knowledge domains in regard to discipline (field of study), but no significant difference was found related to technology enhanced teaching knowledge domain. This concur with other studies Lye (2013) and prove that the university teachers have similar self-perception of knowledge related to technology enhanced teaching regardless of the discipline to which they belongs.

Finally, the researchers did not find any significant difference in the self-perception of the constructs of the framework among university teachers' having different teaching experience. This confirms results obtained by Lin, Tsai, Chai, and Lee (2013) in Singapore and also those obtained conducted in the united states of America by (Blackburn, 2014) in spite of the fact that the researchers expected a greater perception in teachers with more professional work experience.

5.2 Implication

The implications for practical contribution of this study as stated earlier is using the TPACK framework as a tool to guide teachers with knowledge and competences that can be used to effectively use technology in education context in Engineering education at institutes of higher learning. The study further identifies three advanced knowledge domains extracted out of the initial seven that enable a teacher to use technology in a pedagogically sound and appropriate way. Furthermore, the study highlights how knowledge of conventional teaching positively affect knowledge of technology enhanced teaching i.e. the correlation between conventional teaching knowledge and technology enhanced teaching knowledge is very strong. Previous efforts to effectively apply technology in educational context, the assumption was to train teachers in technology knowledge, however, such approaches can easily create resistance in conservative teachers who may feel technology knowledge is aimed at displacing their conventional teaching knowledge (Alienation of TK). A better approach is to first develop their Conventional teaching knowledge, then introduce technology knowledge as vehicle/vessel to support, improve and simplify their teaching and learning practice. Therefore, policy makers should look into advocating for continuous professional development in both technology knowledge and conventional teaching knowledge and how they can be applied in engineering education context.

Focused on higher education and engineering education in particular, the results of this study confirm the independence of technology knowledge from other knowledge domains, and further shows a strong association between content and technology enhanced teaching in engineering education. This provides us with a number of insights on how to integrate technology enhanced teaching into engineering education. Firstly, the need to progressively train teachers in trending and emerging technologies and how those technologies can simplify their teaching practice. Secondly, intertwining of content with technology enhanced teaching points teachers in a direction where they have to rethink ways of reconstructing content so that it is adapted to the ever changing technologies thereby benefiting both learners and teachers for example changing 2D models into 3D or Augmented reality for better insights and understanding.

This study further supports the need to train teachers in all types of knowledge in order to achieve effective integration of technology in engineering education as results show close intertwining among the knowledge constructs/domains(Benson & Ward, 2013; Cubeles & Riu, 2018) with no practical demarcations.

5.3 Limitation

The limitations of this study are in line with the framework used, the TPACK framework is not the only framework used to introduce technology in education context. Many alternative frameworks have been proposed and developed to evaluate teacher's use of technology in the classroom context (Davis & Thompson, 2005). Although all the frameworks have different philosophies, they all coincide on one common issue regarding how technology can be integrated to teaching and learning. that is, teachers have to possess different kind of knowledge in order to be able to visualize how application of technology will transform the content and change ways in which content is delivered to learners (Davis & Thompson, 2005; Schmidt et al., 2009; Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013). in regard to the sample and sample size, the study has been conducted in two engineering universities in Bangladesh which are having one specific area of knowledge i.e. Engineering and are located within and near the business division of the country i.e. Dhaka. Therefore, the effect of this center may influence the results obtained and on the other hand, the sample size i.e. 136 respondents does not permit the researchers to perform deeper analytical studies of confirmatory factors. An interesting line of research in the future could be further extending this study of applying the TPACK framework to engineering education in Bangladesh universities to a broader sample with more universities surveyed and also expanding on the geographical area. A further dive into the relationship between different domains of the TPACK framework for an engineering teacher would be interesting.

5.4 Conclusion

This research examines the application of the TPACK framework to higher education and engineering education in particular. It further highlights the knowledge that the university teacher needs in order to introduce technology in his/her teaching practice. The findings show the need to improve the development of the core knowledge i.e. technology, pedagogy and content so that the interaction/intertwining between them is further understood. The curriculum of university teachers needs to be continuously developed at the rate of technology pace in order to take advantages of the opportunities that the technology provides to teaching and learning.

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Appendix A: The TPACK ITEMS MODIFIED FROM (Chen and Jang (2014))

Survey Questionnaire

Dear Sir/ Madam,

I am a Masters' Student at Islamic University of Technology (IUT), Department of Technical and Vocational Education Specializing in Computer Science and Engineering conducting a research study in the area of Technological, Pedagogical, and Content Knowledge titled "Effective integration of ICTs in Bangladesh Engineering Universities: Role of professors' knowledge and academic experience".

Please note that your honest response will have a significant impact on this research project and will

be highly appreciated.

a. Email address

……………………………………………………………………………………………

Demographic data Section

b. Gender

Male ☐ **Female** ☐

c. Age

…………………………………………………………………………………………….

d. Department

E.g. EEE, MCE, CSE, CEE

………………………………………………………………………………………………

e. Teaching Experience

……………………………………………………………………………………………

Technology Knowledge Section

The knowledge and skills of various traditional, current, and emerging technologies used in academic environment

1. I know how to solve my own technical problems.

e.g. connecting a projector to a computer, solving software related malfunction on a laptop like installing an operating system

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

2. I can learn technology easily.

e.g. using power-point to create a presentation, easily learning to use different tools to write a research paper

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

3. I keep up with important new technologies.

e.g. any new technology which simplify teaching and learning

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

4. I frequently play around with the technology.

e.g. use a smartphone to chat, auto cad to draw engineering models, the internet to learn new things.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

5.I know a lot of different technologies, which facilitate teaching and learning.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

6. I have acquired knowledge and technical skills to use technology.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

7. I have had sufficient opportunities to work with different technologies.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

Pedagogical Knowledge Section

knowledge about methods (approaches) and process of teaching for achieving desired learning outcomes

8. I can adapt my teaching based upon what students currently understand or do not understand.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

9. I can adapt my teaching style to different learners.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

10. I can assess student learning in multiple ways.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

11. I can use a wide range of teaching approaches in a lecture room setting.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

12. I am familiar with common student understandings and misconceptions.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

13. I know how to organize and maintain classroom management.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Content Knowledge Section

knowledge about the subject matter (content) for teaching and learning

14. I have sufficient knowledge about the subject matter that I teach.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

15. I visualize subject matter in different ways.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

16. I have various ways and strategies of developing my understanding of the subject matter that I teach.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

Pedagogical Content knowledge Section

The effective way of blending content and pedagogy for developing better teaching practices

17. I can adapt my teaching based upon what students currently understand or do not understand.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

18. I can select effective teaching approaches to guide student thinking and learning in specific content (topic) that I teach.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

19. I can choose suitable teaching approaches (methods) based on subject's content (topic) that I teach.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

20. I know how to create a classroom circumstance to promote students' interest in specific subject area for learning.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

Technological Content knowledge Section

The knowledge of media selection (technology) based on the topic that need to be taught.

21. I know about technologies that I can use to simplify and elaborate on subject matter.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

22. I know about technologies that allow me to represent concepts that would otherwise be difficult to teach.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

23. I know about technologies that allow me to record data that would otherwise be difficult to obtain such as Mat lab

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

Technological Pedagogical Knowledge Section

The knowledge of the affordances of technologies and what teaching strategies can be combined with those affordances to leverage learning outcomes

24. I can choose technologies that enhance the teaching approaches for a lesson.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

25. I can choose technologies that enhance students' learning for a lesson.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

26. I am thinking critically about how to use technology in my lecture room.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

27. I can adapt the use of the technologies that I am learning about to different teaching activities.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Technological, Pedagogical, and Content Knowledge Section

Professors' understanding of the interplay among content, pedagogy, and technology, as well as the procedural knowledge of integrating technologies into their teaching routines.

28. I can teach lessons that appropriately combine the subject matters, technologies, and teaching approaches.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

29. I can select technologies to use in my lecture room that enhance what I teach, how I teach, and what students learn.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

30. I can use strategies that combine content, technologies, and teaching approaches.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

31. I can choose technologies that simplifies content for a lesson.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Appreciation

Thank you very much for sacrificing your prestigious time to respond and participate in this study. Your response will surely play a vital role in this study.

kind regards,

....

Mr. MUGIGAYI FAHADI

Islamic University of Technology

jfahadi@gmail.com, mugigayifahadi@iut-dhaka.edu

Appendix B (Chen & Jang, 2014) Original Items

TK

1. I know how to solve my own technical problems.
2. I can learn technology easily.
3. I keep up with important new technologies.
4. I frequently play around with the technology.
5. I know about a lot of different technologies.
6. I have the technical skills I need to use technology.
7. I have had sufficient opportunities to work with different technologies.

PK

1. I know how to assess student performance in a classroom.
2. I can adapt my teaching based upon what students currently understand or do not understand.
3. I can adapt my teaching style to different learners.
4. I can assess student learning in multiple ways.
5. I can use a wide range of teaching approaches in a classroom setting.
6. I am familiar with common student understandings and misconceptions.
7. I know how to organize and maintain classroom management.

CK

1. I have sufficient knowledge about the subject matter that I teach.
2. I can use a way of thinking in my specialized subject area.
3. I have various ways and strategies of developing my understanding of the subject matter that I teach.

PCK

1. I can select effective teaching approaches to guide student thinking and learning in the subject area that I teach.
2. I can use a variety of teaching approaches to transform subject matter into comprehensible knowledge.
3. I know how to create a classroom circumstance to promote students' interest for learning.

4. I know students’ learning difficulties of the subject matter.

TCK

1. I know about technologies that I can use for understanding and doing the subject matter.
2. I know about technologies that allow me to represent things that would otherwise be difficult to teach.
3. I know about technologies that allow me to record data that would otherwise be difficult to gather.
4. I know about digital technologies that allow me to organize and see patterns in their data that would otherwise be hard to see.

TPK

1. I can choose technologies that enhance the teaching approaches for a lesson.
2. I can choose technologies that enhance students’ learning for a lesson.
3. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
4. I am thinking critically about how to use technology in my classroom.
5. I can adapt the use of the technologies that I am learning about to different teaching activities.

TPACK

1. I can teach lessons that appropriately combine the subject matters, technologies, and teaching approaches.
2. I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.
3. I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom.
4. I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/or district.
5. I can choose technologies that enhance the content for a lesson

Appendix C Participant Information Statement

INTEGRATING ICT IN ENGINEERING EDUCATION IN UNIVERSITIES: TEACHER'S KNOWLEDGE PERSPECTIVE

PARTICIPANT INFORMATION STATEMENT

(1) What is the study about?

The aim of this study is to investigate the knowledge required by university lecturers to effectively integrate ICT in their teaching and learning practice. It would like to explore your understanding and knowledge towards technology, content (subject matter), and pedagogy (teaching approaches) while you are teaching Engineering Education.

(2) Who is carrying out the study?

This study is being conducted by M.sc TE student of the Department of Technical and Vocational Education (TVE), Islamic University of Technology, a subsidiary organ of the Organisation of Islamic Cooperation (OIC), under the supervision of Dr. Shahadat Hossain Khan, Professor Technical and Vocational Education (TVE) Department; Islamic University of Technology (IUT).

(3) What does the study involve?

This study involves filling a structured questionnaire to complete at a time suitable for you. The questionnaire can either be online or physically distributed to you.

(4) How much time will the study take?

It may take 15-25 minutes.

(5) Can I withdraw from the study?

Yes. Being in this study is completely voluntary you are not under any obligation to consent and - if you do consent - you can withdraw at any time without affecting your relationship with Islamic University of Technology, and without having to give a reason. If you decide to withdraw from the study, please inform Dr. Shahadat Hossain Khan. (telephone: +8801798470248, Email: **skha8285@iut-dhaka.edu**).

(6) Will anyone else know the results?

All aspects of the study, including results, will be strictly confidential and only the researcher will have access to information about participants. A report of the study will be prepared and submit to the IUT for partial fulfilments for the award of masters of Science in Technical Education in Computer Science and Engineering. It is important to note that Individual participants will not be identifiable in such reports.

(7) Will the study benefit me?

While there are no direct benefits to the participants, as there is no reward or reimbursement for participation in this study, but there may be indirect benefits in terms of the findings of this study contributing to Effective Integration of ICT in Engineering education of Bangladesh using TPACK Framework.

(8) Can I tell other people about the study?

Yes.

(9) What if I require further information about the study or my involvement in it?

When you have read this information, the researchers will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact: Dr. Shahadat Hossain Khan (telephone: +8801798470248, email: **shkhants@gmail.com; skha8285@iut-dhaka.edu**).

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Web:http://tve.iutoic-dhaka.edu/faculty.php?id=7

This information sheet is for you to keep

Appendix D Permission letter to institutes

To: ……………………………………..

……………………………………….

……………………………………….

Dear Sir/Madam.

RE: Permission to collect data from your Faculty

I write to your office in reference to the above subject.

I am a final year Masters student in Technical and Vocational Education department majoring in Computer Science and Engineering carrying out my final year thesis titled "**INTEGRATING ICT IN ENGINEERING EDUCATION IN UNIVERSITIES: TEACHER'S KNOWLEDGE PERSPECTIVE** "In order to fulfill my research work, I have selected your Faculty Members as my esteemed respondents as it fits to the decided criteria. Kindly permit me to collect data at your faculty.

Anticipating your kind cooperation and response.

Yours Faithfully

Mr. Mugigayi Fahadi
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