ENGINEERING UNIVERSITY TEACHERS' CONCEPTIONS OF ICT ENHANCED TEACHING: BANGLADESH PERSPECTIVE

By

Mboka Khalid

Student Number: 181031403

MScTE (CSE)

Supervised by

Prof. Dr. Md. Shahadat Hossain Khan

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ISLAMIC UNIVERSITY OF TECHNOLOGY, ORGANIZATION OF ISLAMIC COOPERATION, BOARD BAZAR, GAZIPUR – 1704, DHAKA-BANGLADESH

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Declaration

This thesis was prepared by Mboka Khalid with Student ID. 181031403, under the Supervision of Prof. Dr. Md. Shahadat Hossain Khan and has not been presented before for award of Master's degree in any Institution of higher learning.

Prof. Dr. Md. Shahadat Hossain Khan
Technical and Vocational Education
Islamic University of Technology

Mboka Khalid
Master of Science in Technical Education
Islamic University of Technology

Approval by Board of Examiners

We hereby recommend that, the thesis prepared by Mboka Khalid whose student number is 181031403 under the title "Engineering university teachers' conceptions of ICT enhanced teaching: Bangladesh perspective" will prove beneficial beyond reasonable doubts as a partial fulfillment of the requirement for the award of Master of Science in Technical Education, specialized in Computer Science and Engineering of the Islamic University of Technology.

Endorsement of Board of Examiners

Prof. Dr. Md. Shahadat Hossain Khan TVE Department	**Chairman** [Supervisor]
Prof. Dr. Md. Abu Raihan Head, TVE Department	**Member** [Ex-Officio]
15/03/2021 **Dr. Mahbub Hassan** Assistant Prof. TVE	**Member**
Prof. Dr. Mohammad Ali Zinnah Dhaka University	**Member** [External examiner]

ii

Dedication

This piece of work is dedicated to my family members especially, my father (late), who closely monitored and guided my process of development in education up to my first degree at Islamic University in Uganda. In a special way, I also wish to dedicate the work to my lovely and motivating mother for her enormous sacrifices toward my wellbeing in this struggle not forgetting my course mates.

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First and foremost, praise and thanks to Allah the Almighty for favor and protection in acquiring knowledge throughout my educational career.

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Abstract

This is a qualitative study on the rising concerns of using Information and Communication Technology [ICT] in higher education. The purpose of this study was to investigate views, practices and attitudes that define varying conceptions of engineering university teachers' use of ICT in their teaching. A cohort of 14 teachers was selected from two universities in Bangladesh to participate in a semi-structured interview. Phenomenography research design was used to analyze data. The findings revealed five qualitatively different categories of description such as: imparting information, transmitting structured knowledge, offering guided learning, engaging students toward practice and engaging students toward innovation. Relationships among the categories of description revealed four dimensions of variation such as: purpose of using ICT in engineering teaching, role of teacher, role of student and TPACK components. The study further found that, ICT-use underpins teacher's pedagogical approach to teaching engineering subjects and therefore provides useful information for university policy makers, teachers and curriculum designers toward quality teaching and learning outcomes. A quantitative investigation to determine impact of pedagogical approaches to teaching underpinned by ICT-use in engineering education is recommended.

Keywords: *ICT, TPACK, engineering teaching, phenomenography and conception.*

Table of contents

Declaration .... Error! Bookmark not defined.

Approval by Board of Examiners .... Error! Bookmark not defined.

Dedication iii

Acknowledgement iv

Abstract v

Table of contents vi

Lists of tables viii

List of figures ix

Abbreviations x

Chapter one: Introduction 1

1.0 Introduction 1

1.1 Background of the study 2

1.2 Problem statement 3

1.3 Objective of the study 3

1.4 Specific objectives 3

1.5 Research questions 4

1.6 Subsequent outline of chapters 4

1.7 Conclusion: 4

Chapter two: Literature review 5

2.0 Introduction 5

2.1 ICT 5

2.2 ICT enhanced teaching 5

2.3 Teaching conceptions in higher education 6

2.4 Use of conception-related technology in engineering teaching 8

2.5 Teachers' conceptions of ICT enhanced teaching 10

2.6 Conclusion: 14

Chapter three: Research design 15

3.0 Introduction 15

3.1 Research methodology 15

3.2 Rationale for applying phenomenography approach 17

3.3 Participants 18

3.3.1 Sampling 18

3.4 Data collection 20
3.4.1 Pilot interview and review 20
3.4.2 Final Interview 22
3.5 Data Analysis 23
3.6 The outcome space 24
3.7 Validity and reliability 25
3.8 Ethical concerns 26
3.9 Conclusion: 26
Chapter four: Data Interpretation and findings 27
4.0 Introduction 27
4.1 Section I: Categories of description 27
4.2 Section II: Relationships among categories of description 36
4.3 Section III: The outcome space 51
4.4 Conclusion: 54
Chapter five: Discussion and conclusion 55
5.0 Introduction 55
5.1 Discussion 55
5.1.1 Implications of the study 61
5.1.2 Recommendations for Engineering Education 62
5.1.3 Limitations of the study 63
5.1.4 Recommendation for Further Research 65
5.2 Conclusion 66
REFERENCES 67
APPENDICES 76
APPENDIX I: Participant Information Sheet (PIS) 76
APPENDIX II: Participant Consent Form 78
APPENDIX III: Interview Guide 79
APPENDIX IV: Researcher Experience 80

Lists of tables

Table 1. Available phenomenographic studies by small sample size 18

Table 2. Demographic variation.. 19

Table 3. Seven-step data analysis procedure adopted from Marton 23

Table 4. Purpose of ICT in university engineering teaching.. 37

Table 5. Role of teacher in ICT enhanced teaching.. 40

Table 6. Role of student in ICT enhanced teaching.. 43

Table 7. TPACK components... 46

Table 8. Relationships among categories of description underpinning pedagogy.................... 50

Table 9. University teachers' response to ICT-use in teaching.. 51

Table 10. Outcome space of teachers' conceptions of ICT enhanced teaching 53

Table 11. Previous studies consistent with the present findings 58

List of figures

Figure 1. Linking conception and teaching approach: Kember and Kwan (2000) 7

Figure 2. Creative and routine problem solving adopted from Cropley (2015) 9

Figure 3. Phenomenography relationality adopted from Bowden and Green (2005) 16

Figure 4. A way of experiencing something adopted from Khan (2015) 16

Figure 5. Information transmission from teacher to students 27

Figure 6. Structured knowledge transmission from teacher to learner.................................... 29

Figure 7. Controlled communication by teacher.. 31

Abbreviations

IUT	Islamic University of Technology
ICT	Information and Communication Technology
MScTE	Master of Science in Technical Education
CS	Computer Science
CSE	Computer Science and Engineering
TVE	Technical and Vocational Education
EEE	Electrical and Electronics Engineering
CEE	Civil and Environmental Engineering
MPE	Mechanical and Production Engineering
GoB	Government of Bangladesh
TEIs	Teacher Education Institutions
TPACK	Technological Pedagogical Content Knowledge
STEM	Science, Technology, Engineering, Mathematics

Chapter one: Introduction

1.0 Introduction

Technology prevails in and presides over most of the students' daily activities within and outside higher education institutions (Miller et al., 2000). Previous studies into teaching and learning have indicated both theoretical and practical implications of using ICT to improve education for sustainable development (Eynon, 2005; Richardson, 2005; Corazon et al., 2019; Bibi & Khan, 2017). UNESCO in 2005 defined education for sustainable development as "a learning process or approach to teaching based on ideals and principles that prepare people of all walks of life to plan for, cope with and find solutions for issues that threaten the sustainability of our planet" (Leal Filho et al., 2019, p. 3).

The use of ICT in teaching has created diversified opportunities for learning (Rajasekhar, 2012; Latif & Lajiman, 2011). Roberts (2003) found self-paced learning, (Traxler, 2018), identified distance learning, while González (2009) revealed blended learning. Hands on experience and collaborative learning has been evidently reported by many scholars (Kaur, 2012; Bansal, 2016; Harati et al., 2019; Saxena, 2017). The existing teachers' instructional approaches have been enhanced and in some cases, a few of those approaches have been created with hopes for better options to encounter COVID-19 impacts (Rapanta et al., 2020). In contrary, teacher isolation in class has been reported to have negative impact on learning outcomes (Bauer & Brazer, 2013; Hongboontri & Keawkhong, 2014). However, communication through social networks has indicated positive impact on minimizing teacher isolation (Watkins, 2013).

Therefore, the impact of ICT on student learning outcome depends on the type of subject, discipline and technology used (Fernández-Gutiérrez et al., 2020; Richardson, 2005; Norton et al., 2005). This means that student learning can be affected by the differences in technological concepts applied that are not properly aligned with the student's subjects and discipline. Moreover, technology alone has not been sufficient enough to achieve the desired teaching and learning outcomes (Kirkwood & Price, 2013; Ertmer & Ottenbreit-Leftwich, 2013; Koehler & Mishra, 2005). Teachers' conceptions of teaching determine how they approach teaching and their teaching approaches relate to the way students learn (Trigwell & Prosser, 1996; Kember, 1997; Biggs & Tang, 2011; Lawlis et al., 1985). Marton and Booth (1997) perceived conception as the awareness or ways of experiencing a particular phenomenon. 'Conception' is the unit of description in phenomenography (Marton &

Pong, 2005, p 335). Thus, the use of technology depends on teaching approaches (Mirete et al., 2020), which may or may not be appropriate for the current higher education needs. Walther et al. (2017) demonstrates the need for engineering education community to engage in purposeful and reflective qualitative research methodology practices currently being adopted such as phenomenography. Therefore, there is need to investigate the differences in teaching conceptions more particularly influenced by the changing technology that may affect engineering education in addressing innovation-related challenges across the globe (Bain et al., 1998; Samueeowicz & Bain, 2001).

1.1 Background of the study

Recent data from University Grant Commission [UGC] indicates three categories of universities in Bangladesh as public, private and international. The Ministry of Education [MoE], through Bangladesh Bureau of Educational Information and Statistics (BANBEIS), reported in a study conducted on Bangladesh Education Statistics [BES] that, there are 135 universities in Bangladesh, of which 40 are public and 95 are private (*Bangladesh Education Statistics 1*, 2018). The universities are affiliated with UGC, whose recent data in 2020-2021 shows rise in the number of public universities to 46 and private to 107, totaling to 153 universities in Bangladesh to date. Many principal branches of engineering disciplines such as chemical engineering, civil engineering, electrical engineering, and mechanical engineering spread across various tertiary institutions in Bangladesh. Technical and vocational institutes, universities, colleges and polytechnic institutes offer engineering undergraduate and postgraduate courses in order to innovate and generate knowledge for building skilled manpower. At present, there are 22 universities in Bangladesh with specialized curricula, of which, 6 are engineering oriented.

In 1997, the Government of Bangladesh [GoB] officially recognized ICT as one of the contributors to the country's development and formulated the first ICT policy in 2002, which was revised in 2008 and 2015 respectively. According to Ministry of Education (2010), ICT is an important tool for matching international standards through modern and updated education systems. This was seen possible by extending the use of ICT in the education process at every educational level through competent pedagogies, physical infrastructure and favorable social ambience. Since then, the GoB has made it compulsory for every citizen to have twelve years of education and this has been seen as one of the stepping stones toward achieving "vision 2021" of making Bangladesh a middle income country and a developed country in its "vision 2041".

ICT infrastructure and affordable internet access have been established in the education sector in the recent years in Bangladesh (Philosophy, 2015). As a result, the quality of teaching in Bangladesh has been improving (Nahar et al., 2020). Nevertheless, developing skilled human resource towards equally distributed opportunities among Bangladesh citizens is yet to be fully achieved. Other challenges such as negative attitudes toward ICT use in teaching, lack of appropriate training programs and funding, biased ICT practices such as using ICT only for administrative tasks, uncoordinated ICT practices especially in undertaking classroom activities, logistics and different organizational ICT culture related issues still prevail.

Notwithstanding the improving quality of teaching as a result of ICT infrastructure development, less has been done to uncover teachers' conceptions of ICT enhanced teaching in Bangladesh universities and therefore, phenomenography inquiry is imperative for this study. Timsal et al. (2018) reported that, the use of technology has impacted on students in less developed regions, such as, South Asia. Subsequently, a recent report also indicated a growing pressure on tertiary education systems in relation to the economy needs of Bangladesh (Rahman et al., 2019). Therefore, the purpose of this study was to investigate different views, practices and attitudes that define varying conceptions of university engineering teachers' use of ICT in their teaching for meeting current industry demands.

1.2 Problem statement

The problem investigated in this study titled 'Teachers' conceptions of ICT enhanced teaching' was: "The ways engineering university teachers use ICT in teaching."

1.3 Objective of the study

The general objective was to investigate engineering university teachers' perceptions and practices of ICT enhanced teaching in Bangladesh.

1.4 Specific objectives

The specific objectives were (a) to identify the various ways university engineering teachers use ICT in their teaching (b) to determine the relationships [dimensions of variation] among the teaching approaches.

1.5 Research questions

In order to achieve the main objective of the study, the following research questions were addressed. (1) What do the engineering university teachers in Bangladesh perceive of or mean by ICT enhanced teaching? (2) To what extent does the teachers practice ICT enhanced teaching in classroom?

1.6 Subsequent outline of chapters

This subsection outlines five thesis chapters as follows: - Chapter one: Introduction, Chapter two: Literature review, Chapter three: Research methodology, Chapter four: Data interpretation and findings, Chapter five: Discussion and Conclusion.

1.7 Conclusion: The main goal of chapter one was to present introduction of the study and background of the problem, problem statement and objectives, research questions, significance and subsequent list of chapters in the document. The purpose of chapter two is to provide review of the related literature and justify the need for the present study.

Chapter two: Literature review

2.0 Introduction

The purpose of this chapter is to provide a critical review of literature related to ICT enhanced teaching in higher education. The previous studies are analyzed for possible insights, critics, dilemma or debates to justify the need for this research study.

2.1 ICT

ICT is an umbrella term with primary definition revolving around the devices and infrastructure that facilitate the transfer of information through digital means (Zuppo, 2012). It may also refer to digital tools that are delivered via computers and internet such as web resources, e-learning technologies and multimedia programs (Fomunyam, 2019). Ingole (2020) views ICT as expansion of technologies that can be used to collect, store and share information between people using multiple devices and multiple media. ICT, thus, refers to the union of information technology and telecommunication capable of collecting, manipulating, storing and sharing information through devices. It is mainly categorized into three concepts: firstly, Information Technology specific disciplines such as Artificial intelligence, computer science and computer graphics. Second, Information Technology intensive disciplines for example ICT mediated instructional design, digital library, information system. Third, Information Technology supportive disciplines that include computer technicians, network technicians and help desk technicians (Njoki et al., 2016).

2.2 ICT enhanced teaching

Technology as a transformational tool has contributed to the improvement of university teaching and learning (Munyengabe et al., 2019). Nowadays, many university teachings are approached in a constructive, self-regulated and cooperative manner in order to meet different student needs (Wogu et al., 2019). This aspect of teaching in modern terms is referred to as ICT enhanced teaching, simply because of using technology to improve student motivation, achievements and preparing them for the outside world (Kaur, 2012; Bansal, 2016; Harati et al., 2019; Saxena, 2017). Therefore, ICT enhanced teaching in simple term refers to a technique used to improve the ways including methods and approaches to teaching and learning for better outcome/output. ICT enhanced teaching in general refers to the application or use of different technologies in teaching and learning (Kirkwood & Price, 2014). ICT can improve the quality of education through more advanced teaching methods and other classroom techniques (Corazon et al., 2019). However, major issues related to using technology in education for better teaching and learning practices show up in first and second order barriers, such as, time and teachers' attitudes respectively (Ertmer P.A., 1999). Ertmer and Ottenbreit-Leftwich (2013) reiterated that, teachers need knowledge of using technology to support student-centered instruction. Dyer (2020) conclusively added that, technology does not only offer students new ways of interaction and acting in universities, but also casts concerns about teachers' practices. For instance the increasing demand for 24/7 contact hours of recording and delivering lectures. ICT supports both teachers and students however, how teaching and learning is improved depends on barrier (Ertmer P.A., 1999). Technology related challenges in teaching and learning have been due to its rapid change and incapability to single handedly address the current teaching and learning challenges as expected. Pulkkinen (2007) observed that such challenges end up causing unresolved imbalance between global and local context in the use of ICT in education, thus, requires solutions.

2.3 Teaching conceptions in higher education

Gow and Kernbet (1993) conducted a study to discover whether parallel conceptions of teaching was possible and further wanted to know whether the conceptions relate to student learning outcomes. Results were positive and two extreme conceptions were revealed as learning facilitation and knowledge transmission. Learning facilitation was more focused on student learning as opposed to knowledge transmission that emphasized on teacher's expertise to deliver content/knowledge. However, by review of 13 related papers, Kember (1997) discovered two broad teaching orientations as teacher-centered and student-centered conceptions. Teacher-centered pole revealed teaching as impartial information and transmission of learning materials. Student-centered conception was basically focused on teaching as facilitation for student understanding and their conceptual change. Additionally, a transitional category was discovered connecting the two broad teaching orientations. Elsewhere, Kember and Kwan (2000) carried out an investigation in a Chinese Polytechnic university EDC, Hong Kong, about lecturer's approaches to teaching in relation to their conception of good teaching in higher education. The lecturers' conceptions were described as mainly transmissive and facilitative. There was no evidence of the intermediate link between the two broad orientations, contrary to Kember's finding. However, all the lower categories were consistent. Lecturers who perceived transmissive conceptions were more likely to use teacher-centered approach while the ones who perceived facilitative conceptions were likely to use student-centered approach. The study conclusively suggested that, lecturers' conception of teaching is important for fundamental changes required for good teaching.

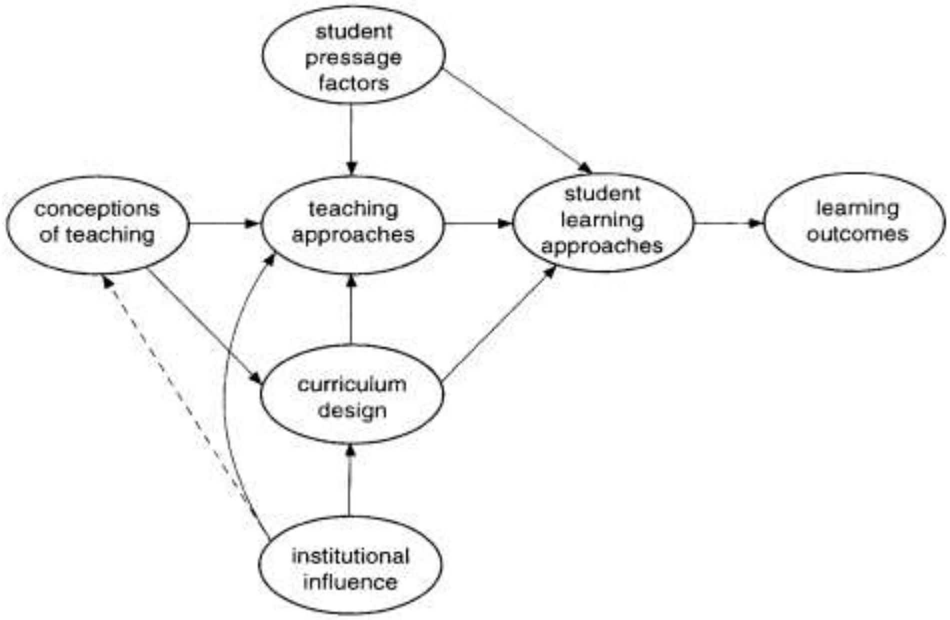

Figure 1. Linking conception and teaching approach: Kember and Kwan (2000)

Recently, Khan and Markauskaite (2017), in their study conducted in Australia, university of Sydney, reported two main strategic variations derived from five qualitatively different categories of description of ICT enhanced teaching. The teaching orientations ranged from teacher-centered pole to student-centered pole and were found related with previous findings, for instance, transmission and facilitation orientations (González, 2012; Gow & Kernbet-, 1993; Kember & Kwan, 2000); teacher centered and student centered conceptions (Kember, 1997). Student-focused/industry oriented approach to teaching was new knowledge reported in the study. Kain (2003) described teacher-centered approach as judgment about appropriate areas and methods of inquiry, legitimacy of information and what constitutes knowledge rest with the teacher while learner centered approach as a derivation from constructivist view of education, where construction of knowledge is shared and learning is achieved through student's engagement with activities in which they are invested. Nowadays, students' deep learning arise within their favorable teaching conditions (Biggs, 1999). "For students to be at the same level of learning as academic students, it requires change in their visual ways of learning and teachers' methods of teaching through technology, (p. 58)." In support of Biggs's view, Brown (2003) stated that, learner-centered approach substitutes the paradigm in a diverse population of learners where success is not realized using teacher-centered approach. In his study on the conceptions of and approaches to teaching online, Gonzalez (2009) modified the work of Roberts (2003) where some of Robert's findings were not applied. Gonzalez discovered three categories of descriptions as (a) individual access to learning materials and information and for individual assessment (b) for learning related communication (c) as a medium of networked learning. However, two broad web teaching approaches emerged as informative/individual learning focused and communicative/networked learning focused.

Postareff and Lindblom-Ylänne (2008) conducted a phenomenographic study in Finland, university of Helsinki and revealed two broad categories of description to describe understanding of teaching in higher education, the findings implied that, the theory of approaches to teaching should go beyond student/teacher centered dichotomy because the two categories share similar elements but with different variations, only when, focus is placed on the purpose of teaching. The study was biased on the basis of voluntary pedagogical training organized by the university, upon which, the researcher depended on to capture data. Although Postareff and Lindblom-Ylänne (2008) reported an implication on the extension of theory of teacher/student centered conceptions, most phenomenographic studies have been consistent with Kember (1997) findings. The following section reviews cognitive-related use of ICT in engineering teaching from teachers' perspectives.

2.4 Use of conception-related technology in engineering teaching

Recently a quantitative study based on quasi-experimental design by Lin et al. (2021) investigated 28 pre-service technology teachers' cognitive structures and how they construct engineering design in technology learning activities. Results revealed two viewpoints: firstly, application of engineering design process to Science, Technology, Engineering, Mathematics [STEM] project-based learning is beneficial for engineering design thinking, particularly in problem clarification, idea generation, modeling and feasibility analysis. Secondly, encouraging teachers to further explore systematic concepts of engineering design thinking and expand their abilities by merging engineering design process into STEM project-based learning. Lin further recommended, exploring solutions to the weaknesses of teachers' pedagogical engineering design thinking. The present study sought to identify engineering pedagogical solutions by understanding the relationship of using ICT for teaching engineering subjects.

According to Cropley (2015), in a study conducted in South Australia, there are three types of creative and two routine problem solving in engineering perspective. In a situation where problems and solutions are old, the problem solving paradigm is routine for example 'replication' where new problems remain tied to old solutions and 'stagnation' in which no progress is made towards the old problems. In the case of new problems with new solutions, the problem solving paradigm shifts from routine to creative such as 'forward incrementation' where a new solution satisfies an old problem in a better, faster and cheaper way, 're-direction' where a new solution opens up new possibilities and as a result satisfies a new problem and 're-initiation' where a new problem can only be satisfied by a new solution and therefore, new engineering problems require new solutions [re-initiation] in the aspects of both technicality and creativity for innovation. Cropley identified some benefits of creativity in engineering curriculum for example at individual level where students with moderate IQ levels can out-compete the ones with high IQ levels and indicated that, creativity can be taught. This implies that engineering students can be taught to be creative using ICT for providing new solutions to new engineering problems which is one of the main aims of the present study.

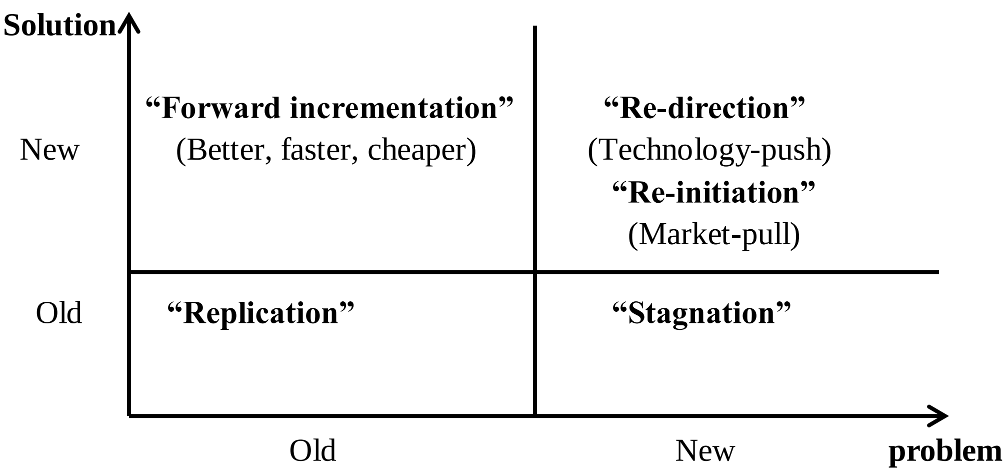

Figure 2. Creative and routine problem solving adopted from Cropley (2015)

At a glance, Cropley (2015) reiterated, engineering problems caused by change require new and effective technological solutions, which is lacking. Additionally, Lin et al. (2021) called for further exploration for solutions to the weaknesses of teachers' pedagogical engineering design thinking in relation to using technology and this study sought to illuminate teaching and learning space across engineering departments with focus on ICT-propelled teaching knowledge and skills for enhanced learning outcome.

2.5 Teachers' conceptions of ICT enhanced teaching

Although ICT infrastructure and resources to counter balance challenges related to teaching and learning have evidently been reported, studies prove that technology alone cannot address such challenges to the desired outcome (Kirkwood & Price, 2013; Ertmer & Ottenbreit-Leftwich, 2013; Koehler & Mishra, 2005). Koehler and Mishra (2005) warned against introducing ICT into educational process alone, understanding teachers' varying beliefs, perceptions and practices is important (Ashworth & Lucas, 1998; Biggs, 1999; Marton, 1981). Teachers beliefs and perceptions are vital to comprehend because using technology in teaching depends on teachers' perceptions of teaching (e.g. Mirete et al., 2020). This notion relates to the views of different scholars (e.g. Bain et al., 1998; Samueeowicz & Bain, 2001) suggesting more investigations into teaching conceptions regarding use of technology in higher education. According to Eynon (2005), exploring academics' experiences of using ICT in higher education is scarce and argued that, academics are best placed where ICT should be used. Furthermore, teachers' pedagogical approaches are influenced by their conceptions of ICT, for instance, attitude (Islam et al., 2018). It is, therefore, incorporation of such attributes into teachers' instructional practices can facilitate the achievement of the desired levels of student competence in higher education (Roberts, 2003). Evidence from available studies show that teacher related factors have acquit influence on ICT integration and student learning outcome than other factors (Baş & Baştuğ, 2020). Therefore, some responses to prior arguments have been reported in related phenomenographic studies as follows.

Tsai and Tsai (2019) conducted an interview based phenomenographic study in which relationships among 47 pre-service teachers' conceptions of teaching using mobile devices and the quality of technology integration in lesson plans was investigated. Findings revealed four qualitatively different conceptions of teaching as follows: 'technology support', 'knowledge transmission', 'learning facilitation' and 'supporting students to learn'. The result further revealed that teachers with constructivist perceptions about mobile devices for student facilitation were more likely to attain improved technology integration in their lesson plans than teachers with traditional perceptions. The first two conceptions were content focused while the last two were learning oriented. Most of the conceptions are consistent with related previous study results for instance knowledge transmission, learning facilitation (Kember and Kwan, 2000) and supporting students to learn (González, 2010).

Timsal et al. (2018) conducted a phenomenographic research in Pakistan, in which, 23 Master of Business Administration (MBA) students were interviewed of their experiences of using technology in their learning process. The main aim was to understand whether technology had any impacts on learning approaches in a way of its purpose of use or not. The following categories of description were revealed: access to learning materials and other information sources, organization of course related activities, improved communication and connectivity, developing collaboration/cooperation and means of overcoming socio-cultural barriers. The variations between the categories of description were compliant to deep level and surface level learning processes (Marton & Säljö, 1976). Some students preferred to use technology in the way they were told by the teacher whereas others were critical thinkers in using the technologies. The study further revealed that, the use of technology has impacted on students in relatively less developed regions by shifting their learning perceptions to more active and participatory practices.

Hodgson and Shah (2017) investigated 29 lecturers' understanding of using learning technology in a Pakistani context. Their aim was to explore how lecturers'-use of learning technology was underpinned by their pedagogical approaches. It further aimed at showing the prevailing contextual socio-economic and technological limitations affecting lecturers' pedagogical practices and use of learning technology. Positive results were revealed as follows: 'retaining attention', 'professional skills development', 'information enrichment', 'connectivity' and 'Omni potential'. The results were found relating with previous study findings such as using technology for knowledge transmission (Kember & Kwan, 2000), to meet external expectations (Khan, 2015), for aiding communication (Timsal et al., 2018); for collaboration and knowledge building (González, 2010). Omni potential was the new finding of the study. Additionally, it was revealed that socio-economic and technological limitations affected lecturers' daily pedagogical practices and use of learning technology. Lecturers with more student-centered pedagogical understanding were prompt to respond actively and find their way through the daily technology related contextual limitations encountered in teaching contrary to the technological practices of lecturers with teacher centered pedagogical understanding.

Degago and Kaino (2015) selected and interviewed twenty instructors based on convenient sampling technique from four public Ethiopian universities to explore their conceptions of teaching in view of improving the quality of teaching in higher education in Ethiopia. The study claimed revelation of categorizations and conceptualizations that substantiate recent investigations, were as follows, teaching as satisfying syllabus demands, teaching as presenting structured information to students, teaching as helping students learn what they learn and teaching as helping students expand their knowledge. From the analysis, the categories of description were seen relating from a more teacher-centered to a more student-centered structure. Conceptions in higher levels contained awareness of conceptions in lower levels which was not the case otherwise. Instructors categorized at higher level were seen to have alternatives to their teaching practices beyond their conceptions unlike those placed at lower levels. Relationships emerged as (1) essence of teaching (2) role of instructor (3) role of student (4) outcome of teaching (5) approach to teaching. The conceptions were found closely related to many study findings (e.g. Hodgson & Shah, 2017; Tsai & Tsai, 2019; Trigwell & Prosser, 1996; González, 2011). Of the five variations, the second [role of instructor] and third [role of student] are consistent with findings of Khan (2015). The fourth variation [outcome of teaching] relates to findings by González (2010). However, differences were also noticed in the first dimension [essence of teaching] and the fifth [approach to teaching].

González (2010) investigated different teachers' thoughts on e-learning using phenomenographic approach in a Chilean university, faculty of education and reported the following categories of description (a) provide information to students (b) for occasional communication among unit participants (c) engage students in online discussions and (d) support knowledge building tasks. Gonzalez's first conception that is providing information to students relates to imparting and transmitting information reported in findings by Roberts (2003) while Degago and Kaino (2015) presented it as satisfying syllabus demand and presenting structured information. The most sophisticated conception in both studies (Degago & Kaino, 2015; González, 2010), that is, to support knowledge expansion and knowledge building were consistent with Gonzalez's fourth category [support knowledge building tasks]. However, in the case of Hodgson and Shah (2017), technology was used for connectivity purposes placed under student-centered conception contrary to Gonzalez's occasional online communication space for students which was a teacher-centered conception. Student engagement in online discussion (González, 2010) and improved communication and connectivity (Timsal et al., 2018) were closely related student-centered conceptions. Furthermore, four dimensions of variations relating Gonzalez's categories of description were: (1) role of teacher, (2) role of student, (3) unit participants' interaction and (4) perception of embedding with face to face components.

In nutshell, ICT is used to transform teaching and learning practices from classical face to face to modern approaches apparent in blended and online in order to enhance learning outcomes (Munyengabe et al., 2019; Wogu et al., 2019). Teachers need teaching knowledge (Ertmer & Ottenbreit-Leftwich, 2013), many of whom, welcome ICT-use in their teaching (e.g. Silviyanti & Yusuf, 2015). Although lack of ICT training and financial support have been reported in related studies, university teachers' beliefs, perceptions and practices about teaching is vital particularly using ICT and has effect on student's learning, which, together can be translated into 'teaching conception' also known as 'category of description', terminology used in phenomenographic study (e.g. Degago & Kaino 2015; Hodgson & Shah 2017; Timsal et al., 2018).

Many phenomenographic studies that focused on ICT-use in teaching have contributed new knowledge, insights and pedagogies for enhancing teaching and learning at university level. For instance, Tsai and Tsai (2019) informed that, constructivist perceptions of teaching using mobile devices appeared to attain quality technology integration into lesson plans than teachers with objective perceptions. Much as the study was intended to meet subject requirements through quality technology integration into lesson plans, there was no direct relationship reported based on ICT knowledge and skills required for teaching those subjects, especially, regarding engineering education.

Timsal et al. (2018) admits that there is need for instructors to provide correct direction for students on how to interact with the diverse technologies while learning but argues that there is no disconnect in so doing contratry to the view of Landgrebe et al. (2016), where students are believed to be developing alternative or parallel infrastructure to the institutional offerings which could be problematic to their learning process. In support of Timsal et al. (2018) assertion, the use of ICT to acquire knowledge and skills beyond subject needs was not accounted for, hence, students are believed to be developing parallel infrastructure to institutional offerings.

Hodgson and Shah (2017) identified relationship between contextual socio-economic/technological limitations, conception of using learning technology and pedagogy in a Pakistani context. Technological limitations affected teaching approaches and were also found relating with lecturers' conceptions of using learning technology. However, the study did not report any technology specific limitation related to a particular discipline but rather considered list of various knowledge fields such as Law, health science and administrative science.

Degago and Kaino (2015) informed that, the categorization of more number of instructors in student-centered conception in their findings was an attempt made so far to change instructors' conceptions of teaching towards student learning in higher education and recommended teaching improvement programs that can expand instructors' conceptions of teaching, of which, the present study is part.

Therefore, technology use depends on teaching approaches (Mirete et al., 2020) and teaching approaches are underpinned by conceptions of teaching (Prosser & Trigwell, 1997; Trigwell & Prosser, 1996) which requires more investigations due to the differences in meaning of teaching which may or may not be appropriate for university teaching and learning (Bain et al., 1998; Samueeowicz & Bain, 2001). Phenomenographic studies have not been conducted substantially to uncover teachers' conceptions of teaching using technology not only in Bangladesh as a region (Khan & Markauskaite, 2017; Khan, 2015), but in higher education as a whole (Tight, 2016). Timsal et al. (2018) reiterated that, teaching using technology shifts students' perceived-learning to a more active and participatory practices, particularly in less developed regions like South Asia, which is the context of the present study in general and Bangladesh in particular. In addition, the available literature has not revealed any phenomenographic discovery to create space for teacher-education based on the necessary ICT knowledge and skills for engineering teaching, thus, the present study sought to fill this gap by understanding the relationship between ICT-use, subject and pedagogy in engineering education using phenomenographic research design.

2.6 Conclusion: In chapter two, literature related to ICT enhanced teaching in higher education was reviewed by understanding the findings of the previous studies in order to justify the need for this study. The goal of chapter three is to outline the research method used, indicate the procedures involved and present the theoretical process of how data was collected.

Chapter three: Research design

3.0 Introduction

This chapter presents the qualitative research methodology, its brief background and rationale for selection. It further outlines the data collection technique and analytical procedures used in providing answers to the research questions for this study.

3.1 Research methodology

Phenomenography, rooted in a set of studies of learning from 1970s, focuses on uncovering qualitatively different ways people experience, conceptualize or understand phenomena (Marton, 1981, 1986). It is seen as an innovative research design with interest in higher education, that is, focusing on improving student learning, discovering variations in teaching approaches and a research design that stimulates both methodological and theoretical developments (Tight, 2016). In phenomenography, conception and understanding of a particular phenomenon is captured by participants' collective understanding in a limited number of categories of description (Marton, 1981b). Svensson (1984) clarified the term 'conception' as one that signifies the relation between man and aspect of the surrounding world (in Sandbergh, 1997). Phenomenographic research investigates relationship between subject and phenomenon under study in a non-dualistic manner considering the Inner [internal] and the outer [external] world as one (Bowden & Green, 2005). This relation [object of study] should be maintained independent of researcher's influence while obtaining people's experiences of a phenomenon through practical implications such as not integrating new inputs during interview process, maintaining questions and comments restricted within request for further explanation and pilot interview rehearsals in order to attain stronger research outcomes. In phenomenography study, the levels of outcome constitutes the outcome space of a certain concept (Marton & Säljö, 1976). Phenomenography study outcome refers to a limited number of qualitatively different ways people experience phenomena (Science, 1981; Marton, 1992). Categories of description together with dimensions of variation represent the outcome space as the final phenomenography result (Åkerlind, 2005; Marton, 1981, 1986, 2004; Science, 1981).

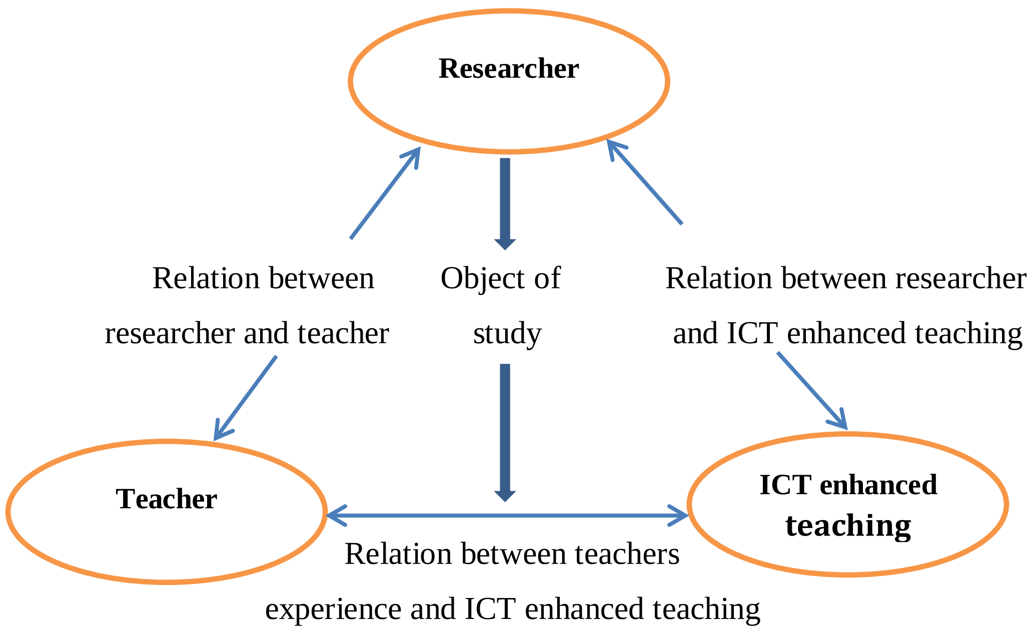

Figure 3. Phenomenography relationality adopted from Bowden and Green (2005)

In the present study, phenomenography was selected to explore engineering university teachers' conceptions of ICT enhanced teaching. In **Figure 1**, the subject of study is teacher and phenomenon is ICT enhanced teaching. The researcher focused on investigating the relationship between the teacher and ICT enhanced teaching to determine categories of description and dimensions of variation of the study as further illustrated below.

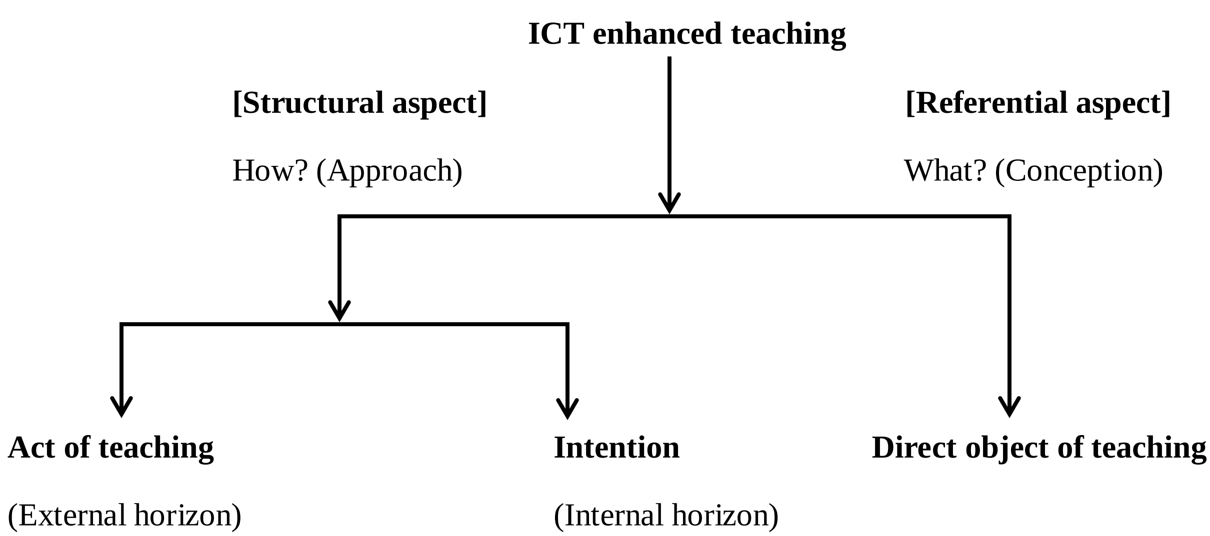

Figure 4. A way of experiencing something adopted from Khan (2015)

The referential aspect reveals what ICT enhanced teaching means to engineering university teachers and the structural aspect, on the other hand, is divided in two parts: - The intentions of ICT enhanced teaching (internal horizon) and how the intentions relate to the act of teaching using ICT in philosophical teaching and learning concepts.

3.2 Rationale for applying phenomenography approach

Phenomenography approach leads to insights that can provide solutions connected to empirical research associated with cognitive viewpoint (Limberg, 2000), and generate high quality results (Bailey, 2008). Call-Cummings and Ross (2019) stated that “reflexivity is a step to take to establish validity, rigor or ethical nature of the research being done, p. 3.” The quality issue of phenomenographic approach to research has been considerably sorted beyond satisfaction of criteria for rigor, particularly the analysis process (Collier-Reed et al., 2009a; Sin, 2010; Cope, 2004). Rotar (2020) developed a reflective practice framework for advanced analysis of unstructured phenomenographic data as a response to doubts cast by some scholars about the practical application of reflexivity in qualitative research. The author further informed, not to neglect speculating the idea of the subjective nature of knowledge because a phenomenographer represents the research participants’ perspectives as close as possible with reflective consideration of a personal contribution. Moffitt (2020) asserts that phenomenographic approach is prosperous and growing while providing the needed information, This notion confirms Walther et al. (2017) recommendation for researchers to engage in qualitative research methodologies for engineering education. Phenomenographic approach contributes new way of understanding university teaching and learning particularly in the engineering universities of Bangladesh where it has not commonly been practiced.

3.3 Participants

According to Polkinghorne (2005), the general focus of qualitative inquiry is describing, understanding and clarifying a human experience leading to collecting of a series of intense, full and saturated description of the aspect under investigation. Phenomenography is aligned with Polkinghorne's view (Åkerlind, 2005; Marton, 1981). In the present study, participants' in-depth understanding and maximum variations in their experiences of the phenomena was achieved by considering three recommendations: first, purposive participants selection based on experience in ICT enhanced teaching was applied (Limberg, 2000; Yates et al., 2012). Second, variation of participant selection upon factors such as age, gender, academic experience, department and geographical location was managed (Åkerlind, 2005). Third, the practice of 7-20 respondents for semi-structured interview was maintained (Roberts, 2003; Gonzalez, 2009; Larsson & Holmström, 2007; Limberg, 2000). Few examples are given in Table 1.

Table 1. Available phenomenographic studies by small sample size

Author (s)	Year	Sample
M . J . Dunkin and R . P . Precians	1992	12 award winners for excellent teaching
Gonzalez	2009	07 lecturers from faculty of science
Roberts	2003	17 teachers from Modern Scottish university
Khan	2014c	23 teachers from TAFE Australia
Keith Trigwell , Michael Prosser and Philip Taylor	2016	24 teachers from Chemistry and Physics departments
David Pastoriza Rivas and Serge Poisson-de Haro	2020	49 professors from 4 business school, academy of management
Priyowidodo, n.d.	2019	21 research subjects from Christian millennial
Salberg et al.	2019	16 Nursing staff members

3.3.1 Sampling

The research topic was approved by the research committee of IUT consisting of external research experts. After obtaining an approval, the researcher proceeded to data gathering where purposive sampling was used to select participants across the various departments of two universities. The reason for selecting participants purposively from those engineering universities was to meet the study requirement of subjects' experience of the phenomenon under study. The targeted participants were the lecturers, assistant professors and professors with experience of using ICT in their teaching. The researcher contacted six different Heads of engineering departments from those universities over telephone. It was done as a precautionary measure to maintain health security and safety from the infection risks of COVID19 outbreak. The contact was to seek consent for access to the participants. The phone call conversations were backed by Participant Information Sheet (PIS) **[Appendix I]** containing information about the study. The information was presented to the participants on request to participate in the study. The participants were given time to study the information in the PIS, then requested to voluntarily confirm their willingness to participate in the study by signing underneath a Research Consent Form (RCF) [**Appendix II]**. This was important to clear any doubts of misconceptions from the PIS. Such misconceptions arose due to unpredictable situations such as ambiguity, time factor, emotions and suspicions. The interview dates were fixed based on mutual understanding at the time of presenting the RCF. Table 2 shows the participants' demographic characteristics of the sample.

Table 2. Demographic variation

University (U1 And U2)	Teacher-Id (1-14)	Fluency In English	Department	Experience (Years)	Gender
	P01	Fluent	CSE	8	Male
	P02	Fluent	CSE	2	Female
	P03	Fluent	TVE	4	Male
	P04	Fluent	TVE	10	Male
	P05	Fluent	EEE	5	Male
	P06	Fluent	EEE	2	Male
U1	P07	Fluent	EEE	17	Male
	P08	Fluent	CEE	5	Male
	P09	Fluent	MPE	10	Male
	P10	Fluent	CSE	5	Male
	P11	Fluent	CSE	12	Male
	P12	Fluent	CS	17	Male
U2	P13	Fluent	CS	21	Female
	P14	Fluent	CS	12	Male

In summary, the study sample was a total of 14 participants including 2 female and 12 male teachers who are experienced in teaching using technology, selected from six departments of two universities in Bangladesh. The participants were selected on the basis of their current or past teaching practices using technology.

3.4 Data collection

Data collection refers to the procedure of collecting, transcribing and analyzing accurate insights for the purpose of conducting a research study using validated techniques.

3.4.1 Pilot interview and review

In a phenomenographic study, interview is the most common data collection method (Åkerlind & Bowden, 2005; Marton, 1986; 2004). The other methods such as written responses may also be used (Tight, 2016; Limberg, 2000). It is important to note that the ways of expressing understanding of a phenomenon by the subjects and understanding object of study by the researcher can be affected by many factors such as emotion. Phenomenographic inquiry therefore, strongly recommends pilot study before starting to conduct the final interview especially for novice researchers (Åkerlind & Bowden, 2005; Jacobvitz et al., 2002). Therefore, the researcher started conducting the pilot study from early January 2020 to early February 2020. This exercise [pilot] was meant for the researcher to be familiar with the interview process and/or activities, gain skills on how to dig deeper into participants' understandings of the phenomenon through follow up questions, identify and correct any mistakes before starting the final interview as advised by the scholars (Åkerlind, 2005; Åkerlind & Bowden, 2005).

The pilot study consisted of three participants from Technical and Vocational Education department with engineering backgrounds as their areas of specialization. The researcher made an appointment with the participants through phone calls and managed their consent to participate in the pilot interview voluntarily. The pilot participants were briefed by the researcher about what they were expected to keep track of during the pilot interview for instance time management and follow up questions to mention but a few (Bowden & Green, 2005). However, they were required to have certain qualities such as experience in teaching and learning using technology and having a related experience of engineering education as Marton (1981) suggested. This helped to build better understanding and appropriate identification of researcher's mistakes made in the pilot exercise.

An in-depth semi structured interview guide was administered with the actual interview topics of the study **[Appendix III]** followed by feedback from the pilot participants of what the mistakes were and how they needed to be modified, removed or added. Among the most common mistakes realized and identified were researcher's frequent interference into participants' responses, inappropriate time management, loss of direction as discussion intensified, question qualities and pattern of flow of questions. Modifications were later made based on the feedback from the pilot participants' observations keeping the suggestions of the scholars (e.g. Bowden & Green, 2005; Åkerlind & Bowden, 2005) in mind.

3.4.2 Final Interview

According to Cuadraz and Uttal (1999) “more common in-depth interview practice is to study small homogeneous samples in order to achieve an in-depth understanding of particular lived experiences, p. 162.” In the present study, 14 teachers of two engineering universities participated in an in-depth interview in two ways that is a face to face audio recorded interviews with 11 teachers and a video recorded zoom meeting with 3 remaining teachers. This second option was executed due to COVID-19 restrictions. The video recording in the zoom meeting was a request by the researcher to compensate for lack of face to face meeting in order to attain additional information about the participant’s emotions and gesture during response (Js, 1994; Jacobvitz et al., 2002). Therefore, data generated from the interview was recorded for verbatim transcription with focus on teachers’ responses to the research questions of the study (Larsson & Holmström, 2007; Jacobvitz, Curran, & Moller, 2002; Åkerlind, 2005; Marton, 1994). However, the what, why and how questions were addressed in three main topics as follows: (a) meaning of ICT enhanced teaching [What], (b) reasons for ICT enhanced teaching [Why] and (c) ways or methods of conducting teaching using technology [How].

The three main questions were followed by unstructured follow-up questions aimed at obtaining participants experiences about the phenomena (Åkerlind, 2005; Åkerlind & Bowden, 2005). The researcher asked follow-up questions such as “what is the importance of that?”, “could you highlight more on [specific point] please?” Such questions were asked depending on what level of details the interviewee was revealing in response to questions. This was important to obtain good study results. The interview lasted between 30 to 40 minutes per participant.

3.5 Data Analysis

Data analysis started after the completion of data collection (Åkerlind & Bowden, 2005). The main purpose was to discern the participants' interview data through sorting, interpretation and representation (Bailey, 2008; Khan, 2014; Bowden & Green, 2005). Marton (1986) informed that, there is no specific procedure for analyzing phenomenographic data. For example, González (2010) used the five-step analysis procedure while other scholars (e.g. Sjöström & Dahlgren, (2002); Khan, (2014b) followed the seven-step analysis process in their study. Marton (1994) explained that "phenomenographic analysis is not a measurement procedure but one of discovery, (in Mcmanus, 2009, p. 16)." In the present study, the researcher followed the seven-step phenomenographic analysis process to discover teachers' conceptions of ICT enhanced teaching because the procedure is independent of its counterpart, familiar in many phenomenographic studies and easy to understand and apply. The conceptions were determined through careful selection of meaningful data while developing limited groups of similar statements by different participants. This was cautiously done through judging what level of details to consider through data interpretation and representation for example 'ICT and hence' from 'ICT enhanced' in order to attain quality information (Bailey, 2008). The seven steps are described in Table 3.

Table 3. Seven-step data analysis procedure adopted from Marton

1.	Familiarization	The recorded data was transcribed to form a data pool (Åkerlind, 2005) which appeared ambiguous and less meaningful at first. The transcripts were iteratively read by the analysis team so as to gain familiarity of their contents
2.	Compilation	Identification of statements with meanings relating to the conceptions under question were gathered
3.	Condensation	Most significant data were selected through data reduction process mostly long answers from some participants
4.	Grouping	This was where the gathering of conceptions with similar contents were separated
5.	Comparison	These separated concepts were then sorted into categories through careful combinations leading to more meaningful statements. Categories were then compared to one another when identifying definite boundaries in terms of their contents
6.	Naming the categories	Categories were named in reflection of their essence based on the meaning of parts (concepts) it contained
7.	Contrastive comparison	The difference in each of the categories were indicated by means of quoting to demonstrate the different conceptions of the phenomena under study completely without any indications from which participant they originated from

3.6 The outcome space

In phenomenography approach, research investigates relationship between subject and phenomenon of study in a non-dualistic manner considering the Inner [internal] and the outer [external] world as one (Bowden & Green, 2005). This relation [object of study] was maintained independent of researcher's influence for example by not integrating new inputs while conducting the pre-planned interview. The final result of study conducted using phenomenography approach is referred to as outcome space (Marton & Säljö, 1976; Marton, 1981, 1986; Science, 1981; Limberg, 2000). Phenomenography study outcome space consists of categories of description and dimensions of variation (Larsson & Holmström, 2007; Science, 1981). The variations represent relationships among qualitatively different groups of categories of description according to Marton and Saljo (1976) meanwhile categories of description possess certain important attributes as well as uniqueness from one another (Marton, 1994). In phenomenography study, the structural relationships between qualitatively different categories of description constitute the outcome space of a certain concept as the final result. In this study, the referential aspect of engineering university teachers' approach to teaching using ICT relates to their ICT knowledge and skills required for teaching engineering subjects.

3.7 Validity and reliability

The questions of validity and reliability of qualitative research are yet to be addressed of which phenomenography has much in common regarding the assumptions (Åkerlind, 2005b). Validity refers to “the degree to which the research findings actually reflect the phenomenon being studied”, (Åkerlind, 2005b, p. 330). It can also be termed as the internal consistence of the object of study, data and findings (Sin, 2010). There are two types of validity checks commonly practiced in phenomenography studies namely communicative and pragmatic validity checks. Reliability on the other hand “reflects the use of appropriate methodological procedure for ensuring quality and consistency in data interpretation”, (Åkerlind, 2005b, p. 331). Sin (2010) views reliability as the extent to which the findings of a study can be replicated. Similarly, two reliability checks are: coder reliability check and Dialogic reliability check. Arguments are that validity can be achieved using participants’ responses toward questions about the phenomenon (Dowling-Guyer et al., 1994) but in the opinion of Åkerlind (2005), participants do not have the main concept of the study and therefore cannot provide appropriate validation to the study. Many interpretive, non-scientific and traditional studies have always been considered good research from a philosophical point of view which the current interpretive nature of the analysis process rests upon (Collier-Reed et al., 2009). Previous studies conducted through phenomenography approach show consistent results (Kember, 1997; Gonzalez, 2009; González, 2010; Kember & Kwan, 2000; Khan & Markauskaite, 2017; Khan, 2015). Many scholars (Cope, 2004; Sin, 2010) assert that, studies adopting validity and reliability have shown progress in educational development. Collier-Reed et al. (2009) claims trustworthiness basically replaced the aspects of validity and reliability through dependability, credibility and transferability to the outside world. In this study, trustworthiness was achieved by analyzing the distinction between internal horizon [Multiple legitimate interpretations of the same data through persuasive arguments] and external horizon [The impact of study outcome upon the surrounding world].

3.8 Ethical concerns

This study was approved by the department of research committee of Islamic University of Technology in Bangladesh. There were a number of ethical concerns considered while conducting the research, for instance, getting participant's consent to participate in the study, participant identity anonymity and participant data confidentiality.

Basing on the above ethical concerns, the researcher sought for consent of each of the fourteen participants before involving them in the study. The PIS and RCF were used to convey a summarized account of the nature and the likely implications of the study. The participants were requested to voluntarily confirm acceptance by signing after reviewing the terms and conditions. The interview sheets were presented to the participants few minutes before the interview started off. Regarding the anonymity and confidentiality concerns, the two university names were represented by U1 and U2 meaning university one and two respectively. For participant anonymity P01, P02…P0n was used meaning participant one, two and n. Additionally, the statements, words and utterances from participants were combined during the analysis process making it anonymous to identify who said what and hence confidentiality maintained.

3.9 Conclusion: The goal of chapter three was to outline the research method, discuss the procedures involved and outline the theoretical process of how data was collected. A phenomenographic approach was used to analyze and develop engineering university teachers' experiences of using ICT in their teaching. The goal of chapter four is to provide study findings and demonstrate that phenomenography approached described in chapter three was followed.

Chapter four: Data Interpretation and findings

4.0 Introduction

The main aim of conducting this study was to investigate engineering university teachers' conceptions of ICT enhanced teaching.

This chapter presents findings and description of analysis organized in the following structure: Elaboration of categories of description, relationships among categories of description and illustration of the outcome space. A demonstration of the procedure followed to attain the two specific objectives, that is, to identify the various ways engineering university teachers use ICT in their teaching and to determine relationships among teaching approaches, are provided.

4.1 Section I: Categories of description

The analysis process revealed five qualitatively different categories of description about the perceived meaning of ICT enhanced teaching. The categories of description are as follows: -

A: imparting information
B: transmitting structured knowledge
C: offering guided learning
D: engaging students toward practice
E: engaging students toward innovation

4.1.1 Category A: Teaching as imparting information

Category 'A' represents participants' conceptions on ICT use in teaching as a means of transferring subjects' information to the students. ICT is seen to help in transferring subject's content information from teacher to the student through internet enabled platforms like email and Google classrooms through phones and computers. For example, one of the participants affirms,

> "From power point presentation to Google classroom are some of the tools I use to reach my students especially when passing information in which process you barely find anything new." P14-U2

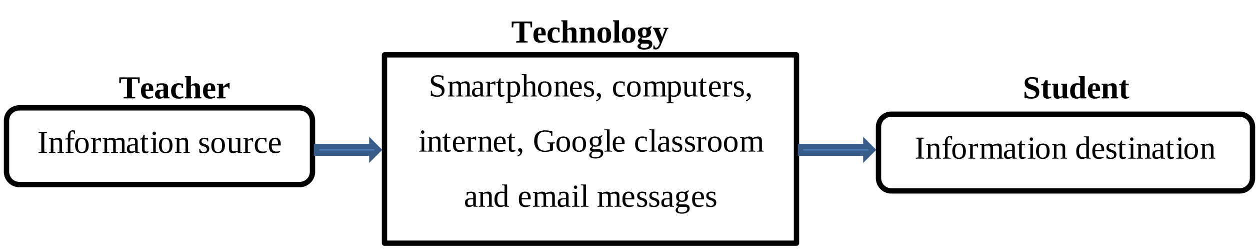

Figure 5. Information transmission from teacher to students

Teachers in category ‘A’ describe their views of teaching as presenting content. Three broad intentions such as, saving time, accessing information and posting class assignments and results are seen in this category. First, teachers are seen to use ICT for conveying information to students for saving their time. For example, a participant believed that, by sending content files through Google classroom to the students prior to class session speeds up their presentation and was quoted saying,

> “…….it could be up to open presentation or sending materials to students a head of lecture time. ICT gives me the opportunity to have a wider coverage of syllabus pretty much quicker and be able to meet other requirements, compared to the previous chalk and blackboard approach.” P08-U1

Moreover, some participants considered teaching as a means of acquiring available information for their students. Teachers with this view not only use text books from the library but also internet for acquiring information for teaching. A participant informed that he uses ICT to acquire information from online sources to teach his students and envisages as follows.

> “I am you can even say a learner. Each year, I learn from the various cloud-based online sites like Massachusetts Institute of Technology [MIT] and this makes my class different. In my class, I tell my students that all my lectures are not only from the text books but also the internet as well.” P12-U2

Additionally, participants perceived that, ICT is used in teaching for posting class assignments and results for students. Teachers in this subscale believed that ICT helps them in transferring assignment information to the learners. ICT devices like phones, computers and platforms such as Google classrooms were seen commonly used in this situation. For instance, a participant grasps,

> “Actually, I’m using Google classroom to deliver assignments and feedback to students. They don’t need paper and pen to produce the answers and then spend money on these things but rather receive notifications from me online, of what they need to do.” P06-U1

In a nutshell, category ‘A’ represents teachers’ views on ICT use in teaching as a means of presenting a body of subjects’ contents to the learners. Teachers mainly focus on completing the syllabus by using ICT tools. In this case, academic knowledge is seen very vital for the teacher to deliver subject content appropriately.

4.1.2 Category B: Teaching as transmitting structured knowledge

Category 'B' represents participants' views on ICT use in teaching as sending structured knowledge to the learners of engineering education. Therefore, the main focus of a teacher is to deliver a simplified content to students in a way that is easy for them to understand and remember. However, students are passive during teaching process. Computers and smartphones are used to transmit images, multimedia files and texts to the learners as one participant asserts,

> "When I am having this opportunity to organize my delivery, like, I have all the tools at hand that suit my methods of organization, the learners can then receive knowledge in a more easily understandable way." P10-U1

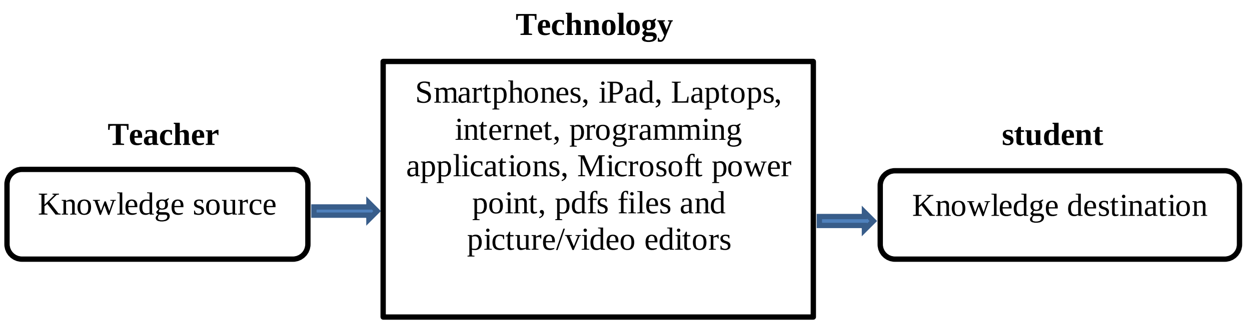

Figure 6. Structured knowledge transmission from teacher to learner

Teachers in this category viewed teaching as presenting precisely meaningful contents to the students. Programming software is seen to be used to execute program codes that produce different image features. For example one of the participants informed that for his learners to understand operation of program codes, he needs to show images for comparison with execution results of codes and postulates,

> "I think I will be specific to you in my view on this based on the course I teach which is computer graphics. Computer graphics is basically output oriented, I mean the outcome of every class is an image produced and therefore, I need to focus on using color, texture and image shade well." P12-U2

Appropriate presentation of complicated diagrams is seen easily accomplished through use of ICT tools. Teachers with this view believed that the ideas relating to the features and functionalities of diagrams are represented more clearly through technology. For instance, one participant pointed out,

> "…….drawing human blood circulation system using a marker pen or chalk on a board is complicated right? From my experience, I feel students get it much easier when diagrams are represented through technology." P14-U2

While some participants perceived ICT-use in teaching for organizing contents for easy follow up by students. Teachers believed that such content organizations are made possible through use of ICT platforms, for instance, the Learning Management Systems (LMS), Microsoft power point, word processor, pdfs, Google drive, picture and video editors with support of internet, computers and smartphones. For example, a participant viewed teaching using ICT, is for orderly delivering of knowledge through proper design preceding. Moreover, another participant believed ICT enhanced teaching is preparing presentation slides for knowledge transmission. Technology was seen as a means to summarize huge amounts of contents into main points in order for students to make sense out of. For illustration, one of the participants affirms,

> "….what I do, design a separate presentation slide that is kept in the Google classroom or Google drive for the students, it contains summary of the main points of a class content for clarity because students will not really coordinate the concepts easily, given that much of syllabus content." P14-U2

In category 'B', the concept of teaching as transmitting structured knowledge to students is content oriented just like the case in category 'A'. In both cases, student's role is not visible during teaching and is seen as silent knowledge recipient. However, category 'B' is distinct from category A in a way that the information transmitted is organized in a more meaningfully summarized way for easy follow up by students.

4.1.3 Category C: Teaching as offering guided learning

Category 'C' represents participants' views on ICT enhanced teaching as a way of establishing good communication relationship with students during teaching. It is a transitional category which resulted from the interaction between teacher and the student. Teachers' main emphasis was to have a good relationship with students so that they could interactively respond to teaching. Participants in this category viewed students not to be entirely passive to knowledge in class because students often got involved in demonstration activities. However, they further believed that whatever the students engage in remained within the teacher's framework. Teacher becomes responsible for providing feedback, doing research on students' learning and encouraging demonstrative learning activities. Two aspects of views emerged in this category as follows:

a. **Attaining good teaching habits**: Teachers viewed students in a way that they were not scared or worried of making mistakes in their learning process when good communication relationship is established. For example, a participant informed that she always puts her students to a task of presenting and asking questions regarding contents taught so as to understand how she [teacher] could move on with the topic of next class. Participants conceived that, by maintaining interactivity during teaching helps teachers identify areas of emphasis in the content. ICT tools such as power point slides, Arduino and other programming applications are used to present and demonstrate activities during teaching. For instance, a participant presumes,

> "…. I maintain them in a control in order to attain a good teaching habit. It's the reason I need to communicate with them and understand what they are doing [progress]." P13-U2

For further illustration, another participant posits,

> "......for example, in some of my CISCO classes, I check and give practical examples after which I ask them[students] to demonstrate how packets travel in a network using packet tracer simulation software." P03-U1

b. **Sharing responsibility**: Some participants in this category viewed teaching using technology as sharing teaching responsibility. For example, a participant considers that teaching burden is reduced if his students are able to demonstrate ideas based on previous classes in a new topic. ICT tools like collaboration platforms and programming applications are used for demonstrating activities during teaching process. For example, one of the participants contends,

> "I request my students to demonstrate how a related activity in my previous example applies in their next learning…being an activity for the next class, is just to see if they've got an idea." P12-U2

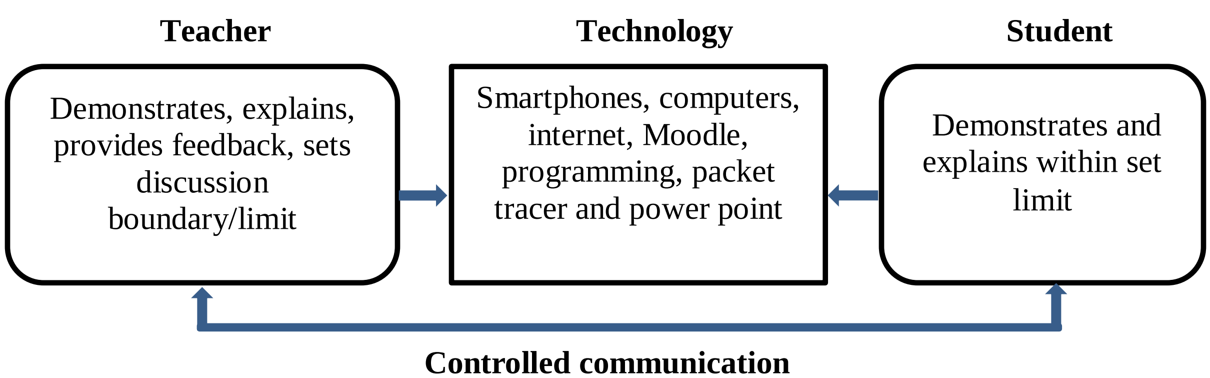

Figure 7. Controlled communication by teacher

Therefore, in category ‘C’, the concept of teaching as offering guided learning is teacher centered similar to cases in categories ‘A’ and ‘B’, because teacher mainly focuses on content delivery. However, category ‘C’ is distinct from category ‘B’ in a way that, focus is additionally placed on building good communication relationship with students through demonstrative activities.

4.1.4 Category D: Teaching as engaging students toward practice

Category ‘D’ entails independent student learning practices. The teaching views held in this category are focused on student learning contrary to views categorized in ‘A’, ‘B’ and ‘C’. The main emphasis is to engage students in their own learning process through self-motivation. For example, a participant conceived that he needs to enhance his students’ understanding by freely allowing them to use technology in their learning process. Therefore, teachers are seen as creators of suitable learning environment and guide students to learn freely using ICT tools. Teachers motivate students to pick interest and involve them into active learning through Web 2.0 platforms, online libraries and classes, analysis software, modeling applications, simulators, programming software and YouTube videos.

Two subscales emerged in Category ‘D’ as guiding students to acquire the necessary information they need and guiding students to improve their problem solving skills. First, students are believed to be both online and offline ICT users for example, graphics design applications, Microsoft office packages and cloud-based interactive and collaborative tools. A participant pointed out that, after going home, students may happen to study at night which may need support that is usually managed by them [students] through ICT and envisages,

> “……so the information has to be in a server somewhere else where the students are passionate to access because their late night studies require help for information of which they now have all the options to systematically access that which is very important in their learning.” P13-U2

Another participant notes,

> “I am you can even say a learner. Each year, I learn from the various cloud-based online sites like Massachusetts Institute of Technology [MIT] and this makes my class different. In my class, I tell my students that all my lectures are not only from the text books but also the internet as well.” P12-U2

Even some perceived guiding students to improve their problem solving skills was the reason to use ICT in their teaching. Participants in this subscale conceived that student engagement into critical thinking activities for solving problems differently makes them understand in a diverse way. For example, a participant believes that ICT enhanced teaching is all about exposure to discovery of new phenomena and observes that,

> “From our field point of view [CSE], every day we have new tools so I give my students problems to find solutions using new tools. Nowadays, knowledge cannot be limited to oneself” P13-U2

In category ‘D’, the concept of teaching to engage students toward practice is student-focused. Students take independent responsibilities through engagement into learning for solving course related problems. Category ‘D’ is distinct from category ‘C’ in a way that teaching focus is fully shifted to student learning.

4.1.5 Category E: Teaching as engaging students toward innovation

In category ‘E’, participants’ perceived use of ICT in teaching is for creating space to engage engineering students toward innovation. The participants believed that creative and imaginative thoughts change students’ approaches of applying engineering knowledge and skills toward innovation, for example, programs to execute sophisticated systems and authoring software for developing new ideas into content were common among students during their learning process. Teachers viewed students’ practices of using ICT for innovation to be linking with professional solutions to teacher-related problems. Four types of student engagement are seen in category ‘E’.

First, teachers are seen to provide learning space where students are actively involved in activities that support development of knowledge and skills that has relationship with teachers’ instruction. A participant points out that with ICT, you need not to struggle a lot to start things from scratch because students have privilege to information they need and asserts as,

> “Some students bring very important arrangements and agreements in what I give them, because they searched through and found other things related to my instructions and I do think that, technology draws their learning interests from all directions and when considered, may lead to producing their best because it’s in the direction of their interest.” P06-U1

Second, students’ involvement into learning activities such as research is seen contributing for departmental [disciplinary] growth. Participants in this category believed that students’ exposure to this [innovative] kind of ICT supported learning process is allowing them to develop new ideas. A participant from one of the departments informed that he loves seeing students performing tasks in different ways because it's easy for them to remember and apply knowledge that way. One of the participants was quoted saying,

> Technology provides numerous services to the users but the best out of all can be realized based on relevance of application and my main aim as a teacher is to influence, encourage and supervise students or do research on teaching and learning to support this department grow." P08-U1

Third, students' technology related practices are seen contributing to community development. Teachers perceive that, students engage in learning activities toward creating new things beyond their main subject areas. A participant from EEE department conceived that if a student can timely search for information, he may learn beyond the needs of subject matter and remarks as follows,

> "Much of the technology talked about here, were invented and designed by electrical engineers, which is important to let students know. In order to improve for the future, in a way that communities benefit, I guide my students in applying ideas toward creating new and better products." P07-U1

Fourth, students are seen getting involved in a variety of learning activities such as accessing digital libraries to gain new learning experiences, using authoring software to create their own learning materials, analytical and evaluation software for critical thinking towards global needs. This is seen as a preparation process for engineering university students toward an expanded future career at workplace while addressing industry challenges with innovative intentions. A teacher informed that the world is now moving towards a global learning whereby the teacher is not entitled to teach that small class alone. The concept of using ICT in category 'E' offers the highest level of students' engagement in their learning process which could not be found in the previous four categories. A participant in this category notices that,

> "A lot is expected of ICT in relation to improving the capacity and capability of students in learning not only within their subjects of specialization but also other knowledge areas for sustainable globe." P09-U1

Category 'E' differs from category 'D' in a way that, it goes beyond content modification and enhancement to transforming students' skills through higher order thinking activities such as analyzing, evaluating and creating their own learning materials in relation to innovation and industry demands.

In summary, the demonstration of category development process from ‘A’ to ‘E’ in section I, satisfies the first specific objective, that is, to identify the various ways university engineering teachers use ICT in their teaching, thus, provides answer to the first research question ‘what do the engineering university teachers in Bangladesh perceive of or mean by ICT enhanced teaching?’. Five qualitatively different categories of description for engineering teaching emerged as follows: - imparting information, transmitting structured knowledge, offering guided learning, engaging students toward practice and engaging students toward innovation. The goal of section II is to demonstrate the relationships among the categories of description.

4.2 Section II: Relationships among categories of description

In this section, further meaning of the five qualitatively different categories of description is described, satisfying the second specific objective, that is, to determine the relationships [dimensions of variation] among the teaching approaches.

Four dimensions of variations emerged, supported by participants' excerpts in the transcripts. Following are variations among the categories of description: -

1. Purpose of ICT in engineering teaching
2. Role of teacher
3. Role of student
4. TPACK components

The internal and external horizons were the main focus during the development and establishment of dimensions of variation. Teacher's role shifted from information delivery to being a facilitator. Therefore, the role of information delivery constitutes the first dimension of variation consisting of category 'A' and 'B'. In the second dimension [role of teacher], teachers focus which was entirely on content delivery in 'A' and 'B' shifted to interactive teaching through demonstrations. Thus, students are partly active while demonstrating activities and passive when receiving information from the teacher. Students depend on teacher for interaction in a controlled manner unlike in category 'B', where teachers prepare, organize and transmit content knowledge without expecting any sorts of ideas from the students. The first two dimensions are in line with internal horizon however, the last two, that is, role of student and TPACK components represent the external horizon. Therefore, teacher's role is seen gradually shifting with focus from teacher-centered to student-centered approaches to teaching. This is viewed as a gateway to addressing global innovation related industry challenges in engineering education.

4.2.1 First dimension: The purpose of ICT in engineering teaching

The purpose of using ICT in engineering education expands from category ‘A’ to ‘E’. In category ‘A’, ICT is used for information access and transmission only while in category ‘E’, ICT provides wider learning space for students toward innovation, represented in Table 4.

Table 4. Purpose of ICT in university engineering teaching

Category		Purpose of ICT in engineering teaching
A	Teaching as imparting information	ICT is used for accessing and transmitting information
B	Teaching as transmitting structured knowledge	ICT is used for accessing and transmitting structured knowledge
C	Teaching as offering guided learning	ICT is used for building communication among teachers and students
D	Teaching as engaging students toward practice	ICT is used for creating active learning space for subject matter
E	Teaching as engaging students toward innovation	ICT is used for providing wider learning space [beyond subject matter]

ICT is used for two purposes in Category ‘A’ and ‘B’. First, teachers use ICT for transmitting information [Category ‘A’] and structure knowledge [Category ‘B’] and students use ICT for receiving that information and knowledge. Therefore, ICT is used for accessing and transferring information during teaching and learning in engineering education. For illustration, a participant comments as,

> “…..I give lecture by power point and at the end of it, I ask students to download the content files Google class for study purposes.” P10-U1

Moreover, another participant asserts,

> “…for each animation, there is mathematics/geometry done at the back of the scene that learners need to be served along with so that they understand and hopefully perform better in the context of rotation and transportation.” P13-U2

In category ‘C’, ICT is not only used for transmitting and accessing information like in Category ‘A’ and ‘B’ but also for building communication among teachers and students. The ICT tools such as social media platforms, emails, and Google classrooms are commonly used. Therefore, ICT is used for controlled communication with learners during teaching. A participant envisages,

> "Whenever we are having a new facility, I think of re-organizing teaching contents because students want to know and interact with latest technologies in their daily practices." P08-U1

For further example, one of the participants in university 1 reflects,

> "…..so whenever students browse many different things, they may get important information from other view-points which exposes them to how people think on the topic which they discuss with me and I arrange and make connections between such points of view within the teaching content in slides as methods known vary from person to person." P10-U1

For category 'D', ICT is additionally used for creating active learning space for students. Students are left to interact freely with ICT tools for instance programming languages such as C, C++ and Java, Microsoft power point and word processor, pdf, video and picture editors. A participant discerns,

> "As we are in a sea of information especially, in the use of the internet, I mean am there to guide students to proper information from these technologies and proper guide on how to use them. You know, without technology I would not be able to optimize their time or channel the use of this technology to proper ends." P05-U1

In category 'E', ICT is used for creating active and wider learning space for students toward innovation. Engineering students are seen acquiring expertise knowledge and skills beyond their main subject areas through You Tube videos, tutorials, social media (discussion classes, groups and forums) and pdf files/books. A participant in university 1 declares that,

> "I always tell my students to just try to understand 20% in class and then look for the remaining 80% through pdf books, topics, news and every major thing I direct them to read or practice. In my view this will make the learner to become the teacher or even better because I don't think that I know everything. I think I know something as well as my student, together then, we make it 100%." P09-U1

While another participant states,

> "……because nowadays students have the liberty to go through any sites connecting to any subject matter, it is actually easier for them [students] to learn on their own as long as a few instructions are well followed." P08-U1

Moreover,

> "Some students bring very important arrangements and agreements in what I give them, because they searched through and found other things related to my instructions and I do think that, technology draws their learning interests from all directions and when considered, may lead to producing their best because it's in the direction of their interest." P06-U1

Therefore, the purpose of ICT in engineering teaching is for accessing and transmitting subject information along with building communication links for interaction in the lower categories, 'A' 'B' and 'C' respectively. In upper categories, 'D' and 'E', the purpose of ICT is for creating active and wider learning space for the students.

4.2.2 Second dimension: The role of teacher in ICT enhanced teaching

The second dimension emerged as a result of the relationship between categories ‘B’ and ‘C’. In category ‘C’, teaching becomes interactive through communication in a controlled way. However, teacher’s role remains central to conveying content information to the students in all the three categories ‘A’, ‘B’ and ‘C’.

Table 5. Role of teacher in ICT enhanced teaching

Category		Role of teacher
A	Teaching as imparting information	Conveys information to students
B	Teaching as transmitting structured knowledge	Conveys organized knowledge to students
C	Teaching as offering guided learning	Conveys knowledge and engages students toward activities in a controlled way
D	Teaching as engaging students toward practice	Creates learning environment and guides students toward active learning within subject matter
E	Teaching as engaging students toward innovation	Creates learning environment and guides students toward activities for acquiring knowledge and skills beyond subject matter

In categories ‘A’ and ‘B’, teacher’s role is providing information to the learner however; there is distinction between the two categories. In category ‘A’, teacher’s main target is to transfer the entire syllabus information to students. ICT is applied only in accessing and passing information to the student. For example, a participant indicates that he uses ICT to show the output [image] of a program whose codes are written on the whiteboard using marker pen, for explanation, one of the participants with a related view comments,

> “…….it could be up to open presentation or sending materials to students a head of lecture time. ICT gives me the opportunity to have a wider coverage of syllabus pretty much quicker and be able to meet other requirements, compared to the previous chalk and blackboard approach.” P08-U1

Meanwhile in category ‘B’, teacher’s focus is on simplifying knowledge for easy understanding by students. Teacher’s role is to use ICT for accessing, preparing, organizing, and transmitting the necessary information to students. A participant asserts,

> "The use of ICT is basically to support teaching, easing teaching, helping us to prepare and deliver contents because teaching itself involves so many things from preparations, planning to delivery. So I think anything that I do in teaching using technology, kind of like, assists that teaching process." P03-U1

From category 'B' to 'C', there is change seen in teacher's responsibility of transmitting a body of well-structured knowledge to creating a communication link with the student for interaction during teaching. Teacher is seen to create space for students to demonstrate their ideas during teaching. A participant declares that,

> "Through simulation program, I find it easier to explain lines of codes from an output point of view. I later request students to demonstrate a few of such programs based on the previously shared examples." P11-1

Moreover, another participant states,

> "So, whether practical or theory classes it is completely graphics programming meaning that every student in my class will be guided to practice how to program using C programming language with open gel which is a graphics API." P12-U2

From category 'C' to 'D', teachers' role is seen shifting from building communication relationship with students to creating student learning environment and guiding them to learn on their own. Teacher is seen as a guide to students on what, where, how and when to freely acquire learning resources with the technologies surrounding them. One of the participants notices,

> "Previously knowledge was only for the teachers so if I write something in the Google address bar now and my student does the same, the results would equally be the same. So for me, the 24 hours in a day is limited for teaching and learning, coupled with other activities and therefore, if I include my students in the learning process, the 24 hours will become multiple of the number of students involved in acquiring skills and knowledge. This makes the learning environment knowledge and skills rich." P07-U1

Lastly, from category 'D' to 'E', teachers' role is seen shifting to creating learning environment and guiding students toward acquiring knowledge and skills beyond their subject matter. Teachers use myriad ICT tools to create learning environment for engineering students to acquire critical thinking skills in system analysis, evaluation and creativity, linking with professional future career. One of the participants explains,

> "…… you may be trained as a public administrator but tomorrow you are a network administrator because during reading that public administration course you had to go into contact with all that information." P05-U1

The role of teacher is to access and transmit subject information along with creating a communication link for interaction with students in the lower categories, ‘A’ ‘B’ and ‘C’ respectively. In upper categories, ‘D’ and ‘E’, the role of teacher is to create learning environment and guide students toward active learning within and beyond their subject matters.

4.2.3 Third dimension: The role of student in ICT enhanced teaching

The third dimension emerged as a result of the relationship between category 'C' and 'D'. In category 'D', students are seen fully engaged in active learning through myriads of ICT tools. Students take responsibility of their own learning outcomes. Therefore, the focus expands from creating an interactive communication [category 'C'] to entirely student engagement into active learning activities [Category D].

Table 6. Role of student in ICT enhanced teaching

Category		Role of student
A	Teaching as imparting information	Receives information from the teacher (Passive)
B	Teaching as transmitting structured knowledge	Receives structured information from the teacher (Passive)
C	Teaching as offering guided learning	Passive while receiving information and active when responding to the teacher
D	Teaching as engaging students toward practice	Engages in learning activities for acquiring subject knowledge and skills (active)
E	Teaching as engaging students toward innovation	Engages in learning activities for acquiring knowledge and skills beyond subject matters (active)

In category 'A', students are viewed as receivers of information from teachers with limited understanding. The main aim of the information is for reproduction during examination. Students are seen interacting with ICT tools such as emails, Google search, YouTube videos and pdf files during their learning process. A participant reflects,

> "See up there in the book shelves, I have a couple of books but I cannot see whether you have got any of your own. But the truth now is, you might be having a thousand pdf books in your SD card of your smartphone right, and as I struggle with my two small shelves of books, technology has given you every book that I don't have therefore you can have access to as many copies of books as you may need." P09-U1

While another participant comments,

> "I always use presentation slides and whatever goes more than two hundred slides, no problem because they [students] have their copies, all they need is to put in some concentration in order to pass their exams" P07-U1

The role of student in category ‘B’ is receiving structured information from teacher. The structured information is received in various formats and forms including pdfs, texts, graphs, videos, images and pictures. Student is expected to deploy the respective technologies to access the information. For illustration, one of the participants asserts,

> “Diagrams were drawn on white piece of paper and then shown and given to us to visualize but with the advent of technology, now I don’t see myself wasting time to draw complex diagrams on pieces of paper for students. Students receive graphs and other images opened in a picture editor, pdf reader, Microsoft word and power point for their easy learning.” P02-U1

In the view of another participant,

> “ICT is good for teaching fraternity given the various software and other tools. Take an example of designing assignments in Google form and then upload for students to access on their devices feels more convenient and efficient to both me and my students, as this can be done anywhere and at any time.” P08-U1

The role of students from category ‘B’ to ‘C’ shifts from entirely passive to only passive while receiving content and partially active when responding to teacher during teaching. More specifically, students are seen to engage in activities in a limited way based on teacher’s directives. A participant was quoted as,

> “Before I involve any ICT platform in my instruction, I need to know how to properly use it, so that, I can also effectively guide my students on how to use for organizing their materials I give.” P04-U1

The role of students from category ‘C’ to ‘D’, shifts from less active to more active where students are seen becoming more responsible for acquiring knowledge and skills related to problem solving on their own. Students are also seen having access to all the necessary ICT resources and devices that support their learning activities toward subject matter (content). A participant says,

> “Of course, as a teacher you have got to show perfect by giving guidelines but the students sometimes end up going six steps a head using computer and internet. What is the ultimate objective?” P09-U1

The role of student in category ‘E’ is the highest level of engagement in learning. Student’s active learning via ICT is seen getting beyond subject matter towards innovation. The activities student is getting involved in using authoring software, advanced analytical software, tutorials and You Tube videos is seen to develop a sense of ability to analyze, evaluate, create new ideas and be able to provide alternative solutions to solve existing problems at workplace. A participant observes,

> "Much of the technology talked about here, were invented and designed by electrical engineers, which is important to let students know. In order to improve for the future, in a way that communities benefit, I guide my students in applying ideas toward creating new and better products." P07-U1

The role of student is to receive information and partially respond to teaching within teacher's demand in the lower categories, 'A' 'B' and 'C'. In upper categories, 'D' and 'E', the role of student is to own responsibility by engaging into active learning using myriads of ICT tools within and beyond subject matter.

4.2.4 Fourth dimension: TPACK components

Fourth dimension is a relationship that emerged as a result of expansion from category 'D' to 'E'. It represents the expansion in the way TPACK components are used in the five categories of description. TPACK components are seen adjoining and becoming more compact towards the higher levels of categories of description. This is seen as a result of active learning towards innovation.

Table 7. TPACK components

Category		TPACK Components
A	Teaching as imparting information	Technology and Content focused, pedagogy and knowledge are very limited
B	Teaching as transmitting structured knowledge	Technology and Content Knowledge focused, Pedagogy is not dominant
C	Teaching as offering guided learning	Technology and Content Knowledge focused; Pedagogy is moderately present
D	Teaching as engaging students toward practice	Technology, Pedagogy and Content Knowledge focused
E	Teaching as engaging students toward innovation	Technology, Pedagogy and Content Knowledge focused (advance level of interaction among the components)

For category 'A', teaching and learning is mainly focused on Technology and Content [TC] components. Teacher is seen using technology to access and transmit subject content to the learners. Therefore in category 'A', not all TPACK components are vividly seen present. Limited ICT tools such as email, Google classrooms, power point slides, pdf files and YouTube videos are common during teaching. For example, a participant believed that technology gives access to learning materials you physically do not have. Therefore you can have access to as many copies of pdf books as you may need. One of the participants marks,

> "I always use presentation slides and whatever goes more than two hundred slides, no problem because they [students] have their copies, all they need is to put in some concentration in order to pass their exams" P07-U1

In Category 'B', teaching and learning process is not only about the Technologies used and Contents accessed but also Knowledge [TCK] passed in the contents of transmission to learners [TCK]. The presence of TPACK components are seen expanding from Technology and Content to Knowledge during teaching. ICT tools such as power point presentations, pdf editors, picture managing applications, multimedia design tools and word processors are used to simplify and summarize content for easy understanding by the student. A participant envisages that,

> "Computer graphics is basically output oriented I mean the outcome of every class [programming] is an image produced. Coloring, texture and shading are easily adjusted and simple for students to comprehend." P12-U2

Moreover, another participant mentions that,

> "Well, I think that ICT actually helps teachers more because some of the contents presented in the slides or in other related ICT tools are self-explanatory. Students just get ready made things to read, sit for examination to express their understanding." P02-U1

Category 'C' is Technology and Content Knowledge focused. Pedagogy is moderately present. ICT tools such as overleaf/online LaTeX editors, collaborative web 2.0 tools, presentation software and Google document are being used to guide teaching and learning process. One of the participants illustrates that,

> "…. maybe you expect 60% output from what you give students [Content and Knowledge] which will be impossible to attain if you didn't guide them well, yes some students can manage but they really need some guidance because we do not just teach anyhow [Pedagogy], we have some syllabus to follow. Based on this syllabus we tell them what to do." P05-U1

Category 'D' is Technology, Pedagogy and Content Knowledge [TPACK] focused. Active learning is seen throughout the whole process of teaching and learning. Myriads of ICT tools such as authoring software, programming languages, evaluation and analytical software are seen commonly used during learning process. A participant notices that,

> "…..whenever students browse [technology] many different things, they may get important information from other view-points [Learning style]. This gives them the exposure of how people think on the topic [Content] and therefore do not only depend on my views alone [Knowledge] as methods known vary from person to person [Learning approach]." P10-U1

Category 'E' is not only institution specific TPACK interaction focused but the advanced level of interaction among TPACK components is also seen. ICT is seen to create learning activities that support globalization of content, active learning practices and knowledge sharing through cloud computing powered ICT tools such as collaborative and interactive web 2.0 tools. A participant declares that,

> "Look, Students are more motivated in learning [Knowledge] from their own digital sources [Content and Technology] maybe due to the way they are designed [Learning style]." P03-U1

While another participant points out that,

> "I will allow students to teach themselves [Knowledge creation] because some students will like to exhibit their knowhow or they understand something that they would like to teach their fellow students [Learning style/Pedagogy]. So I give them the opportunity to work in groups so as to share [Technology] what they understand [content]." P05-U1

In brief, the purpose of ICT is for interaction, access and transmission of information in the lower categories, 'A', 'B' and 'C' and for active learning in the upper categories, 'D' and 'E', of the first dimension. The role of teacher is to access and transmit information while establishing communication with students in the lower categories and creates learning environment while guiding students to learn in the upper categories of the second dimension. In the third dimension, the role of student is to receive information and partially respond to teaching within teacher's demand in the lower categories and engagement in active learning in the upper categories. For the fourth dimension, Technology, Content and Knowledge [TCK] components of TPACK are applied with limited knowledge in category 'A', pedagogy not dominant in 'B' and moderate in 'C'. In category 'D', all the TPACK components are at acceptable level, while in 'E', TPACK components are applied at advanced level. Following is a summary of discussion on the relationships among the categories of description.

4.2.5 The summary of relationships among categories of description

The analysis process revealed five qualitatively different categories of description of ICT enhanced teaching as follows: -

A: Imparting information
B: Transmitting structured knowledge
C: Offering guided learning
D: Engaging students toward practice
E: Engaging students toward innovation

The five categories of description are in adjoining relationship from category ‘A’ to ‘E’. Two broader relationships emerged; what teacher does during teaching process [internal role] and what teacher does during student learning process [external role]. Teacher’s roles are discovered internally in the first two variations [purpose of ICT in engineering teaching and role of teacher] and externally in the last two [role of student and TPACK components]. The foci are unique from one another in a way that information is seen originating from teacher then transmitted to student in the internal role while for external role, teachers’ focus shifts to students’ active learning through creating ICT enabled learning environment. Teacher’s role is seen expanding with focus shifting from imparting information [category ‘A’] to transmitting structured knowledge [category ‘B’]. In category ‘B’, the focus is on content simplification for students to understand. For example, in the first variation [purpose of ICT in engineering teaching], emphasis is put on teacher’s use of technology for organizing content/knowledge for learners. Therefore, the role of teacher in category ‘A’ and ‘B’ is to transfer information to the students, shown in Table 4. Table 5 represents the second dimension with aspects of category ‘B’ [transmitting structured knowledge] and ‘C’ [offering guided learning]. In category ‘C’, teachers’ focus shifts to establishing communication with students. Teacher determines what interactive communication to have with students during teaching. Students are partially passive and active depending on whether teacher requires them to receive information or respond [demonstrate] to teaching. The emphasis on teacher’s expert knowledge in the first three lower level categories ‘A’, ‘B’ and ‘C’ shifts to facilitating role in Tables 6 & 7. Teacher provides guidelines and instructions for student engagement in active learning. Teacher focuses on creating learning environment for acquiring knowledge and skills within [category ‘D’] and beyond [category ‘E’] the syllabus of subject matter.

Table 8. Relationships among categories of description underpinning pedagogy

Variations	Categories of description				
	Category A	**Category B**	**Category C**	**Category D**	**Category E**
Purpose of ICT in engineering teaching	Access & transmission	Structure & transmission	For building communication	For active learning space	For wider active learning space
Role of teacher	Conveys information	Conveys structured knowledge	Establishes communication	Creates learning environment for subject matter needs	Creates learning environment beyond subject matter needs
Role of student	Receives information	Receives structured knowledge	Receives information/ Responds to teaching	Engages in learning within subject matter (active)	Engages in learning beyond subject matter (active)
Technological Pedagogical Content Knowledge [TPACK] Components	TC focused, limited P and K	TCK focused, limited P	TCK focused, moderate P	TPACK acceptable level of application	TPACK advanced level of application

In a nutshell, the demonstration of dimensions of variation from 1 to 4 in section II satisfies the second specific objective, that is, to determine the relationships [dimensions of variation] among teaching approaches of engineering university teachers such as, purpose of ICT in engineering teaching, role of teacher, role of student and TPACK components and hence the outcome space as follows.

4.3 Section III: The outcome space

In this section, further meaning of the five qualitatively different categories of description is discussed through the structural representation of the findings [categories of description and dimensions of variation].

Four dimensions of variations emerged supported by participants' excerpts in the transcripts. Following are variations among the categories of description: -

1. Purpose of ICT in engineering teaching
2. Role of teacher
3. Role of student
4. TPACK components

Engineering teachers' experiences of ICT enhanced teaching were discovered in a way of conceptions. The referential perspective represents the 'What aspects' of engineering teachers' understanding of ICT enhanced teaching and structural perspective is represented by the 'How aspects' of the different conceptions of teachers' flow of thoughts in order of arrangement.

Table 9. University teachers' response to ICT-use in teaching

Dimension of Variations	**Categories of description**				
			Expansion ⟷		
	Category A	**Category B**	**Category C**	**Category D**	**Category E**
Purpose of ICT in engineering teaching	Limited	Moderate	Significant	More significant	Most significant
Role of teacher	Delivery	Delivery	Delivery	Facilitator	Facilitator
Role of student	Passive	Passive	Partially passive & active	Active	More Active
TPACK Components	Least applied	Less applied	Moderate application	Acceptable application	Advanced application

Table 9 represents the pedagogical implications as a result of the relationship between categories of description and dimensions of variation. It is observed that, the first dimension of variation [purpose of ICT in engineering teaching], expanded from category 'A' to 'B', 'C', 'D' and 'E' respectively. The purpose of ICT in engineering teaching is limited and moderate in categories 'A' and 'B' respectively. It is significant in category 'C', more significant in 'D' and most significant in 'E' respectively. In the second dimension of variation, role of teacher, is to deliver information to students apparent in categories ['A', 'B' and 'C'], teachers are partially facilitators in category 'C', and full facilitators in categories 'D' and 'E' which relates to levels of significance of purpose of ICT in engineering teaching. This implies that, students are typically passive to knowledge in categories 'A' and 'B'. In category 'C', students are partially active to knowledge and fully active in categories 'D' and 'E'. The increasing levels of significance of purpose of ICT in engineering teaching apparent in categories ['C', 'D' and 'E'] relates to students' involvement in active ['D'] and more active ['E'] learning practices, accepted and advanced levels of applying TPACK components.

Therefore, ICT enhanced teaching conceptions expand toward student centered learning with increase in the significance of purpose of ICT in engineering teaching and hence answers the second research question: 'To what extent does the teachers practice ICT enhanced teaching in classroom?' Following is the structural illustration of outcome space of teachers' conceptions of ICT enhanced teaching

Table 10. Outcome space of teachers' conceptions of ICT enhanced teaching

Referential aspect (What aspect)		**Structural aspect (How aspect)**			
Categories of description		Teacher-centered/ content oriented	Teacher-centered/ activity oriented	Student centered/ activity oriented	Student centered/ industry oriented
A	Teaching as imparting information	**A**			
B	Teaching as transmitting structured knowledge	**B**			
C	Teaching as offering guided learning		**C**		
D	Teaching as engaging students toward practice			**D**	
E	Teaching as engaging students toward innovation				**E**

The result of categories of description and their variations led to the hierarchical outcome space in Table 10 (Limberg, 2000; Marton, Saljo, 1976). The referential and structural aspects of the study discerned two broad structural categories grouped as teacher-centered and student-centered conceptions. The student-centered approach further expanded into student-centered/Activity-oriented and student-centered/Industry-oriented as the most student centered conception of the study outcome. The five qualitatively distinct categories of description vary from teacher-centered/content oriented to student-centered/Industry oriented. Categories 'A', 'B' and 'C' are structurally placed under teacher-centered orientation because teachers' role is to deliver content with an average use of ICT in engineering teaching. This leaves no alternative options for teachers in a socio-economic situation and limited ICT knowledge and skills to appropriately teach a subject.

The use of ICT by university teachers during teaching process is seen to reveal a better understanding of student learning in categories 'D' and 'E' because students are responsible for their own learning process. Therefore, categories 'D' and 'E' are structurally placed under student-centered orientation. In category 'D', students become fully engaged in acquiring knowledge and skills on subject matter placed under student-centered/Activity oriented paradigm. While in category ‘E’, students are seen to fully engage in acquiring knowledge and skills beyond their subject matters, believed to lead them towards developing expertise knowledge with innovative minds.

4.4 Conclusion: The main research objective was to investigate engineering university teachers’ perceptions and practices of ICT enhanced teaching in Bangladesh. The analysis result revealed five qualitatively different meanings of ICT enhanced teaching to engineering university teachers, as follows, imparting information, transmitting structured knowledge, offering guided learning, engaging students toward practice, engaging students toward innovation. Four relationships emerged among the categories of description, such as, purpose of using ICT in engineering teaching, role of teacher, role of student and TPACK components. The fifth category of description [engaging students toward innovation] and the fourth dimension of variation [TPACK components] are new findings of the study. The analysis result illustrated in Table 9 and explained in its subsequent summary provides evidence of engineering university teachers’ practices of ICT enhanced teaching in Bangladesh, which is expanding towards student-centered learning.

Chapter five: Discussion and conclusion

5.0 Introduction

The aim of this study was to investigate engineering university teachers' conceptions of ICT enhanced teaching. The results are reported in chapter four. Chapter five consists of discussion and conclusion. The research questions, summary and reflection on the research, implications and contributions of the research study to existing knowledge, future research work and limitations. The study findings revealed five qualitatively different categories of description and four relationships among them as follows: -

A: Imparting information
B: Transmitting structured knowledge
C: Offering guided learning
D: Engaging students toward practice
E: Engaging students toward innovation

And four dimensions of variation

1. Purpose of using ICT in engineering teaching
2. The role of teacher
3. The role of student
4. TPACK components

5.1 Discussion

The five qualitatively different categories of description represent different characteristics of university teachers' conceptions of ICT enhanced teaching and range from teacher centered/content oriented to student-centered/industry oriented. Categories of description 'A' and 'B' are considered less complex ways of teaching because in category 'A', teacher simply focuses on transferring/delivering syllabus information to the student and in category 'B', the emphasis is on simplifying content before delivery for students to easily understand. While for category 'C' [offering guided learning], interactive environment is created for building good relationship with students through communication. The good communication relationship has been seen as a way for students to respond to teaching contrary to entirely being passive in category 'A' and 'B'. Students are seen not getting scared of and worried for making mistakes in class while learning. Teachers look at this, as a way of identifying areas of emphasis in the content and sharing teaching responsibility.

The present result not only relates to the broad framework of teacher centered and student centered orientations but also agrees with the transitional/intermediary category between the two orientations. Category ‘C’ [offering guided learning] links categories ‘A’ and ‘B’ to ‘D’ and ‘E’. The intermediate category ‘C’ of the present study relates to finding by Kember (1997). Kember identified student teacher interaction as intermediate category where the interaction between teacher and student was found important. Academics were reported encouraging students to predict demonstration results before they were told however, Samueeowicz and Bain (2001) later did not find the linking category in their study and further claimed that the idea of Kember’s intermediate category was from their work of 1992. The level of interactivity/communication during teaching remains within teacher’s framework [control] in category ‘C’. Category ‘D’ [engaging students toward practice] is a more sophisticated way of teaching. Teaching focus shifts from information delivery to student learning. There are two levels of conceptions in category ‘D’, first, as a facilitator for students to acquire the necessary information they need and secondly as a facilitator to guide and instruct students to acquire knowledge and skills for improving their subject matter. In category ‘D’, students are seen actively involved in activities that develop their skills and knowledge in content modification and enhancement.

Category ‘E’ [engaging students toward innovation] is the most sophisticated conception held by engineering teachers. Teachers teach for students’ creation of new knowledge and skills as solution to industry challenges related to innovation. Four levels of conceptions are acquiring teaching knowledge and skills for personal development, acquiring knowledge and skills for enhancing subject matter, acquiring knowledge and skills in subject matter for improving other knowledge fields and acquiring knowledge and skills to encounter challenges in teaching and learning. The teaching intentions in the higher categories include awareness of the teaching intentions in the lower categories but not otherwise. For instance, the teaching intention in category ‘A’ [imparting information] expands to intentions in category ‘B’ [transmitting structured knowledge] by additionally focusing on student understanding before information transmission and so on respectively. Teachers with teaching conceptions in the sophisticated categories such as ‘D’ and ’E’ possess more teaching alternatives as opposed to the teachers with conceptions in the lower categories such as ‘A’, ’B’ and ’C’.

Four categories ‘A’, ‘B’, ‘C’ and ‘D’ are consistent with findings from previous studies unlike ‘E’ [engaging students toward innovation]. Categories ‘A’, ‘B’ and ‘D’ that is imparting information, transmitting structured knowledge and engaging students toward practice relate to findings by Kember and Kwan (2000). Category ‘A’ and ‘B’ have also been reported by Degago and Kaino (2015). Meanwhile category ‘C’, offering guided learning supports Kember (1997) transitional conception linking teacher centered to student centered conceptions. However, category ‘E’ is a new knowledge in engineering education. Phenomenographic study of teachers’ conceptions of ICT enhanced teaching in engineering education has not been found in the available literature in general and Bangladesh in particular.

Phenomenography research design leads to insights connected to empirical research associated with cognitive viewpoints (Bailey, 2008). Recently a quantitative study conducted by Lin et al. (2021) investigated pre-service technology teachers’ cognitive structures and how they construct engineering design in technology learning activities and realized that, further exploration for solutions to the weaknesses of teachers’ pedagogical engineering design thinking in relation to using technology is necessary. The present study discovered five pedagogical approaches to engineering teaching using ICT which may enhance the practices of engineering designs. Cropley (2015) informed that, there are three creative engineering problem solving approaches, they are forward incrementation, redirection and re-initiation, henceforth, new engineering problems require new technological solutions [re-initiation], yet little support is provided for creative students. In the present study, engineering students use ICT tools for creative learning activities toward innovation apparent in category ‘E’ [engaging students toward innovation]. In category ‘D’, creative ideas developed and practiced by students through ICT extends previous literature by the attained ability to acquire the necessary information needed for student’s own learning [forward increment] and improve their problem solving skills [re-direction]. Additionally, category ‘B’ enhances previous findings through easy follow up of content information, and category ‘C’ through attainment of good teaching habits along with sharing teaching responsibility. Category ‘E’ therefore, emanates four levels of new knowledge as developing teaching knowledge and skills, contributing to departmental/disciplinary growth, contributing to community development and responding to global industry challenges.

Table 11. Previous studies consistent with the present findings

Conceptions	(Kember, 1997)	(Kember & Kwan, 2000)	(Degago & Kaino, 2015)	(Tsai & Tsai, 2019)	Current study
Less complete					
(Knowledge transmission)	Imparting information	Passing information	Satisfying syllabus demands	Technology support	Imparting information
	Transmitting structured knowledge	Making it easier for students to understand	Presenting structured information	Knowledge transmission	Transmitting structured knowledge
Intermediate	Teacher-student interaction				Offering guided learning
More complete (Learning	Facilitating understanding	Meeting students learning needs	Helping students learn	Learning facilitation	Engaging students toward practice
facilitation)	Conceptual change	Facilitating students to become independent learners	Helping students expand their knowledge	Supporting students to learn	Engaging students toward innovation

In order to identify relationships, four dimensions of variation among the five categories of description emerged reported in chapter four. Dimensions of variation were purpose of ICT in engineering teaching, role of teacher, role of student and TPACK components. The second [role of teacher] and third [role of student] dimensions of variation have been reported in many previous studies, for example, Degago and Kaino (2015); Khan (2015). The fourth dimension that is TPACK components is new information. Degago and Kaino, (2015) reported essence of teaching in a traditional face to face approach closely related to purpose of ICT in engineering teaching, however, the prior study did not consider ICT for creating space for student learning towards innovation. Advanced ICT is used for advanced application of Pedagogy, Content and Knowledge by creating and accessing knowledge beyond subject matter through the various software/applications and free online courses respectively, which translates into a new knowledge in engineering teaching.

The relationship between engineering university teachers' conceptions of ICT enhanced teaching and using ICT for teaching engineering subjects was discovered in this study. Lecturers with teacher centered conceptions were more likely to teach engineering subjects that require advanced ICT knowledge and skills inappropriately noticeable in categories 'A', 'B' and 'C'. Students are passive and restricted to only teacher's knowledge though in 'C', controlled interaction was present but still remained within teacher's framework. Teachers in this category gave the impression of very limited interest in using ICT in teaching engineering subjects. On the other hand, student centered teachers seemed to be more likely to outmaneuver through advanced ICT tools and resources to address engineering subject needs evident in the last two categories, that is, engaging students toward practice and engaging students toward innovation. Teachers with student centered conceptions were more likely to teach engineering subjects that require advanced ICT knowledge and skills appropriately. Hodgson and Shah (2017), reported results relating contextual socio-economic and technology limitations, conception of using learning technology and pedagogy by geographical context of South Asia in general and Pakistan in particular. Technological limitations were found affecting teaching approaches in the various knowledge fields such as science, arts, health science, law and administrative science, which, to some extent relates with the present result. There was also relationship of technological limitation with lecturers' conceptions of using learning technology, closely related to the present finding.

However, Bangladesh [a developing country] in South Asia is where the present study was conducted and the technological limitation referred to in the present study is ICT knowledge and skills in relation to engineering subject requirements/needs, contrary to the more general views in the prior study. Additionally, ICT practices during engineering teaching were also found relating to teachers' conceptions of ICT enhanced teaching. Therefore, the relationship between engineering university teachers' conceptions of ICT enhanced teaching, ICT knowledge and skills for teaching engineering subjects and pedagogical approaches is a new knowledge that can be applied in all the engineering departments toward student development. ICT related pedagogical development within engineering field is seen having better alignment with engineering subject requirements across different engineering departments/disciplines.

Moffitt (2020), a United Kingdom based investigation, found that, the aspects of scholarly interactions with theory in TEL relates to academics' competence, criticality and enhancement in teaching practices which is important and meaningful for scholarship. The author further informed that, the conceptions of scholarly interactions with theory in TEL relates to academics' use of theory for their teaching-focused scholarship identities. The findings reflect to the present result, for example, the ICT related teaching approaches [pedagogies] discovered in this study could result into improving engineering teachers/students' competence, criticality and enhancement in developing scholars in engineering fields. Elsewhere, constructivists perceptions of teaching using mobile devices show quality technology integration in their lesson plans (Tsai & Tsai, 2019). The perceptions relate to the present analysis results of categories 'D' and 'E', in terms of significance of purpose of ICT in engineering teaching. The more significant the purpose of ICT in engineering teaching, the likely engineering subject lesson plans could be enhanced.

In a nutshell, engineering teacher's pedagogical approach to teaching engineering subject is underpinned by engineering related ICT knowledge and skills. The study illuminated five pedagogical approaches to engineering teaching and four dimensions of variation among them, of which, the last [engaging students toward innovation] and [TPACK components] respectively, were new knowledge, along with, other insights, for example, category 'B' and 'C', easy follow up of content and sharing teaching responsibility respectively. Insight regarding dimension, relates to purpose of ICT in engineering teaching as discussed above. Following is the study implication/contribution to engineering education.

5.1.1 Implications of the study

The findings have implications to four categories of higher education stake holders, that is, the teachers, policy makers, curriculum designers and students. The better use of ICT in teaching can lead to achievement of teaching and learning aims which depend on teacher's approach of and conception to teaching (Prosser & Trigwell, 1997; Trigwell & Prosser, 1996). Previous phenomenographic studies have revealed findings relating to incorporation of ICT into teaching practices, for example, Khan (2014b). The practical application of ICT knowledge is seen as an effective instructional technique (Koehler & Mishra, 2005). It is also reported that, the relevance of courses is underpinned by the balance between theory and practical (Ed et al., 2010). According to Cropley (2015), the engineering problems caused by change require new and effective technological solutions.

Therefore, the present findings revealed the following implications: -

- Provision of knowledge for engineering university teachers' further understanding of ICT enhanced teaching in the perspective of engineering education.
- The five pedagogies discovered in the present study could be adopted for implementation by different institution policy makers. Teachers would then incorporate the pedagogies into their instructional practices for enhanced student learning outcome in engineering education.
- The findings are important for curriculum designers in decision making during course, subject and content selection/development for enhanced relevance of engineering university education.
- It also has implications on teaching and learning, for instance, creating space beyond teachers/students major knowledge field/areas.

5.1.2 Recommendations for Engineering Education

- Teachers should embark on advanced use of TPACK components to enhance their engineering knowledge and skills for addressing global engineering challenges such as teaching and learning.
- Engineering departments should adopt ICT-driven pedagogies to teaching engineering courses for addressing new problems/challenges with innovate minds, for example, category 'E' [engaging students toward innovation]
- Engineering departments should place emphasis on identifying or selecting courses, subjects and contents based on available ICT knowledge and skills related to such contents
- Engineering university teachers and students should engage in application of TPACK components at advanced level for expertise development within and beyond their knowledge fields to minimize expenses on expert hiring

5.1.3 Limitations of the study

Phenomenography is a context based research orientation, investigating peoples' understanding by collectively analyzing their subjective experiences of the world around them. The more general context of a specific case [phenomenon] is described, the better is the validity and the basis for generalization (Queensland University of Technology, 1994). Contextual generalization of phenomenographic study outcome also depends on the explorative character of data collection and the contextual analytic character of the treatment data (p. 18). In the present study, description of the general context of engineering university teachers conceptions of ICT enhanced teaching, for instance, regarding substantial coverage of up to six different engineering departments in two prominent engineering universities and the contextual analytic character justify generalization of the findings for Bangladesh engineering universities, excluding other tertiary institutions of learning because teaching practices vary with teaching contexts.

Although many previous phenomenography studies have used interview for data gathering Degago and Kaino (2015); Hodgson and Shah (2017); Gonzalez (2009); Tsai and Tsai (2019), what university teachers say about their practice and does not directly observe what they do is at risk of telling half the story (Kane et al., 2002). Yet, developing university teachers' conceptual understanding on the nature of teaching and learning is believed to have more impact on teaching than methods and techniques (Prosser & Trigwell, 1997; Trigwell & Prosser, 1996, 1997). Therefore, there is more to the experience of being a teacher than simply teaching because teaching experience [methods and techniques] is believed to have separated from greater experience of being a teacher [conceptual understanding] (p. 11). This sort of scenario might result into provision of inappropriate data by the participants through interviews. However, researcher minimized this limitation through follow-up questions to participants diverting from their conceptual views about the phenomenon under discussion.

Sampling should be aimed at capturing variety of experiences rather than generating statistically balanced representations or relationships (Alsop & Tompsett, 2006). Therefore, in this study, the specifics relating to why and how of teaching experiences, age, gender and discipline influencing university teachers' conceptions of ICT enhanced teaching were not focused upon during analysis because views were categorically considered towards finding. Sampling and outcome criticisms have been an issue for quite a long period of time, for example, Hazel et al. (1997) reported that poor women representation [patriarchal] in the sample causes a distorted outcome space by not paying attention to the hidden and explicit aspects of what learners are coming to know. The study further claimed that outcome spaces are mostly defined in cognitive terms other than affective dimensions often related to women's ways of knowing. Of the 14 participants sampled for the study, two were females. Further, phenomenography as a research approach has undergone a number of critiques such as facing comparison with the practices of phenomenology. Stolz (2020) expressed concerns of the chances of viewing the concepts of the two research approaches as 'one-and-the-same' in educational setting due to the ways of picking and choosing ideas, concepts and methods.

5.1.4 Recommendation for Further Research

The solution to the research problem investigated in this study has led to an extension for further study. A quantitative investigation to determine impact of pedagogical approaches to teaching underpinned by ICT-use in engineering education is recommended.

5.2 Conclusion

The purpose of this study was to explore engineering university teachers' conceptions of ICT enhanced teaching in Bangladesh. It sought to investigate the research questions: 'What do the engineering university teachers in Bangladesh perceive of or mean by ICT enhanced teaching?' and 'To what extent does the teachers practice ICT enhanced teaching in classroom?'

It is a qualitative research conducted using phenomenography approach. In-depth semi-structured interview was used to gather data through audio/video recording. Five qualitatively different teachers conceptions emerged out of which, the first four were consistent with previous findings meanwhile the last one [teaching as engaging students toward innovation was a new knowledge]. Four dimensions of variation were identified from categories of description. The first three were found consistent with previous findings and the fourth [TPACK components was a new variation]. The conceptions in the study were consistent with teacher centered and student centered framework. The first three conceptions are teacher centered and the last two are student centered. The findings have implications on pedagogical development within the various engineering departments/disciplines by appropriating ICT knowledge and skills for teaching engineering subjects. It also has implication on aligning teachers' perceptions and attitudes toward ICT enhanced teaching in engineering education. However, some limitations were found that relates to context, interview data, sampling and outcome space. In brief, a quantitative investigation to determine impact of pedagogical approaches to teaching underpinned by ICT-use in engineering education is recommended. This study finally confirms that, engineering teacher's pedagogical approach to teaching engineering subject appropriately is underpinned by engineering related ICT knowledge and skills of the teacher.

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APPENDICES

APPENDIX I: Participant Information Sheet (PIS)

The details below show the basic information about the study you are about to contribute upon. You are requested to go through it for convenience purposes during the exercise.

What is the study about?

The study is about university engineering teachers' conceptions of ICT enhanced teaching.

Who is conducting the study?

The study is conducted by Mboka Khalid, a student of Master of Science in Technical Education (MScTE), department of Technical and Vocational Education (TVE), Islamic University of Technology (IUT), bearing Student Number: 181031403. The researcher is under the supervision of Prof. Dr. Shahadat Hossain Khan of TVE department, IUT.

1. What does the study involve?

a) Conducting face to face audio/video recorded interviews with engineering lecturers.
b) Use of the recorded data to generate findings for the purpose of publication and fulfillment of course requirement.
c) Interview data shall be destroyed if not used or kept confidential if still needed for the study.
d) The information about the participant shall not be displayed in public during the study

2. How much time will the interview take?

The interview is scheduled take 30-40 minutes) per participant

3. Can I withdraw from the study?

Participation in this study is voluntary and therefore, no obligation. You are free to withdraw as a person as well as the data you have already provided if you so wish to which I don't hope for. Your participation is highly regarded in the success of this study.

4. Will anyone else know the results?

The result of this study can only be known to others after the research committee of Islamic University of Technology liaises with the external experts to approve it through a successful defending before the panel. Besides, it will be submitted to the University as partial fulfillment for the award of Masters of Science in Technical Education in Computer Science and Engineering.

5. Will the study benefit me?

Participating voluntarily in the development of this study has no direct benefit [reward] but indirectly benefit can be through the findings to improve ICT enabled teaching and learning

6. Can I let other people know about the study?

Telling other people about the study is okay as it may lead you to developing more insight to what is required in the interview.

7. What if I require further information about the study or my involvement in it?

Further information about the study during its development process is welcome by both researcher and supervisor.

APPENDIX II: Participant Consent Form

Name of the researcher: **Date: …………………...….**

…………………………. **Signature: ………………..**

Title of the study:

Engineering university teachers' conceptions of ICT enhanced teaching:

Bangladesh perspective

<u>Instructions</u>

Please you are requested to confirm your willingness to participate in this study by going through the summary of the concepts from the Participant Information Sheet.

I have had the research satisfactorily explained to me in the Participant Information Sheet dated……………..….

I understand that the research will involve interview for 30-40 minutes which will be audiotape recorded.

I understand that I may withdraw from this study at any time without having to give an explanation and without any future consequences upon me.

I understand that all information about me will be treated in strict confidence and that I will not be named in any written work arising from this study.

I understand that any audiotape material of me will be used solely for research purposes and will be destroyed on completion of the study.

I consent to use of data in the research.

Name of Participant	**Date**	**Signature**
………………………………….	**…………………….…**	**………..…………**

APPENDIX III: Interview Guide

Purpose of the interview

The main purpose is to collect data on the varying teachers' understanding of ICT supported teaching in Bangladesh universities.

Demographic Information

1. Since how long have you been in ICT enhanced teaching?
2. What role do you play during teaching using technology?
3. What do you teach using ICT?

Topic 1: Conception of ICT enhanced teaching

4. Basing on your teaching experience, what does ICT enhanced teaching mean to you? Or what does teaching using ICT mean to you?

   Probes

   i) "…..teaching differently using technology every year!"

   ii) Highlight more on that please?

Topic 2: Reasons for ICT enhanced teaching

5. Why do you use ICT in teaching?

   Probes

   i) As mentioned earlier, what's the importance of teaching that is different every year?

   ii) Could you highlight more on [specific point] please?

   iii) Would you prove that with an example please?

Topic 3: Ways or methods of ICT enhanced teaching

6. a) How do you use ICT in an enhanced teaching?

   Probes

   i) Highlight more on the activities provided by this tool during teaching?

   ii) How important are such activities in student learning?

7. How does teaching using technology generally of benefit?

   Probes

   i) To you as a teacher? Expecting examples

   ii) To your learners? Expecting examples too

   iii) How do your learners apply ICT in learning during teaching?

Is there anything you would like to add that you think would be helpful in the study in relation to our discussion?

APPENDIX IV: Researcher Experience

There are three main areas to share about researcher's experience during this study. They are categorized as pre-study experience, interview experience and analysis experience as follows.

The pre-study experience

This sub-section describes activities that the researcher went through during the identification of problem area. This is important because of the high stakes toward new academic adventure. The journey started by getting through a systematic orientation process of understanding phenomenography enquiry in terms of its contributions, limitations and prevailing debates in the field of educational research thanks to my supervisor Prof. Dr. Shahadat Hossain Khan. The researcher got engaged in deep thoughts about conception, enhanced teaching and learning technologies through related previous studies. The vision and interest in phenomenography research approach kept developing each time I found something new. A lot of questions and answers to myself became order of the day for instance, teachers' different approaches to teaching being informed by their different beliefs and understanding of a phenomenon was making it look possible to influence such beliefs for better approaches toward better learning practices. This appeared promising especially in a situation where better teaching approaches implemented across different engineering departments would likely result into appropriate ICT use in addressing specific engineering course requirements. The researcher finally decided to explore university engineering teachers' conceptions of ICT enhanced teaching.

Experience during interview

Data collection process was one of the challenging experiences the researcher encountered during the study for example pilot and final interview. The first pilot interview result revealed many clumsy aspects including using more minutes than stated, providing idea or clue to the posed question, uncoordinated and aimless follow up questions. Together with pilot participants, mistakes were analyzed and interview was repeated for confirmation. The exercise had a great impact on the quality of the final interview in many aspects for example confidence, focus and interactivity with participants that consisted of instructors, Assistant professors, professors and Associate professors. The first main Interview started on 13^{th} February, 2020 up to 11^{th} March, 2020 when most of Bangladesh university activities came to a standstill due to Covid19 pandemic. The few remaining interview programs scheduled for Match, 2020 were interrupted though contacts and visitations were already made to the distant university. Interviews continued in May through online meetings with its own constraints. Some of the participants objected video interview recording but since interview approach targets to get more insights through reading participant's body language, the researcher was able to convince the participants to accept video recorded interviews to compensate for lack of face to face interaction.

Experience during analysis

This was the most challenging experience the researcher faced. The process was hectic and time consuming with a lot of interpretations, judgments and data representations. The researcher transcribed data in Microsoft word and cross checked it by listening to the audio records for the second time while following the text for participants verbatim. This activity resulted into misrepresentations which were later corrected. The data misrepresentation was mainly due to the difference between the accent of the researcher and the participants. A native master student was invited to help translate by writing on a piece of paper what specific participants meant in the audio recording. One of the worst experiences was categorizing views that appeared to have either similar or different attributes in relation to different or similar meanings for example views from two different participants may look to would appear to have similar attributes yet are different by meaning. In situations like this, the researcher takes a break and revisits the problem with freshness and starts by reading the transcripts. This repetitive act of revisiting the transcript data helped in producing findings with integrity