COMPARISON OF TECHNOLOGICAL KNOWLEDGE, CONTENT KNOWLEDGE, AND TECHNOLOGICAL CONTENT KNOWLEDGE AMONG UNDERGRADUATE STUDENTS AT INTERNATIONAL ISLAMIC UNIVERSITY ISLAMABAD

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AUTHOR'S DECLARATION

It is hereby declared that author of the study has completed the entire requirement for submitting this research work in partial fulfillment for the degree of MS Education. This thesis in its present form is the original work of the author except those which are acknowledged in the text. The material included in the thesis has not been submitted wholly or partially for award of any other academic certification than for which it is being presented.

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SUPERVISOR'S CERTIFICATE

The thesis titled "Comparison of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among Undergraduate Students at International Islamic University, Islamabad" submitted by Ms. Qudsia Shami Regd. No. 1- FOE /MSEDU/ S23 is partial fulfillment of MS Education, has been completed under my guidance and supervision. I am satisfied with the quality of student's research work and allow her to submit this for further process as per IIUI rules and regulations.

Prof. Dr Samina Malik

DEDICATION

In the name of Almighty Allah, the Most Gracious, the Most Merciful. I dedicated this thesis to Almighty Allah, who gave me the strength and patience to complete this work, to my family members, for their continuous prayers, love, and moral support, to my dear husband, for his continuous support, quiet sacrifices and believe in me. This achievement is as much yours as it is mine. May this work serve as a small step toward the endless pursuit of knowledge. Ameen sum Ameen

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QUDSIA SHAMI

ABSTRACT

In the current educational scenario, technological knowledge seems to have gained unimagined significance in its connection with content knowledge. By applying related tools of Technological Knowledge efficiently, the undergraduate students become confident to deliver their content effectively. The basic purpose of the study was to compare the levels of Technological Knowledge, Content Knowledge and Technological Content Knowledge among undergraduate students across different faculties in the particular context of International Islamic University, Islamabad. The objectives for the study were to assess and compare the Technological Knowledge, Content Knowledge, and Technological Content Knowledge among undergraduate students enrolled at IIUI. Another objective of the study was to explore the factors and problems that are associated with these knowledge levels. The population for the study included all female undergraduate students of different faculties from 2nd semester those were studying course of “Applications of Information and Communication Technologies” during their semester Fall 2024. The population of the study was comprised of 1343 undergraduate students. Using Stratified Random sampling technique sample of 297 students was selected ensuring maximum representation from different faculties. The study employed Mixed Methods approach to collect data from undergraduate students from varied academic faculties. Five-point Likert scale questionnaire about statements related to; Technological Knowledge, Content Knowledge, and Technological Content Knowledge was used. A general knowledge MCQ test regarding basic knowledge about computer was taken from respondents to counter check their self-reported data about content knowledge. The instrument also involved open-ended questions related to factors and problems undergraduate students face in achieving Technological Knowledge, Content Knowledge and Technological Content Knowledge. The data were analyzed using descriptive statistics (frequency, percentage, mean and cumulative mean score) while ANOVA was applied for comparison of the knowledge areas among the undergraduate students from different academic faculties. The associated factors and problems were explored through open ended questions included in questionnaire from students of respective faculties. Findings of the study show that majority of the undergraduate students were at high level for Technological Knowledge. Whereas majority of them also exhibit high levels for Content and Technological Content Knowledge. On the basis of findings, it is recommended that there may be maximum use of ICT in their teaching learning process. The researcher recommended that undergraduate students may be taught by applying various techniques so they can grasp the concepts, terms and content effectively. The policy makers are recommended to add practical applications of using ICT in teaching and learning so that undergraduate students may become able to integrate technology with in content effectively.

Keywords: *Technological Knowledge, Content Knowledge, Technological Content Knowledge, Undergraduate students, Academic Faculties*

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List of Abbreviations

TK	Technological Knowledge
CK	Content Knowledge
PK	Pedagogical Knowledge
TCK	Technological Content Knowledge
PCK	Pedagogical Content Knowledge
TPK	Technological Pedagogical Knowledge
TPACK	Technological Pedagogical and Content Knowledge
EFL	English as a Foreign Language
SDT	Self Determination Theory
TAM	Technology Acceptance Model
ACOT	Apple Classroom of Tomorrow
ICT	Information and Communication Technology
IT	Information Technology
ANOVA	Analysis of Variance
B.Ed	Bachelors of Education
M.Ed	Masters of Education
M.Phil	Masters of Philosophy
P.hD	Doctorate of Philosophy

CHAPTER 1

INTRODUCTION

Rapid technological development in the 21st century seems to have exerted great impact upon all the fields including field of education. In the current situation, teachers need to equip themselves with the latest technological developments by utilizing TPACK in teaching processes which are the demands of the 21st century that considers technology as a pivotal component of the learning process (Widajati & Mahmuda, 2023). Since teachers are perform a significant role in the educational process, they should be trained professionally and be equipped with modern technologies. In this connection, use of TPACK ensures to enhance teacher's efficiency in the learning process effectively, imparting their expertise to the students with appropriate use of technology (McGraw Hill Canada, 2019). In the current century, TPACK plays a significant role for the teachers to enable them to impart their knowledge and, on the other hand, helps the students learn their target lessons (Ali et al., 2023; Rosenberg & Koehler, 2015).

The model of TPACK supports the development of effective ways to articulate and discover the knowledge and methods of competent teachers using the blend of technology and content. The teachers can better understand differences in skill amalgamation through improved consideration, teachers' kinds of awareness in terms of materials, skills, teaching methods, and interactions (Koehler et al., 2013; Fisser et al., 2015; Schmidth et al., 2009). So, TPACK can be helpful for the teachers in delivering their knowledge to the students.

TPACK seems to have been defined in multiple ways by various professionals during the recent times. In this connection, Mishra and Koehler define TPACK as "a framework that introduces the relationships and the complexities among all three basic components of knowledge (technology, pedagogy, and content)" (Koehler & Mishra, 2009; Mishra & Koehler, 2006). An intuitive understanding of teaching content along with appropriate pedagogical methods and technologies provides the basis of these three knowledge types (Mishra & Koehler, 2008). The teaching process, with the help of technology, exists in a diversified transactional relationship (Bruce, 1997; Dewey & Bentley, 1949; Rosenblatt, 1978) among all its components in this framework. In case of a change in any one of such factors, it becomes essential for the other two factors to bring in a change (Mishra & Koehler, 2006).

Moreover, TPACK is a framework which is widely used in teaching since 2006. Previously, it was termed as pedagogical content knowledge by Shulman (1986). Later on, Mishra & Koehler added technological component in already existing PCK. As a result of addition of this technological component the framework comes to be known as TPACK (Mishra & Koehler 2006). Numerous studies have been conducted on TPACK model with respect to its various components. Numerous researches have also reflected that TPACK participates in designing schemes (Angeli & Valanides 2009; Koehler & Mishra, 2005), micro pedagogical practices as researched by Cavin (2008), and communities of practices (Rodrigues et al., 2003).

As TPACK is increasingly used to support the enhancement of ICT programmes, it plays an important role to recognize the relationship among TK, CK, and TCK of undergraduate students. However, such research is lacking as much of the current research focusses on the relevance of integrating technology within pedagogy. Although some educational institutions suggest that training related to computer should be taken away from the program of teacher education. (Brinkerhoff et al., 2001). Similarly, numerous studies have revealed that the teachers with excellent computer skills are expected to utilise them during their teaching activity. (Litrrell, Zagumny & Zagumny. 2005; Zhao, Pugh, Sheldon & Byres, 2002). Furthermore, TPACK surveys are mostly focused on American teachers and educators (Graham et al., 2009; Archambaault & Crippen, 2009; Schmidth et al., 2009).

In the present educational landscape, Technological Knowledge appears to have gained much pertinence. According to Koehler and Mishra (2009), technological knowledge might be the type of knowledge which informs about the use of computer-based technologies. As technology has emerged in every walk of life during the recent periods, gaining of primary information about the use of technology seems to have become significant for every area of life. Such technological progress has transformed the whole procedure of teaching and learning altogether (Mumtaz et al. 2023). In this connection, Gros and López (2016) contend that digital technology has hugely impacted the educational landscape in terms of enhancing its quality, facilitating universal access to education, and removing differences in the learning process. Hence, one might argue that technology functions like an instrument that builds up learning experience in general. It is included in curriculum and a tool for imparting knowledge and steering the educational process (Saal et al. 2019). In a similar way, it is bringing phenomenal changes in educational hemisphere in which it seems to have emerged as a central instrument for imparting knowledge to the students and for providing diversified range of expertise to the coming generations. Nevertheless, this Technological Knowledge remains insufficient until it is strengthened by the knowledge of content.

Likewise, Content Knowledge can be understood as the comprehension of subject matter knowledge as explained by Koehler and Mishra (2009). It functions as foundational platform for the efficacious learning process at undergraduate level. In opposition, Technological Knowledge comprises the use of computer-based technologies in a dynamic way in an order to make the process of learning more efficient (Koehler & Mishra, 2009). The interaction between the TK and the CK is a crucial constituent and emerges as a requirement for the learning activity of the 21st century Augstini et al. (2019). Undergraduate students, with sound integration of the Technology and Content, carry the capability to excel in the educational landscape and can meet the market pressure of 21st century skills. As well, National Professional Standards (2009) seems to emphasise the acquisition of these knowledge levels high to become properly able to compete in the current world.

Most of the researches on TPACK for prospective teachers and educators have been done in the United States, Turkey, parts of China and Malaysia (Bas & Senturk, 2018). In 2013, Chai, Koh and Tsai reviewed seventy-four researches and found that TPACK is an area of research which is growing in North America in many ways. TPACK is renowned theoretical model that is based on theoretical methods to study the integration of skills in the educational procedures (Muhaimin et al., 2019). A large in number of researches on TPACK use self-reported tool and data (Schmidth et al., 2021). So, TAPCK is becoming a leading framework for assessing student-teacher skills in the present digital world (Mumtaz, 2023).

1.1 Background and Context of the Study

In the current digitalized epoch, amalgamation of technology seems to have grown as a popular phenomenon in every part of the world. Recent decades have seen a growing interest in this area on the part of the researchers and academicians (Valtonen et al. 2022). All aspects of human life have entirely been changed by the use of technology and digital appliances. Educationists and academicians seem to agree that technology must be recognized as a significant part of all initiatives towards education (e.g., Christensen, 2008; Collins & Halverson, 2009; Wellings & Levine, 2009; Woolf et al., 2010). Undergraduate students can utilise digital technology to enhance acquisition of knowledge and skills. In addition, they should realize that learning with technology and about technology has gained much relevance to gain efficiencies to function well in the current social scenario. National Professional Standards (2009) for teachers demonstrates the same requirement for the teachers.

Many studies have been based on usefulness of TPACK in Teacher Education programs. In the context of Pakistan, a study has been conducted by Soomro et al. (2018), that investigates TPACK of faculty members of Sindh University of ICT and Education department. The study finds that both departments are incorporating technology with in pedagogy and content. Likewise, Irum, Munshi, Bhatti and Awan (2018) conducted analysis of teacher educators' preparedness for the domain of TK in Sindh. The results reveal that majority of teacher educators rate themselves low in TK domain. Only those rated high who have a degree of Technology related field knowledge.

Many of the studies have been conducted to explore the effectiveness of TPACK at school, college or university level. Also seen in literature are the studies exploring TPACK with respect to different subject areas as; Science, English, Mathematics, etc. The integration of technology tries to improve the teaching-learning process efficaciously. Such a fast emergence of technology and its amalgamation with educational landscape renders it important to imagine that how the students at undergraduate level conceive and employ technology for their educational pursuits. This study intends to examine the level of TK, CK, and TCK among undergraduate students enrolled in different faculties of International Islamic University Islamabad along with the associated factors which influence them.

1.2 Problem Statement

In the context of modern education, the integration of technology with content has become increasingly crucial for enhancing student learning outcomes. The interplay between Technological Knowledge (TK) and Content Knowledge (CK) together forming Technological Content Knowledge (TCK) plays a significant role in enabling students to effectively understand, engage with, and apply academic content through the use of technological tools.

The Technological Knowledge, Content Knowledge, and Technological Content Knowledge is important for future learning at undergraduate level. If undergraduate students lack in acquiring these knowledge levels it will affect their future learning. In light of these issues, this study was designed to identify the levels of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among undergraduate students across different faculties at IIUI, and what factors do contribute these differences? Identifying and understanding these variations is essential for developing inclusive, effective educational strategies that foster equitable academic progress for all students across the university.

1.3 Objectives of the Study

The objectives of study were to;

i. Measure the current levels of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among undergraduate students.

ii. Compare the levels of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among undergraduate students enrolled in different faculties of IIUI.

iii. Identify the internal and external factors which influence the Technological Knowledge, Content Knowledge and Technological Content Knowledge among undergraduate students.

iv. Explore the problems undergraduate students face in achieving Technological Knowledge, Content Knowledge, and Technological Content Knowledge.

1.4 Research Questions

Following were the research questions for the study;

i. What is the undergraduate students' current level of Technological Knowledge, Content Knowledge, and Technological Content Knowledge?

ii. Which factors do influence the Technological Knowledge, Content Knowledge, and Technological Content Knowledge among the undergraduate students?

iii. Which problems do undergraduate students face in achieving Technological Knowledge, Content Knowledge, and Technological Content Knowledge?

1.5 Hypothesis of Study

Following was the hypothesis for the study;

H_{01}: There is no significant difference between the Technological Knowledge, Content Knowledge, and Technological Content Knowledge levels among undergraduate students enrolled at different faculties of IIUI.

1.6 Significance of the Study

In the 21st century, technological knowledge has been necessitated for every individual working in the discipline of education or elsewhere. It is not confined to the students only in their campus life rather it has emerged as an essential knowledge for all walks of life. Keeping in view this essentialist aspect of Technological Knowledge, this study is intended to explore the levels of Knowledge of Technology, Knowledge of Content, and Technological Content Knowledge among the undergraduate students of the selected faculties. This research work has its implications for both educators and students in the particular context of IIUI. It aims to expand level of understanding of how well undergraduate students grasp technology, their subject matter, and the combination of both in diversified academic disciplines. By comparing these three knowledge domains across various faculties, this research provides valuable insights into areas where students are performing well and where improvements are needed. The findings can help faculty and university administrators make informed decisions about curriculum development, instructional strategies, and the provision of technological resources to enhance student learning.

The study also shed light on the the challenges and obstacles students encounter when incorporating technology into their learning. These insights are crucial for faculty members, and university administrators. By focusing on undergraduate learners rather than pre-service teachers, the study also fills a gap in the literature by emphasizing student engagement with technology from a learning rather than teaching perspective. Moreover, it is crucial for maintaining high-quality education and equipping future educators with the skills needed for effective use of technology in teaching.

By exploring barriers to technology incorporation such as training, resources, infrastructure, and support, this detailed investigation will offer valuable insights into improving students' technological abilities, their understanding of subject matter, and their ability to merge these areas effectively. This in turn, enhances the overall educational quality in various departments at IIUI. Beside this, developing targeted interventions can enhance digital literacy, content understanding, technology integration, and interdisciplinary knowledge in higher education.

1.7 Delimitations of the Study

The study was delimited to;

i. Female undergraduate students enrolled in second semester of BS programs at International Islamic University Islamabad.

ii. The academic faculties which have offered course of "Applications of Information and Communication Technologies" in the semester Fall 2024.

1.8 Operational Definitions

1.8.1 Technological Knowledge

Technological knowledge is defined as to have the knowledge and skills which are required for using many technologies and technological tools with in learning at undergraduate level.

1.8.2 Content Knowledge

Content Knowledge is defined as the content of subject of "Applications of Information and Communication Technologies" being studied by undergraduate students during their coursework in semester Fall 2024.

1.8.3 Technological Content Knowledge

It comprises the knowledge about integration of technology with the content and the effective use of technology for applying content knowledge.

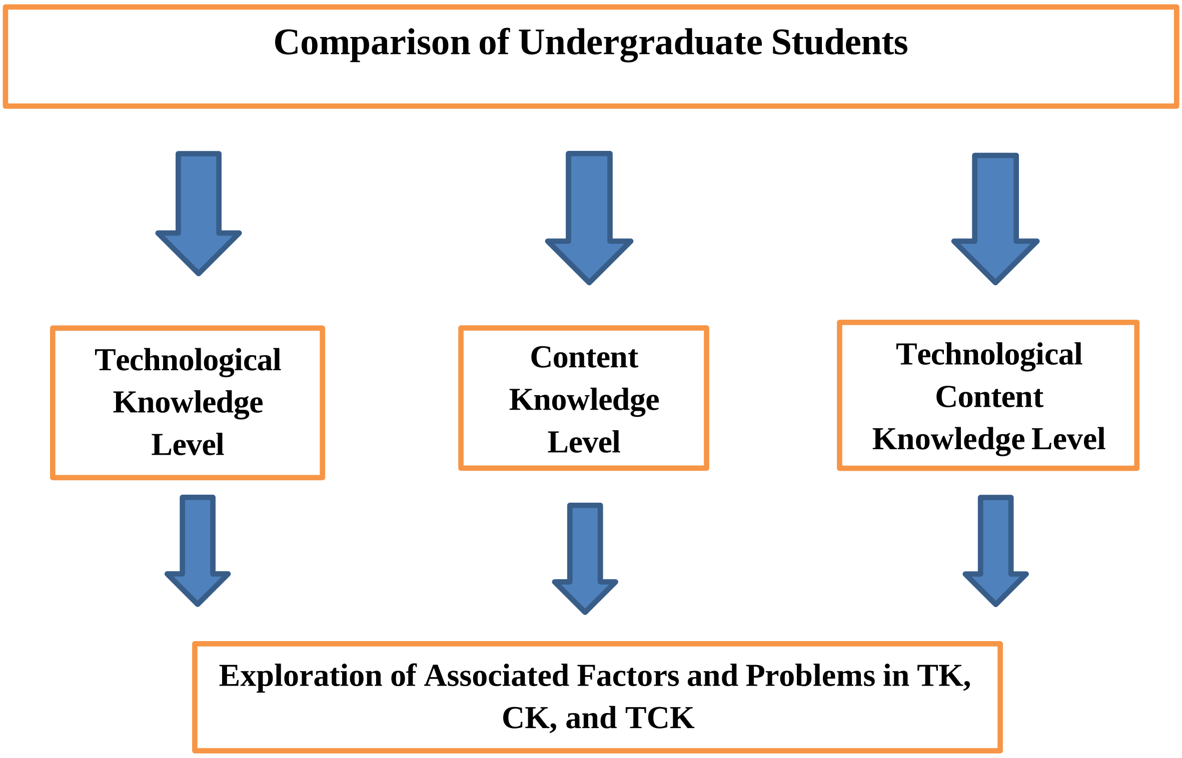
1.9 Conceptual Framework

The conceptual framework for this study is premised on the Theoretical Framework of TPACK theorized by Mishra and Koehler (2006). The framework of TPACK has emerged as a widely used instrument to investigate the attitudes and willingness of educators. Initially, Shulman (1986) uses this framework as PCK which was developed by Mishra and Kohler as TPECK in (2006). With its growing significance on integrating technology into education, the new model of TPACK appeared that focuses on combining technology with both pedagogy and content. This model consists of seven components among which the basic knowledge of technology, pedagogy, and content are the significant ones. It then merges these elements as; TPK, PCK, TCK, and TPACK. The purpose of these TPACK elements is to evaluate the basic understandings of teachers' incorporation of technology into teaching, as highlighted by Akram in (2020).

This study concentrates only on the Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK) constructs. The Pedagogical aspect of TPACK is not included in the study because it is concerned only to the prospective teachers who belong to the subject of Education. As the study focuses on overall undergraduate students therefore the aspect of Pedagogy has been skipped for this study. Moreover, the study comprises measuring the levels of TK, CK, and TCK constructs of knowledge across various academic faculties from IIUI to attain an in-depth assessment of technology and content knowledge of undergraduate students and the level of interconnection between these constructs.

Figure 1.1

Conceptual Framework of the Study



1.10 Summary

This chapter has a detailed description about the use and integration of ICT with in teaching and learning. Beside this this unit also describes about the TPACK model around which the whole study revolves. The background and rationale of study has been discussed which lead great importance on integration of technology with content and pedagogy which arises the need to study the comparison of undergraduate students at international Islamic university Islamabad w.r.t TK, CK, and TCK. Afterwards, research objectives, research questions, limitations, and delimitations were discussed. Conceptual framework was also been added in pictorial form for elaboration. Overall, this chapter is a brief layout about the overall process adopted for study.

CHAPTER 2

LITERATURE REVIEW

Main theme of this study is to draw comparison among the Knowledge of Technology, Knowledge of Content and Technological Content Knowledge among Undergraduate students at IIUI. In this connection, foundation of this section of literature review has been placed on the critical examination of the scholarly and critical sources produced on the key concepts of the study and primary sources selected for this study. The study elaborates the explanation and understanding of Knowledge of Technology, Knowledge of Content and Technological Content Knowledge. This study intends to critically investigate the progress of these knowledge domains among undergraduate students. Likewise, the study examines the critical efforts that surround the factors which influence these components. Therefore, this study, specifically, examines to what extent these knowledge levels differ among undergraduate students at International Islamic University, Islamabad among different departments of IIUI.

The intent of this section is to provide a detailed glimpse of the body of research on TPACK, highlighting any gaps and conflicts in the field. This literature evaluation will provide the research challenge a strong basis and support the need for more study by evaluating and synthesizing the work of academics and researchers in the field. The concepts of Technological Knowledge, Content Knowledge and Technological Content Knowledge will be elaborated in this chapter as discussed by certain scholars in their respective studies. By doing this, it will be helpful in providing information about these levels of knowledge and providing information about gaps in research. By examining the body of knowledge already produced, this study will place its core focus on the perspective. Moreover, it will address both the areas where research has been effective and those where gaps still exist. In a bid to support the aims of research and the methods selected for this study, it will finish by constructing an argument for the significance of filling in these gaps. Of many varieties of literature review, traditional or narrative review of literature appears to be suitable for this study. Chinn (2021) considers traditional literature review as a form of literature reviews that encompasses all published works related to a particular subject matter to the present times. Likewise, it is a detailed, critical, and objective analysis of the knowledge related to the topic. In this context, this section of the study critically examines the research works conducted on TK, CK, and TCK till date. An ultimate goal of the review is to lay the groundwork for the creation of a research design that will significantly advance the TK, CK, and TCK understandings and undergraduate level of these knowledge domains.

Similarly, this chapter aims to achieve a number of objectives. Among them, the premier one is to provide a foundation for the key concepts of this study. In this connection, it provides critical understanding of Technological Knowledge, Content Knowledge, and Technological Content Knowledge. Likewise, this chapter is likely to identify certain factors that are considered hindrances in technology integration.

2.1 Theoretical Review of Literature

A theoretical review is a kind of literature review that focuses on analysing key theories or models related to a research topic. Torraco (2005) explains that a theoretical review looks closely at existing theories to explore their strengths, weaknesses, connections, and any gaps in understanding. In education, this type of review helps researchers understand how ideas like technology use in classrooms have developed over time through different theoretical perspectives. Likewise, a theoretical review is one that explores how various theories relate to each other and how they can be applied to real-world situations (Grant & Booth, 2009). This kind of review is especially important in educational studies, where theories often shape teaching methods, curriculum design, and classroom practices.

The framework of TPACK by Mishra and Koehler (2006) serves as foundational theory for the said study revolving around Technological Knowledge, Content Knowledge, and Technological Content Knowledge. It extends the Shulman's concept of Pedagogical Content Knowledge (PCK) by incorporating technological knowledge, forming a comprehensive framework of TPACK consisting of seven knowledge domains: TK, CK, PK, PCK, TCK, TPK, and TPACK.

This study particularly focuses on three domains: TK, CK, and TCK, as these critical for educators in integration of technology with in content delivery. The framework emphasises the interplay between these domains and suggests that effective technology integration in teaching and learning requires a dynamic balance among them. The theoretical review of related literature includes following headings and subheadings.

2.2 Historical Development of the TPACK Framework

The Technological Pedagogical Content Knowledge (TPACK) framework was developed to explain how teachers can integrate technology effectively into their teaching. It brings together three core areas of teacher knowledge: Content Knowledge (CK)—what is being taught, Pedagogical Knowledge (PK) how it is taught, and Technological Knowledge (TK) the use of digital tools to support learning.

The origin of this framework can be traced back to the concept of Pedagogical Content Knowledge (PCK) introduced by Shulman (1986, 1987). Shulman emphasized that teaching is more than knowing subject matter, it also requires knowing how to present that content in ways students can understand. His work shifted educational thinking towards a more integrated view of teaching knowledge.

Building on this idea, Mishra and Koehler (2006) expanded the model by adding technology as a third essential element. They proposed that for meaningful technology integration, educators must understand how technological tools interact with both pedagogy and content. This led to the creation of the TPACK framework, which includes the three core domains (TK, PK, CK) and their intersections: Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and the combined domain of TPACK. Later, Mishra and Koehler (2008) emphasized that using technology in education is not only about technical skills. It is about creatively combining pedagogy, content, and technology to enhance learning outcomes in a given context. Over time, TPACK has become a well-recognized framework in both research and teacher education. Scholars such as Angeli and Valanides (2009) found the model effective for developing teacher competencies, particularly in pre-service education. Similarly, Voogt et al. (2013) noted the increasing use of TPACK in global studies to understand and support digital teaching practices.

In the context of this study, the TPACK framework provides a solid foundation to examine undergraduate students' knowledge in three key areas: Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK). Since most undergraduate students at the International Islamic University Islamabad (IIUI) are not enrolled in teacher training programs, they are less likely to have formal pedagogical training. Therefore, the pedagogical component (PK) was excluded, and the focus was placed on the aspects of the framework most relevant to their academic experience. Understanding the level of TK, CK, and TCK among IIUI undergraduates is essential for identifying strengths and gaps in their preparedness for digital learning and future professional environments.

2.3 Nature of TPACK

The Technological Pedagogical Content Knowledge (TPACK) framework represents an integrated model of teacher knowledge, emphasizing how educators effectively combine content, pedagogy, and technology in their instructional practices. Initially conceptualized by Mishra and Koehler (2006), TPACK builds upon Shulman's (1986,1987) idea of Pedagogical Content Knowledge (PCK) by incorporating Technological Knowledge (TK) as an essential third domain. The framework identifies three core components; Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) and highlights how these domains intersect to form four additional knowledge areas: Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and the fully integrated TPACK framework (Mishra & Koehler, 2006).

The TPACK model is both dynamic and context-specific, recognizing that effective technology integration varies depending on subject matter, classroom environment, learners' needs, and teacher experience (Mishra & Koehler, 2008). It promotes a flexible and adaptive approach, encouraging teachers to frequently adjust their technological choices to align with changing pedagogical strategies and content requirements (Koehler et al., 2013). Rather than focusing on the use of digital tools in isolation, the framework promotes for pedagogically sound integration of technology to enhance learning outcomes.

Scholars have debated the scientific nature of TPACK. On one hand, Newsom (1999) argued that TPACK is a true synthesis of TK, PK, and CK a unique form of knowledge that cannot be fully understood by examining each component separately. This perspective sees TPACK as more than the sum of its parts, acknowledging the complex and dynamic interactions that occur when technology is purposefully integrated into teaching. On the other hand, some critics suggest that TPACK is not only a theoretical system but rather a practical intersection of TK, PK, and CK used in instructional design (Newsom, 1999).

Despite such differing views, numerous studies support the view that TPACK serves as a valuable knowledge system for understanding how teachers make informed, context-sensitive decisions about technology integration (Angeli & Valanides, 2009). Empirical research has validated its application across diverse areas, including instructional design (Mishra & Koehler, 2005; Angeli & Valanides, 2009), classroom teaching practices (Cavin, 2008), and teacher professional development through communities of practice (Rodrigues, 2003).

In sum, the TPACK framework offers a comprehensive and evolving model that helps educators blend technology with pedagogy and content in meaningful ways. Its adaptability and wide acceptance across teacher education programs globally emphasize its importance in guiding effective technology integration in modern classrooms.

2.4 Components of TPACK

The TPACK Framework is further breakdown in to seven domains i.e; Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK). These components are described as follows.

2.4.1 Technological Knowledge (TK)

Technological Knowledge (TK) means knowing how to use digital tools and technologies in a useful way. It includes basic understanding of hardware (like computers and projectors) and software (like apps or educational programs). TK helps people solve problems, complete tasks, and work more efficiently.

Mishra and Koehler (2006) explained that TK is not just about using tools—it also requires to adjust to new technologies and use them in creative ways. According to Koehler and Mishra (2009), TK involves knowing how technology works, how it can be used in different situations, and how it can support learning or other goals. Technology changes quickly, so TK also means being willing to keep learning and adapting. As Archambault and Crippen (2009) pointed out, both teachers and students need to stay updated with new technologies to be effective in education and the workplace.

2.4.2 Content Knowledge (CK)

Content Knowledge (CK) means having a strong understanding of a specific subject, like math, science, history, or language. It includes knowing important facts, ideas, rules, and how different parts of the subject are connected. For teachers and students, CK is the basic knowledge needed to learn and teach effectively.

CK is rooted in Shulman's (1986) work, which emphasized that teachers must understand the content of subject they teach. Shulman (1986) also explained that CK is not just about remembering facts. It also involves knowing how the subject works and how to teach it clearly. For example, a teacher with good CK in math knows the formulas, why they are used, and how different math topics relate to each other. Mishra and Koehler (2006) pointed out that if teachers do not understand the subject deeply, they may struggle to create good lessons. Good CK helps teachers explain things well, answer students' questions, and fix common misunderstandings. For university students, CK shows how well they know the key topics in their field. It keeps improving with more learning, practice, and experience (Ball, Thames, & Phelps, 2008). Strong CK also helps future teachers and professionals think clearly and use their knowledge in real life.

2.4.3 Pedagogical Knowledge (PK)

Pedagogical Knowledge (PK) refers to a teacher's understanding of effective teaching techniques. It covers areas like teaching methods, classroom organization, planning of lessons, assessment of student progress, and knowing how can the students learn best. While content knowledge is about *what* to teach, PK focuses on *how* to teach. Shulman (1987) explained that PK includes knowing the goals and values of education, and using strategies that support student learning. This involves choosing suitable teaching styles, asking thoughtful questions, and adapting lessons to meet the needs of different learners. According to Mishra and Koehler (2006), teachers with strong PK can manage classrooms well, organize lessons efficiently, and understand the learning process. They know how to keep students involved, explain ideas in clear ways, and apply various teaching strategies based on student needs.

For instance, a teacher with good PK knows when to use group activities, how to give meaningful feedback, and how to modify teaching for students with different learning preferences. This type of knowledge is useful in all subjects and grade levels.

Bransford, Brown, and Cocking (2000) described PK as the collection of tools and strategies teachers use to support student learning. It helps them make smart choices about how to teach in ways that help every student succeed.

2.4.4 Technological Content Knowledge (TCK)

Technological Content Knowledge (TCK) means knowing how to use technology to teach a specific subject betterly. It is not just about using digital tools, but about choosing the right tools that help students understand the content more clearly. As explained by Mishra and Koehler (2006), TCK is about how technology can change or improve the way a subject is taught and learned. Koehler and Mishra (2009) also pointed out that teachers need to understand both the subject they are teaching and the strengths of integrating or using different technologies. This helps them match the right tool to the topic so students can learn more easily and stay engaged. According to Angeli and Valanides (2009), good TCK also means being able to judge whether a digital tool truly helps students learn the subject. Some tools are better than others depending on the topic, so teachers need to think carefully about what to use and why.

To sum up, TCK is about linking technology and subject knowledge in a smart way to improve teaching and learning. It is very important in today's classrooms where technology is a regular part of education.

2.4.5 Technological Pedagogical Knowledge (TPK)

Technological Pedagogical Knowledge (TPK) means knowing how to use technology in smart ways to support teaching. It is about understanding how different digital tools can help improve teaching methods and make learning more effective. As Mishra and Koehler (2006) explained, TPK is not just about using technology, it’s about using it in a way that match the teacher’s style and the classroom setting. It helps teachers know *when* and *how* to use technology to improve the learning experience.

Koehler and Mishra (2009) also said that teachers with good TPK can change or improve their teaching methods by using technology in creative and meaningful ways. Angeli and Valanides (2009) noted that TPK also means understanding what a tool can and cannot do. Teachers need to think carefully and choose the right technology based on what they want students to learn and how they plan to teach it. Another aspect TPK is the understanding of how these tools can be used in education in a way appropriate for classroom development. So, it is the integration of modern technology in to education for general educational accomplishments (Zhang et al., 2019).

In short, TPK is about combining good teaching with the smart use of technology. It helps teachers create lessons that are more engaging, interactive, and suitable for today's learners.

2.4.6 Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge (PCK) is the type of knowledge that helps teachers combine what they know about a subject with how to teach it in a way that students can easily understand. It focuses on how to make subject content meaningful, clear, and accessible for learners. Shulman (1986) introduced this idea, describing PCK as the unique knowledge teachers need to connect subject content with effective teaching strategies. It is not just about knowing the topic or general teaching methods—but knowing how to teach a particular topic to different learners effectively.

As explained by Shulman (1987), PCK includes skills such as choosing suitable teaching techniques for different topics, predicting where students might struggle, and using explanations, examples, or comparisons that help clarify difficult ideas. It also involves recognizing common student misunderstandings and knowing how to address them. Ball, Thames, and Phelps (2008) added that PCK allows teachers to turn their knowledge of a subject into lessons that are well-organized and tailored to students' needs, learning levels, and classroom situations.

In short, PCK helps teachers turn their subject knowledge into successful teaching practices. It is a key part of being an effective educator, allowing them to help students truly understand and apply what they are learning.

2.4.7 Technological Pedagogical and Content Knowledge (TPACK)

Technological Pedagogical and Content Knowledge (TPACK) is a framework that explains the type of knowledge teachers need to use technology effectively in their teaching. It combines three key areas: knowing the subject (Content Knowledge), knowing how to teach (Pedagogical Knowledge), and knowing how to use technology (Technological Knowledge). Mishra and Koehler (2006) developed this framework by building on Shulman's (1986) idea of Pedagogical Content Knowledge. They explained that modern teachers need more than just subject matter knowledge they also need to understand how to use digital tools to support both content and pedagogy.

Koehler and Mishra (2009) pointed out that TPACK is not just a mix of these three areas, but an understanding of how they work together. Teachers with strong TPACK can choose the right technologies to match their lessons and make learning more effective. Angeli and Valanides (2009) added that using TPACK depends on the situation. Teachers must think about the topic they are teaching, the students they are working with, and the classroom setting. Developing TPACK takes time and involves training and experience. Voogt et al., (2013) stressed that TPACK is very important in today's education. It helps teachers use technology in smart ways that improve student learning, rather than using it just for the sake of using it.

In conclusion, the TPACK framework emphasizes the importance of combining content knowledge, teaching strategies, and technological skills to enhance teaching in today's digital classrooms. Each domain of TPACK contributes differently content knowledge provides a strong grasp of the subject, pedagogical knowledge guides effective instruction, and technological knowledge helps integrate digital tools in meaningful ways. The real strength is how these areas work together, allowing educators and undergraduate students to create lessons that are engaging, relevant, and suited to diversified learning needs of students. As technology becomes more central to education, using the TPACK model thoughtfully is essential for effective and future-ready teaching and learning.

2.5 Applicability of TPACK

TPACK framework has been a widely used tool for assessing the capability of integrating technology among the pre-service teachers, in-service teachers, as well as among the undergraduate students. It has its application in the context of education, including both challenges and benefits of integrating the TPACK framework into teaching and learning. As researched by Schmidth et al. (2009), this framework is used in educational research to assess integration of technology among teachers. Likewise, it is an effective tool for selecting and guiding the instructional designs among the educators (Harris et al., 2009). It is applicable for the professional development of teachers to integrate technology in the classroom (Koehler et al., 2013).

Keeping in view the related studies, there is a need to conduct a study that assesses technological knowledge, content knowledge, and technological content knowledge across various academic faculties in the context of IIUI. Moreover, exploring various influencing factors and problems with these domains of knowledge is the prime focus of this study. It will help in analysing the TK, CK, and TCK domains among the undergraduate students at IIUI that can lead to more effective and modern educational experience, preparing students to cope with the challenges of digital age.

2.6 Empirical Review of Related Literature

The empirical literature review looks at studies that are based on real-world data, such as experiments, surveys, interviews, or observations. Unlike theoretical reviews, it focuses on research where data was actually collected and analyzed. This type of review helps researchers understand what has already been discovered, identify gaps in knowledge, and decide what needs further study. Creswell (2012) explains that an empirical review includes research based on original data collection and is used to explore patterns, relationships, or results that have been tested in practice. It helps show what has been proven through evidence.

According to Galvan and Galvan (2017), empirical reviews are important because they support research that is based on actual findings. They help researchers avoid repeating the same work and guide them toward areas that still need to be explored. These reviews usually describe the purpose of each study, the methods used, the participants, the tools, and the main results. Boote and Beile (2005) added that a good empirical review doesn't just describe what others found—it also looks at how strong or weak the research was. This helps ensure that the conclusions drawn are based on high-quality and reliable studies. The empirical review of related literature for this particular study includes following headings and subheadings.

2.6.1 Technological Knowledge (TK)

Technological Knowledge (TK) refers to an individual's ability to understand, use, and manage a wide range of technological tools. These tools can be basic, like pencils, paper, and chalkboards, or more advanced, such as computers, the internet, educational software, and multimedia platforms. TK is not fixed, it continues to change and develop alongside technological advancements. According to Mishra et al. (2009), a key feature of TK is its flexibility especially for teachers who need to adopt and apply new technologies effectively in their teaching. In modern education, especially in the 21st century, this skill is essential as digital tools become an increasingly important part of teaching and learning.

Koehler et al. (2013) add that current digital tools, including communication platforms, research software, and multimedia resources, provide great opportunities for teaching. These tools not only help deliver lessons more effectively but also support collaborative learning and critical thinking. Harris et al. (2009) further explain that TK covers everything from simple tools to high-tech digital systems. They believe that when teachers engage with new technologies, they are more likely to become innovative and motivated educators.

Chang et al. (2017) also agree with this broader view, stating that TK includes both traditional and digital tools used in classrooms. In a similar view, Margerum and Marx (2002) describe TK as a set of methods and tools commonly used in schools to make learning more effective. This shows that TK is not only about knowing how to use technology, but also about applying it in meaningful ways to improve teaching.

Research studies provide further understanding of how TK levels can differ among educators and students. For example, Irum et al. (2018) examined teacher educators in teacher training institutions in Sindh, Pakistan. They found that most of the educators had low levels of TK. However, those who had previous experience with technology showed better skills, suggesting that professional experience plays an important role in developing TK.

In a related study, Koyuncuoğlu (2021) looked at the TPACK skills of 186 graduate students from different academic fields in Turkish universities. The study found that most students had a moderate level of TK. It also revealed that male students scored higher in TK and Technological Content Knowledge (TCK), while female students scored higher in Pedagogical Knowledge (PK). Additionally, students' TK levels varied depending on their academic discipline and education level, indicating that subject area and study experience can affect their TK development.

Another relevant study was conducted by Mumtaz (2023) at the International Islamic University. The focus was on preservice BS students enrolled in a teaching course titled *"Teaching Learning Strategies and Reflective Practices."* This research examined four areas of the TPACK framework: TK, CK (Content Knowledge), PK (Pedagogical Knowledge), and PCK (Pedagogical Content Knowledge). The findings showed that students were most confident in their TK skills, suggesting they were becoming more comfortable with using technology in teaching. This is a positive sign that teacher training programs are helping students build their technological abilities.

On the other hand, a study by Ningtyas et al. (2023) presented a more critical view. This research investigated how English as a Foreign Language (EFL) students perceived their instructors' TPACK skills. It found that many students believed their teachers were weak in using technology, especially in the area of TK. They felt that teachers were not giving enough attention to integrating technology in the classroom. This shows that although digital tools are available, they are not always being used effectively, particularly in language education.

Overall, these studies show that TK is a complex and important part of teaching in today’s classrooms. While there is evidence that teacher education programs are improving TK among future educators, there is still a significant gap in how current teachers apply this knowledge in their teaching. This highlights the need for regular professional development, training workshops, and institutional support to help educators stay updated with new technologies. Without such support, the full benefits of TK cannot be achieved in modern education.

2.6.2 Content Knowledge (CK)

Content Knowledge (CK) refers to the understanding and mastery of the subject matter that a teacher is responsible for delivering to students. It includes the theories, concepts, facts, and methods that are specific to a particular discipline. As defined by Shulman (1986), content knowledge includes not only factual information but also an understanding of evidence, reasoning, proof, and the accepted practices within a subject area. For teachers, this knowledge is essential, as it forms the foundation for subject-specific thinking, reasoning, and problem-solving that are vital for effective instruction.

Mishra and Koehler (2006) expand on this idea by describing content knowledge as a deep understanding of the subject a teacher teaches. This could include subjects like science, mathematics, literature, or social studies. Each subject has its own unique content, skills, and ways of thinking. For example, a science teacher must understand both basic and advanced concepts in physics, while a mathematics teacher should be familiar with formulas, theorems, and methods of calculation across different levels. Harris, Mishra, and Koehler (2009) also point out that the techniques used to teach and understand content vary depending on the subject, making CK a subject-specific form of knowledge.

Importantly, content knowledge is not just about knowing facts. It involves knowing how ideas in a subject are connected, how they develop, and how they can be communicated effectively. If teachers lack strong content knowledge, students may receive incorrect or confusing information, especially when it comes to technical or theoretical topics. Teachers serve as guides who help students build accurate understanding and avoid misconceptions, especially in subjects with complex or abstract content.

Supporting this, Jalani et al. (2021) conducted a study focused on how prospective teachers evaluate their own TPACK competencies. Their research revealed that future teachers ranked their content knowledge relatively low second from the bottom among the seven domains of the TPACK framework. In contrast, they rated their technological knowledge slightly higher. This suggests that while teacher training may emphasize digital skills, there may be a need to strengthen the content-specific understanding of future educators. These findings highlight the importance of ensuring that teachers are not only technologically prepared but also well-grounded in the subject areas they are expected to teach.

Together, these studies emphasize that strong content knowledge is a fundamental element of effective teaching. It enables educators to deliver accurate, clear, and engaging lessons while helping students make meaningful connections between ideas. In the context of TPACK, CK interacts with both pedagogical and technological knowledge to create a comprehensive and adaptable teaching approach. However, research also suggests that more attention may need to be given to content knowledge in teacher education programs to ensure balanced development across all knowledge domains (Jalani et al., 2021; Mishra & Koehler, 2006; Shulman, 1986).

2.6.3 Technological Content Knowledge

Technological Content Knowledge (TCK) refers to a teacher's understanding of how specific technologies can be effectively integrated with subject matter content. It involves recognizing both the possibilities and limitations of technology in enhancing subject-specific teaching and learning. According to Harris et al. (2009), TCK represents a reciprocal relationship between content and technology, highlighting how technology can support or constrain the way content is presented and understood. Similarly, Qualman (2013) points out that TCK is about knowing how technology and content connect, and how these connections can support meaningful learning experiences. When used effectively, technology allows students to better understand complex relationships between concepts, making the learning process more interactive and accessible.

An essential part of TCK is how teachers perceive and manage the integration of technology into subject-specific teaching. Mumtaz (2023) notes that TCK includes the ability to use technological tools strategically within a given subject area to enhance understanding. To do this successfully, teachers must have both the knowledge and the practical skills needed to implement these tools effectively in the classroom. In support of this view, Kasim and Singh (2017) stress that the use of modern technological resources in classrooms is no longer optional but has become a core requirement in the 21st-century education system.

Several empirical studies have investigated TCK across different disciplines and educational contexts. For instance, Yanti et al. (2019) examined the TCK of mathematics education students after they completed a mathematics course. Their study found that students had a good understanding of how to integrate technology into mathematics instruction, with an average TCK score of 3.52, indicating a strong grasp of technology-content integration.

In contrast, Paidi et al. (2019) conducted a similar study focused on students in biology education. This study evaluated students’ ability to design lesson plans that integrate technology into biology teaching. The results showed that students had a relatively low level of TCK, especially in applying technology effectively in their planning, indicating a need for improvement in this area.

Simsek and Yazar (2019) explored the self-efficacy of prospective teachers across 18 universities in Turkey in relation to their use of TPACK. Their findings revealed that the confidence of these future educators in integrating technology varied significantly across different departments, highlighting how institutional and disciplinary differences impact TCK and broader TPACK skills.

Koyuncuoğlu (2021) also examined TPACK competencies among graduate students from natural sciences, social sciences, and educational sciences in Turkey. The study found that while students generally demonstrated moderate competence in technological knowledge, male students reported higher proficiency in both TK and TCK compared to female students. These findings suggest that both gender and academic discipline can influence the development of TCK.

In another context, Fauziah et al. (2023) assessed the TCK of English language teachers in Indonesia. Using interviews, classroom observations, and documentation analysis, they found that teachers had a strong understanding of how to integrate technology into their language lessons, reflecting a high level of TCK competence in this subject area.

Nguyen et al. (2024) carried out a comprehensive study on university teachers from various academic fields to evaluate their TPACK skills. Their research found that while teachers showed strong confidence in their content knowledge (CK) and pedagogical content knowledge (PCK), their competence in the more technology-focused domains such as TPK and TCK—was noticeably lower. The study also reported shifts in teachers' perceptions over time, especially in pedagogical knowledge, indicating that teachers' self-assessments of their TPACK abilities are influenced by their discipline and evolve over time.

Tafli (2021) conducted a longitudinal comparison of TPACK self-efficacy levels among prospective biology teachers from the Faculty of Education and the Faculty of Science across several academic years. The study revealed that those from the Faculty of Education consistently showed higher levels of TPACK self-efficacy than their counterparts in the Faculty of Science. This suggests that teacher training programs within education faculties may provide more effective support for developing technology-integrated teaching skills.

In Pakistan, Hussain (2024) surveyed 200 student teachers from various degree programs (B.Ed., M.Ed., M.Phil., and Ph.D.) across three universities in South Punjab. The study explored perceptions of TPACK, including TCK, and found that most participants had a positive attitude toward using technology in education and felt confident in their abilities. The study recommended that ICT and TPACK training should be made a regular part of teacher education, taught by trained professionals, and integrated into both school and university curricula to improve digital teaching capabilities.

A more recent study by Herzallah (2025) explored how TPACK, confidence in using technology, gender, and perceptions of online teaching effectiveness were related among 434 master's students in Israel. The findings revealed that higher levels of TPACK and technological confidence were associated with stronger beliefs in teaching effectiveness during online learning. The study also showed that gender and technological self-efficacy influenced how TPACK affected online teaching success.

Taken together, these studies show that Technological Content Knowledge plays a vital role in modern teaching practices. However, the level of TCK competence varies widely based on subject area, gender, educational background, institutional support, and cultural context. While some studies report promising levels of TCK, particularly in well-supported environments, others point to significant gaps, especially in areas where teacher training lacks a focus on technology integration. These findings highlight the need for continuous teacher development programs, better training in digital tools, and curriculum reforms that prioritize the effective blending of technology with content instruction.

2.7 Technology Integration in Education

Technology integration in education refers to the meaningful use of digital tools and resources to improve teaching and learning processes. It involves not just adding technology into classrooms, but using it purposefully to create lasting and positive changes in how students learn and how schools operate. As Belland (2009) explains, true integration of technology leads to long-term improvements in education by helping students actively construct knowledge. Similarly, Hew and Brush (2007) define technology integration as the use of information and communication technologies (ICT) in schools for instructional purposes. Lim (2007) adds that technology serves as a support system for both teaching and learning, acting as a bridge between instructional goals and learning outcomes. Polly et al. (2010) further highlight that technology is not just for teachers; students also benefit from using it as a tool to enhance their overall learning experience.

In the broader educational context, technology has both benefits and challenges. A recent study by Folabit et al. (2025) explored how technology affects students' sense of belonging and well-being in higher education institutions in South Africa. Using the Technology Acceptance Model (TAM) and Self-Determination Theory (SDT), the study found mixed results. While digital tools helped promote independent learning and flexibility, they also brought new issues such as increased stress, digital inequality, and emotional isolation. Students reported challenges including limited internet access, low digital skills, lack of technical and emotional support, and financial constraints. These findings highlight the need for inclusive technology policies and support systems to ensure all students benefit equally from digital learning environments.

Various researchers have proposed several frameworks and models to guide effective technology integration in schools. These models provide structured approaches for educators and policymakers to understand how to incorporate technology in a meaningful and sustainable way. Some widely accepted models include: Technological Pedagogical and Content Knowledge (TPACK) Framework (Koehler & Mishra, 2005), Technology Integration Planning Model (Roblyer, 2006), Social Model (Wang, 2008), Systematic Integration Model (Wang & Woo, 2007), Apple Classrooms of Tomorrow (ACOT) Model (Dwyer et al., 1990), Five-Stage Model of Computer Technology Integration (Toledo, 2005), Activity System Model (Demiraslan & Usluel, 2006). These models emphasize different components of the teaching and learning environment, including institutional readiness, teacher roles, curriculum design, student engagement, pedagogical strategies, and the use of digital tools. Each model offers a unique lens through which educators can evaluate and improve their use of technology in the classroom.

Among these models, the Technological Pedagogical and Content Knowledge (TPACK) framework is particularly relevant to the present study. The TPACK model focuses on the interconnected nature of Technological Knowledge (TK), Content Knowledge (CK), and Pedagogical Knowledge (PK). It provides a useful framework for understanding how these areas work together to support effective technology integration in teaching. For this reason, the TPACK model is well-suited for assessing the levels of Technological Knowledge, Content Knowledge, and Technological Content Knowledge (TCK) among undergraduate students at the International Islamic University Islamabad (IIUI).

Overall, technology integration in education is a complex but essential process. While it offers great potential to enhance learning, it also requires thoughtful planning, proper infrastructure, and continuous support for both educators and students. The TPACK framework provides a practical and research-based approach to evaluate and develop these essential knowledge domains among future teachers.

2.8 Importance of ICT in Education

In today's fast-changing world, technology has become a fundamental part of everyday life, including education. It is difficult to imagine modern teaching and learning processes without the involvement of technology. The integration of technology into education represents one of the most significant educational reforms in recent decades, driven by the constant evolution of digital tools (Jhurree, 2005; Jonassen, Peck, & Wilson, 1999; Polly, Mims, Shepherd, & Inan, 2010).

The influence of modern technology has transformed how education is delivered and received. According to Gros and López (2016), technology plays a vital role in enhancing the quality of education, expanding global access to learning, and bridging the educational gap between different student groups. Saal, Ryneveld, and Graham (2019) add that technology is both a medium of instruction and a valuable educational resource that improves the learning experience for students and educators alike.

Information and Communication Technology (ICT), in particular, is often highlighted as a key area of development in education. Researchers describe ICT as a broad term that includes all communication tools, such as computers, smartphones, television, radio, and internet services. Huth, Vishik, and Masucci (2017) support this view, noting that ICT includes both the devices themselves and the services they provide—such as video conferencing, e-learning platforms, and distance education tools. As König, Jäger-Biela, and Glutsch (2020) emphasize, ICT integration has significantly impacted education systems across the globe, altering traditional teaching methods and classroom environments.

Technology has the potential to improve educational standards and prepare learners for the modern workforce. Schmidt et al. (2011) suggest that today's educators are part of a generation that regularly uses technology in their daily lives. This familiarity with digital tools should be reflected in how teaching and learning activities are structured. Social media platforms, virtual learning environments, and interactive applications offer students and teachers new ways to connect, collaborate, and share knowledge.

Moreover, the rapid development of advanced technologies has made it essential for individuals to develop digital literacy skills. Understanding how to use technology effectively has become a necessary skill in modern education. As the digital landscape continues to evolve, learners and educators must adapt to remain relevant. Without proper training and digital readiness, the potential benefits of technology may not be fully realized.

Recent studies have examined how teachers can better integrate technology into classrooms. Smarkola (2007) identifies that students are more successful when they perceive technology as easy to use and useful. Dexter and Riedel (2003) argue that gaining basic digital skills—such as operating computers, browsing the internet, and using educational software—is essential for teachers aiming to incorporate technology into their lessons. Similarly, Chen (2008) highlights that learners need confidence and a positive attitude toward educational technology to fully engage with it. On the other hand, researchers like Greathouse (2018), Muris (2002), and Schwenger (2018) point out that unequal access to digital tools can limit students' ability to benefit from technology, stressing the importance of closing the digital divide in educational settings.

While technology is a powerful tool, it requires skilled individuals to operate and apply it effectively. Education systems have a responsibility to prepare such individuals by promoting both technological proficiency and educational innovation. Human development and IT advancement go hand in hand—without one, the other cannot succeed. Jackson and Songer (2000) argue that relying solely on traditional teaching methods is no longer effective in today's learning environment. Since the 1980s, educational practices have shifted from teacher-centered to learner-centered approaches, largely due to advancements in educational technology. This shift has led to new classroom designs and teaching strategies, moving away from behaviorist methods toward more constructivist, student-focused learning. Kulik (1994) further supports this by showing that when technology is aligned with teaching goals, content, and methods, it significantly improves student learning outcomes.

More recently, Aldalalah et al. (2025) conducted a study at Jadara University to evaluate the impact of interactive digital content based on the TPACK (Technological Pedagogical and Content Knowledge) framework. The study involved 47 female early childhood education students and aimed to enhance their ability to design educational materials. The results showed that using TPACK-based digital content not only improved students' skills in creating instructional aids but also had a positive effect on their academic performance. The study recommended introducing training programs to help future teachers develop skills in designing and using digital course content.

In summary, the integration of technology into education has significantly changed the way teaching and learning occur. It has improved access, engagement, and student-centered learning while also posing new challenges related to equity, training, and infrastructure. Numerous studies confirm that when technology is used effectively—especially within structured frameworks like TPACK—it can greatly enhance educational outcomes. However, to fully harness its potential, both educators and students need adequate support, digital skills, and access to necessary resources.

2.9 Factors Influencing Technology Integration

Barriers to technology integration have been a consistent theme in educational research, particularly in understanding the challenges faced by teachers and institutions. According to WordNet (1997), a barrier is defined as "any condition that makes it difficult to make progress or to achieve an objective." This definition aptly applies to the educational context, where various factors hinder the successful implementation of technology in teaching and learning.

Hew and Brush (2007) conducted a comprehensive analysis of 43 empirical studies and identified 123 specific barriers to technology integration. These barriers were categorized into six broad themes: (i) lack of resources, (ii) insufficient knowledge and skills, (iii) institutional constraints, (iv) teacher attitudes and beliefs, (v) issues related to assessment, and (vi) the culture specific to particular subject areas. These categories provide a structured understanding of the multifaceted challenges educators face when attempting to adopt digital tools in their classrooms.

Adding a theoretical perspective, Belland (2009) emphasizes the importance of teacher beliefs in the technology integration process. He draws on Bruner's (1996) concept of public pedagogy and Bourdieu's (1979) theory of habitus to explain how these beliefs are socially constructed and shaped by broader cultural and educational influences. This highlights that barriers are not only practical or institutional but are also deeply embedded in teachers' professional identities and teaching philosophies.

Tsai and Chai (2012) focus on the classroom environment and argue that barriers can also arise from the instructional design process. They stress the importance of design-oriented thinking, where teachers must be able to develop, organize, and adapt learning materials to align with student needs. When educators lack such skills or support, it becomes an additional form of barrier to effective technology use in classrooms.

Similarly, Kopcha (2012) critiques the ongoing struggle to achieve meaningful technology integration, pointing out that despite advancements in tools and platforms, many schools still fall short of integrating them effectively. He identifies five key obstacles that teachers commonly face: (i) limited access to technology, (ii) absence of a shared vision, (iii) conflicting beliefs about technology's role in education, (iv) time constraints, and (v) lack of professional development opportunities. These challenges often lead to fragmented or superficial use of technology, rather than its full integration into pedagogical practices.

Collectively, these studies demonstrate that technology integration is a complex process influenced by a combination of structural, institutional, cultural, and individual factors. Addressing these barriers requires not only providing physical resources but also fostering supportive environments where teachers' beliefs, time, and professional growth are valued and strategically developed.

1. Resources

Numerous studies have highlighted critical obstacles that hinder the effective integration of technology in educational settings. These include limited access to devices, inadequate availability of technological resources, insufficient technical support, lack of appropriate software, and time constraints for educators (Hew & Brush, 2007). Among these challenges, access to functional and reliable technology, along with the availability of necessary equipment, emerges as one of the most essential conditions for successful technology adoption in classrooms (Hew & Brush, 2007; Nikolopoulou & Gialamas, 2015).

To overcome these barriers, researchers emphasize the importance of providing teachers with continuous support—both in terms of technical assistance and administrative backing—to ensure smooth and meaningful integration of technology into teaching practices (Ertmer & Leftwich, 2013; Hur et al., 2016). Despite this, many educators report receiving little to no technical support within their institutions, which often results in frustration, especially when technical failures disrupt planned instructional activities (Cuban, Kirkpatrick, & Peck, 2001; Sandholtz, 2001).

However, evidence suggests that when teachers are given regular access to well-functioning technology along with sustained support systems, their willingness and ability to incorporate digital tools into the classroom improves significantly (Lowther, Inan, Strahl, & Ross, 2008). This highlights the need for schools to not only invest in technological infrastructure but also establish reliable support mechanisms to facilitate ongoing and effective technology integration.

2. Knowledge and skills

In the context of technology-assisted instruction, one of the most significant barriers to effective integration is the lack of technological expertise, knowledge of how to blend technology with pedagogy, and inadequate classroom management skills related to digital tools (Hew & Brush, 2007).

3. Institutional barriers

Technology integration is also influenced by broader institutional factors such as leadership, strategic school planning, a shared vision, and supportive educational policies. A lack of clear or supportive institutional and national policies can significantly hinder the successful implementation of technology in educational settings (Vanderlinde & Braak, 2010; Mazman & Usluel, 2011).

4. Attitudes and beliefs

Various studies have identified multiple factors that influence teachers' integration of technology in the classroom. These include educators' beliefs about knowledge and instructional methods, their perceptions of the role of technology in enhancing learning, their teaching styles, levels of self-efficacy, access to relevant professional development, openness to innovation, and overall attitudes toward technology use. Among these, personal beliefs—especially those related to teaching philosophy and the perceived value of technology—emerge as the most critical determinants of whether and how teachers incorporate technology into their instructional practices (Ertmer & Leftwich, 2010; Inan & Lowther, 2010).

5. Assessment

Assessment, which refers to the evaluation of student learning, is commonly categorized into two types: formative and summative. Summative assessments typically include standardized national examinations used for graduation or advancement to the next academic level. According to Hew and Brush (2007), the pressure associated with preparing students for such high-stakes exams often acts as a significant barrier to the integration of technology in classroom instruction, as teachers may prioritize exam-focused teaching methods over innovative, technology-supported practices.

2.10 Barriers to Technology Integration in Education: A Review of Global and Contextual Challenges

The integration of technology into education has become an essential yet complex transformation, facing numerous challenges at both systemic and individual levels. Barriers to successful implementation have been widely explored in literature, with various models and frameworks proposed to understand and overcome them. One of the foundational definitions comes from WordNet (1997), which describes a barrier as any condition that hinders progress toward a goal. In the context of educational technology, Hew and Brush (2007) conducted a comprehensive review of 43 empirical studies and categorized 123 identified barriers into six primary groups: availability of resources, teacher knowledge and skills, institutional factors, teacher attitudes and beliefs, assessment demands, and subject-area culture.

Institutional constraints such as inadequate leadership, poor planning, lack of strategic vision, and insufficient policy support have been highlighted as significant structural hurdles (Vanderlinde & Braak, 2010; Mazman & Usluel, 2011). Without supportive national or institutional policies, efforts toward digital transformation in schools may falter despite availability of tools. Further, Belland (2009) emphasized that teachers' beliefs play a pivotal role in the integration process, shaped by broader socio-cultural contexts as explained through Bruner’s (1996) concept of public pedagogy and

Bourdieu's (1979) theory of habitus. These belief systems influence how teachers interpret the value and practicality of using technology in their classrooms.

From a pedagogical standpoint, Tsai and Chai (2012) brought attention to classroom dynamics and advocated for design-based thinking. This approach enables teachers to craft materials and activities that are responsive to learners' needs, yet such instructional design itself can be a barrier if teachers lack the skills to develop it effectively. Kopcha (2012) echoed similar concerns, identifying recurring obstacles like limited access to devices, vague instructional visions, misaligned teacher beliefs, time constraints, and inadequate professional development.

More recent literature has further examined these obstacles in both global and local contexts. Studies consistently show that access to technology and reliable infrastructure remain among the most significant barriers (Hew & Brush, 2007; Nikolopoulou & Gialamas, 2015). Teachers often struggle with minimal technical support and limited digital resources, which can hinder classroom integration efforts (Ertmer & Leftwich, 2013; Hur et al., 2016). Cuban, Kirkpatrick, and Peck (2001) observed that many educators are left frustrated when technical glitches interrupt their planned use of digital tools. However, research also shows that when consistent access and support are provided, teachers are more likely to integrate technology effectively (Lowther et al., 2008).

A major internal barrier is the lack of pedagogical and technological competence among teachers. According to Hew and Brush (2007), one of the most profound challenges is the deficiency in technological, techno-pedagogical, and classroom management skills. These skills are essential for transforming technology from a simple tool into an enabler of meaningful learning experiences. Professional development initiatives targeting these skill gaps have been frequently recommended. Assessment-related pressures also contribute to the problem. Summative assessments, such as national exams, often dominate instructional priorities and discourage innovative, technology-enhanced practices (Hew & Brush, 2007). Teachers under pressure to meet exam benchmarks may find little room for exploratory or constructivist approaches facilitated by digital tools.

The literature reveals that while external barriers (e.g., infrastructure, policy, time) are foundational concerns, internal barriers—such as teacher beliefs, attitudes, and confidence—play a more decisive role once external issues are resolved. Ertmer and Leftwich (2010) and Inan and Lowther (2010) argue that teacher beliefs about knowledge, learning, and the role of technology are critical in shaping whether and how technology is used. These personal factors often outweigh material constraints in influencing instructional behaviour. With technology becoming increasingly embedded in all spheres of life, its integration into education has become not only inevitable but essential. As Jhurree (2005), Jonassen et al. (1999), and Polly et al. (2010) argue, technology is no longer an auxiliary component of learning but a central force driving educational reform. This shift necessitates a corresponding transformation in teacher education, curriculum design, and instructional methodologies.

Scholars such as Gros and López (2016) highlight the transformative potential of technology to enhance educational quality, expand global access, and bridge learning divides. Saal et al. (2019) further note that technology is both a curricular subject and a pedagogical medium. ICT, as emphasized by Khan et al. (2021) and Huth et al. (2017), includes a vast array of tools and services—from basic software to complex digital environments—and has significantly reshaped global education.

Despite its promise, however, many teachers remain limited in their exposure to and effective use of advanced technologies. Hanimoğlu (2018) notes that while basic tools like MS Word and PowerPoint are familiar to educators, there is little engagement with creative platforms such as Photoshop or digital learning apps. This gap restricts digital literacy and reduces the potential for higher-order thinking and problem-solving skills among students (Singhavi & Basargekar, 2019).

The theoretical model developed by Ertmer (2010) continues to guide much of the discussion around these barriers. It distinguishes between first-order (external) and second-order (internal) barriers. While external obstacles such as limited resources and lack of training remain critical, internal barriers such as resistance to change, traditional teaching practices, and limited belief in the value of technology are increasingly recognized as more difficult to overcome.

Recent studies have also emerged from the Pakistani context, revealing a unique set of challenges. Mumtaz et al. (2023) found that university students in Karachi possessed only intermediate computer skills, primarily due to poor infrastructure, lack of maintenance, and insufficient technical support. Similarly, Kozlova and Pikhart

(2021) discovered that environmental and psychological distractions further hinder technology use in educational settings.

Siddiqui et al. (2023) reported a continued deficiency in media literacy and technology use in Pakistani classrooms. Complementing this, Ali et al. (2023) pointed to the challenges educators face in aligning professional development efforts with the TPACK (Technological Pedagogical Content Knowledge) framework. The integration of TPACK remains limited in many teacher education programs. In same way, Ghayyur and Mirza (2021) explored prospective teachers' TPACK skills and found that outdated digital resources, insufficient labs, financial limitations, and poor internet connectivity were major hurdles. Similarly, Iqbal (2017) identified both infrastructural and socio-cultural challenges, particularly in the remote region of Baltistan.

Internationally, research by Amaniampong and Hartmann (2023) in Ghana echoed these findings, citing inadequate infrastructure, lack of training, and overloaded curricula as major impediments. In a broader review, Pelila et al. (2022) analyzed 46 studies and identified both personal and institutional factors, such as training, resources, and technical failures, affecting technology integration. They also suggested solutions including curriculum reform and increased investment in teacher training.

Harrell and Bynum (2018) used the TPACK and SITES frameworks to analyze data from Nigerian teacher educators. Their findings emphasized the impact of teacher experience, class size, and beliefs on effective technology integration. Rudhumbu (2020) added that factors such as individualized staff development, planning time, and infrastructure availability are crucial for success in contexts like Lesotho. Finally, Bas and Senturk (2018) and Schmidt et al. (2021) emphasized the significance of the TPACK framework in global contexts, particularly in countries like China, Turkey, and Malaysia. Their research shows that perception-based tools are widely used to assess pre-service teachers' readiness to integrate technology. This framework has become central in evaluating teaching programs and guiding professional development.

In summary, the integration of technology in education is influenced by a complex interplay of internal and external factors. These include infrastructure, institutional policies, teacher training, personal beliefs, attitudes, and exposure to technology. The TPACK framework continues to serve as a valuable model for understanding these dynamics and improving technology integration across diverse educational contexts.

2.11 Critical Summary

Reviewing of the literature of the conducted studies unpacks various stages of developments of Technological Knowledge, Content Knowledge and Technological Content Knowledge. Bas and Senturk (2018) contend that many research studies have been conducted on TPACK at China, Turkey, Malaysia and United States. According to Schmidth et al. (2021) the studies based on TPACK use perception-based tools for measuring the level of TPACK among Pre-service teachers. In accordance with the studies mentioned above. it is established that TPACK is found as a major framework that helps measure the effectiveness of the teaching program. It is also instrumental in measuring the preparation level of TPACK constructs regarding the prospective teachers.

Critical review of these studies unfolds explanations and understanding of these constructs and expands the horizon of these constructs. Moreover, it also explains different studies that are relevant to the basic themes of the current study. The literature review has demonstrated the studies which appear relevant to different barriers that influence the technological knowledge, content knowledge, integration of technology, and intersection of technological and content knowledge as well.

With an extensive emphasis on technology integration, number of studies have been conducted in the context of developed and underdeveloped countries of the world that seem related to various subjects like; EFL, Science, Mathematics, Physics, Chemistry and Biological sciences. Some of the studies investigate the Technological, Pedagogical, and Content Knowledge levels in relation to different levels in the universities. However, these researches are confined to one department and, in few cases, based on two departments. Existing studies on the subject lack knowledge across the faculties in relation to International Islamic University Islamabad. The study extends the range of data collection to multiple departments for the analysis of TK, CK, and TCK. So, the study addresses this gap of assessing the undergraduate students enrolled at IIUI in different academic faculties.

CHAPTER 3

RESEARCH METHODOLOGY

Research methodology is the systematic procedure designed by the researcher to carry out the process of research according to the objectives of this research. This section of the research deals with the design of the research, details about the targeted population and sample of the study, development of the instrument for the gathering of data and techniques for the data analysis used for the study.

3.1 Research Design

Research design is the procedure of collecting, analyzing, interpreting, and reporting the data in the research study (Creswell & Clark, 2007). According to Creswell (2014) the research design are specific procedures involved in the research process: data collection, data analysis, and report writing. The study has employed Mixed Methods approach to study the phenomena. The study uses convergent parallel technique to assemble the desired data from the respondents. A mixed methods approach involves the collection, analysis, and integration of both qualitative and quantitative data within a single study or research project. The main idea behind this approach is that combining the two types of data offers a more complete and insightful understanding of the research problem than using either method separately (Creswell & Clark, 2018). The study employed convergent parallel design to collect data from undergraduate students. According to Creswell and Clark (2018), in a convergent parallel design, researchers collect both quantitative and qualitative data at the same time, analyze them separately, and then compare or merge the results to get a comprehensive understanding of the research problem. This design allows researchers to directly compare findings from both types of data to see whether they support or contradict each other. The study explores about level of undergraduate students in connection with Knowledge of Technology, Knowledge of Content, and Technological Content Knowledge and its influencing factors and problem among undergraduate students enrolled at IIUI.

3.2 Population of the Study

A population can be defined as some objects, persons, items, organizations, and events, etc. (Gay et al., 2009). The population for study comprised of all the female undergraduate students enrolled in different academic faculties of IIUI. Only female undergraduate students were taken because they were easy to approach and in easy access for the researcher. Only those undergraduates were taken from second semester who have studied the subject “Application of Information and Communication Technologies” during the semester, Fall 2024. Keeping in view this criteria total of 1343 undergraduates were taken as population from 7 faculties comprising 20 departments that has offered the subject in their Fall semester 2024. The number of total population was collected from admission office. These were as follows;

Table 3.1

Population Size with Respect to Departments and Faculties

Sr. No	Faculty and Department Names	Population
1	**Faculty of Education**	
	1. BS (ELT)	70
	2. BS (IT)	60
	3. BS (ELM)	58
2	**Faculty of Sciences**	
	1. BS (Environmental Sciences)	25
	2. BS (Mathematics)	62
	3. BS (Statistics)	25
	4. BS (Physics)	24
3	**Faculty of Management Sciences**	
	1. BS (Public Administration)	28
	2. BS (Accounting and Finance)	49
	3. BBA	60
4	**Faculty of Social Sciences**	
	1. BS (History)	05
	2. BS (Pakistan Studies)	11
	3. BS (Psychology)	230
	4. BS (Sociology)	56
	5. BS (International Relations)	225
	6. BS (Political Science)	75
5	**Faculty of IIIE**	
	1. BS (Economics)	52
	2. BS (Islamic Banking & Finance)	25
6	**Faculty of Usuluddin (Islamic Studies)**	
	1. BS Usuluddin (Islamic Studies)	182
7	**Faculty of Arabic**	21
	1. BS (Hons) Arabic	
Total Population		**1343**

3.3 Sample and Sampling Technique

Sampling is the procedure of selection of individuals for study that represents the larger group of population (Gay et. al., 2003). The study employs Stratified random sampling guarantee maximum representation of the undergraduate students from varied academic faculties at IIUI. The study utilizes the table of Gay et al., (2009) to regulate sample size. The sample for this research comprises 297 undergraduate students from second semester enrolled in the course of “Application of Information and Communication Technologies” in their Semester Fall 2024.A total of 273 students were in sample because of a smaller number of students’ enrollment in Faculty of Arabic. 15% of undergraduate students from each faculty was added in sample, only FOA sample is 7.7% because the total population of FOA is 7.7% so all the students were added in sample. Size of the sample for the study was as follows:

Table 3.2

Size of the Sample with Respect to Department and Faculties

Sr. No	Faculty and Department Names	Sample Size
1	**Faculty of Education**	
	1. BS (ELT)	15
	2. BS (IT)	14
	3. BS (ELM)	13
2	**Faculty of Sciences**	
	1. BS (Environmental Sciences)	08
	2. BS (Mathematics)	18
	3. BS (Statistics)	08
	4. BS (Physics)	08
3	**Faculty of Management Sciences**	
	1. BS (Public Administration)	11
	2. BS (Accounting and Finance)	11
	3. BBA	20
4	**Faculty of Social Sciences**	
	1. BS (History)	01
	2. BS (Pakistan Studies)	02
	3. BS (Psychology)	15
	4. BS (Sociology)	04
	5. BS (International Relations)	15
	6. BS (Political Science)	05
5	**Faculty of IIIE**	
	1. BS (Economics)	28
	2. BS (Islamic Banking & Finance)	14
6	**Faculty of Usuluddin (Islamic Studies)**	
	1. BS Usuluddin (Islamic Studies)	42
7	**Faculty of Arabic**	21
	1. BS (Hons) Arabic	
	Total	**273**

3.4 Instruments

Self-developed research instruments were used for the study.

3.5 Development of Instrument

For developing the instrument related literature was studied in detail, afterwards the instruments were developed. Instruments were developed following the procedure described below:

3.5.1 Self-Developed Questionnaire

A self-developed questionnaire was developed to assess the level of TK, CK, and TCK of undergraduate students. The questionnaire consisted of statements related to Technological Knowledge, Content Knowledge and Technological Content Knowledge. The statements of instrument consisted of three main indicators including Technological Knowledge, Content Knowledge, and Technological Content Knowledge. Each indicator was gauged on five-point Likert scale which ranges from "Strongly Agree" to "Strongly Disagree". A total of 29 statements were added in the questionnaire. The construct of Technological Knowledge was measured through 9 statements. The construct of Content Knowledge was measured through 10 statements, while the construct of Technological Content Knowledge consisted 10 statements. The statements of the questionnaire were developed after thorough literature review of TPACK, and studies conducted on TPACK. Second portion of self-developed questionnaire consisted of open-ended questions about the influencing factors (internal and external) and problems faced by undergraduate students in Technological Knowledge, Content Knowledge, and Technological Content Knowledge.

3.5.2 General Knowledge MCQ Test

A self-developed general knowledge MCQ test comprising the basic knowledge about computer was also added to be asked from the undergraduate students to counter check their self-reported data regarding the indicator of Content Knowledge.

Table 3.3

Table of Specification for MCQ Test

Topics	Number of Items Based on Knowledge Level of Cognitive Domain	Percentage of Items
Basics of Computer	07	43.75%
Input Devices	03	18.75%
Output Devices	03	18.75%
Computer Softwares	03	18.75%
Total	16	100%

3.6 Procedure (Validity, Pilot testing & Reliability)

a. Validity of the Instrument

Before the process of data collection, the self-developed questionnaire and MCQ test were validated through opinions of the experts. Experts for the purpose of validation of instruments were selected from faculty of Education, IIUI. The experts added some suggestions to mold the question wording and at certain places to break down sentences in to short sentences. After feedback and suggestions from experts some statements of self-developed questionnaire were rephrased. No item from the MCQ test got any revision or change. After the said changes in questionnaire the instrument (Questionnaire & MCQ test) were pilot tested.

b. Pilot Testing

After the instruments got validated, that were pilot tested to check for its reliability. The questionnaire and MCQ test were pilot tested on 40 students from whole population to check for its feasibility. The instruments were pilot tested on undergraduate students from varied academic disciplines to ensure validity from all the faculties. The sample of undergraduate students selected for pilot tested was included as the part of original sample designed for the test administration. None of the sample items was omitted or rephrased after the pilot testing because alpha value for each construct was up to the mark.

c. Reliability of Instruments

For the purpose of checking reliability of the self-developed questionnaire, Cronbach Alpha was calculated. No statement was removed or rephrased after the pilot testing of questionnaire because Alpha value for all statements and constructs were good and up to the mark. The open-ended questions were also validated and their reliability was checked by the saturated answers given by the respondents. Split half reliability was also calculated for the MCQ test.

i. Reliability of Questionnaire

The reliability of the questionnaire was examined to ensure that it consistently measured the intended constructs. Internal consistency was evaluated using Cronbach's alpha, based on responses from a pilot sample of 40 undergraduate students. The overall Cronbach's alpha coefficient was 0.82, indicating a high level of internal consistency. The subscales demonstrated alpha values between 0.75 and 0.88, reflecting reliable measurement within each construct. After the pilot testing no any item got omitted or rephrased as the alpha values for items were up to the mark level.

Table 3.4

Reliability of Questionnaire

TPACK Subscales	Alpha Value
Technological Knowledge	0.85
Content Knowledge	0.75
Technological Content Knowledge	0.88
Overall Reliability of Questionnaire	0.82

ii. Reliability of MCQ Test

Analysis of test items was also conducted to ensure the reliability, validity, and overall effectiveness of test. The difficulty index of test items was about 0.30 to 0.35 and calculated discrimination index was about 0.50 to 0.65. The difficulty index and discrimination index values were in ideal range as defined by Gronlund (1998). All items were retained in the final version of test as there were no issues identified with distractors as well.

To ensure the reliability of the MCQ test, Split-half reliability was used to assess the internal consistency. The MCQ test was divided into two halves by assigning odd-numbered items to one half and even-numbered items to the other. A sample of 40 undergraduate students completed the questionnaire. The pilot data collected from 40 undergraduate students was used for analysis. The Pearson correlation between the two halves was r = 0.65. Applying the Spearman-Brown prophecy formula, the adjusted reliability coefficient was 0.79, suggesting that the instrument demonstrates a good degree of internal consistency. These results suggest that the items consistently measured the intended constructs.

3.7 Data Collection

Quantitative tool was utilized to assemble the desired data. The researcher managed personal visits to the undergraduate students for the purpose of collecting data. Moreover, the researcher used google forms to collect data from the respondents. The questionnaire was distributed among the undergraduate students and also emailed to the respective respondents. Any needed guidance was provided to the respondents for smooth collection of data. Before collection of data, all the participants were briefed to highlight the main motives of the research. All ethical considerations for research were followed by the researcher for fair and authentic collection of data. The response rate was 270 undergraduate students from varied academic disciplines.

3.8 Data Analysis

The assembled data was analyzed through descriptive statistics (frequency, percentage, mean and cumulative mean score), and inferential statistic (ANOVA) was used for comparison regarding the knowledge of technology, knowledge of content and technological content knowledge among different faculties of IIUI. Percentage of responses were calculated for the open-ended questions regarding associated factors and problems undergraduate students face in achieving the knowledge of technology, knowledge of content and technological content knowledge. The marks of MCQ test were counter checked with content knowledge construct.

Table 3.5

Objectives, Research Questions/ Hypothesis, Methods of Data Collection and Analysis

Sr. No	Objectives	Research Questions/ Hypothesis	Data Source	Data Analysis
1	Measure the current levels of TK, CK, and TCK among undergraduate students	What is the current level of undergraduate students' TK, CK, and TCK?	Questionnaire And general knowledge MCQ test	Frequency, Percentage, Mean, and Cumulative Mean score Analysis
2	Compare the levels of TK, CK, and TCK among Undergraduate students enrolled in different faculties of IIUI	**H_0:** There is no a significant difference in the levels of TK, CK and TCK among the undergraduate students enrolled at different faculties of IIUI	Questionnaire	ANOVA
3	Identify the factors that influence the TK, CK and TCK among undergraduate students	Which factors do influence undergraduate students TK, CK, and TCK?	Open Ended Questions	Thematic Analysis & Percentage
4	Explore the problems that undergraduate students face in achieving TK, CK, and TCK	Which problems do hinder undergraduate students in achieving TK, CK, and TCK?	Open Ended Questions	Thematic Analysis & Percentage

3.9 Ethical Consideration

Ethics were kept in mind for the study i.e; informed consent were taken from respondents before they participate in the study. All the contributors were clearly apprised and debriefed regarding the purpose and procedure. It was made sure that that participants involved may not get any type of harm or psychological damage. The participants were ensured that the gathered data will remain confidential and were utilized for research purposes only. Moreover, it was guaranteed to them that their particulars and other information would be kept confidential and classified.

3.10 Summary

This portion of the study explains the procedure of the research methodology in detail used for the study. As the study was descriptive in nature, so the quantitative approach was employed to gather the data from the respondents. All the undergraduate students enrolled in different academic faculties of IIUI were taken as population and 7 faculties with 20 departments were taken as sample for this particular study. Self-developed questionnaire using indicators of Technological Knowledge, Content Knowledge and Technological Content Knowledge was used to accomplish the study. Open ended questions regarding internal and external factors and problems encountering in TK, CK, and TCK were also added in the questionnaire. An MCQ test was also added to countercheck the self-reported content knowledge construct questions. Data were collected by the personal visit of the researcher and also through emailing the questionnaire to the respondents. The research ethics were taken in to consideration. Descriptive statistics were used to analyze the data. Same statistics (Frequency, Percentage, Mean Score, Cumulative Mean Score) and inferential statistics (ANOVA) were utilized for the comparison among the faculties. The factors and problems were further analyzed by thematic analysis and percentage of responses from varied academic disciplines.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATIONS

This section of the study is premised on analysis of the gathered data and interpretations of the study. The study was aimed to compare the Technological Knowledge, Content Knowledge, and Technological Content Knowledge among Undergraduate students at International Islamic University Islamabad. Firstly, an overview of participants was provided. Next, interpretation from analysis of data were presented to answer each research question and hypothesis of the study. Followed by presenting descriptive data analysis and ANOVA.

For the collection of data from undergraduate students, two self-developed instruments (one questionnaire & other MCQ test) were employed. After the process of data collection, the data was analyzed and results were drawn from them. For analyzing the data descriptive statistics was used. The frequency, percentage, mean score and cumulative mean score analysis was done. Where frequency is the exact number of members in a group and mean refers to the middle range of distribution.

For the comparison of technological knowledge, content knowledge and technological content knowledge among faculties inferential statistics was used and the technique of ANOVA was applied. This technique helps to compare more than two conditions to analyze the situation. It is employed to test the null hypothesis that the mean of three or more populations are equal or not.

Beside this, for analyzing open-ended questions thematic analysis was done and percentage of responses were calculated. The comparison of faculties, for each construct, was measured through five-point Likert Scale which ranges from strongly disagree to strongly agree. The response categories for the statements were as follows;

- Strongly Disagree= 1
- Disagree= 2
- Undecided= 3
- Agree= 4
- Strongly Agree= 5

The scoring decision for each response of undergraduate students' levels of TK, CK, and TCK against each construct was taken according to the following decided values for mean score analysis as below;

Table 4.1

Analysis of Mean Score Interpretation by Moidunny (2009)

Mean Scores	Interpretation
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.20	Medium
3.21 – 4.20	High
4.21 – 5.00	Very High

Further percentage analysis for each construct was calculated. Percentage method was added because this analysis provides a clear and interpretable representation of the data, it further helps in analysing levels of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among undergraduate students from varied academic faculties. Besides this, the percentage helps in gaining deeper insight about the scores, proportion of respondents etc. Analyzed data were then presented for each construct in two tables; one presenting statement wise mean scores and second percentage wise analysis of each construct. Detail of analyzed data is given below;

Table 4.2

Frequency and Percentage Analysis of Undergraduate Students' According to Different Faculties

S. N	Faculties	Frequency	Percentage
1	Faculty of Education	42	15%
2	Faculty of Arabic	21	7.7%
3	Faculty of Sciences	42	15%
4	Faculty of Management Sciences	42	15%
5	Faculty of Social Sciences	42	15%
6	Faculty of International Institute of Islamic Economics	42	15%
7	Faculty of Ussuluddin	42	15%
	Total	**273**	**100%**

Table 4.2 shows the analysis of undergraduates according to the faculties they belong to. The frequency of each faculty shows the extent of undergraduate students from that respective faculty. The table shows only 21 students from faculty of Arabic because the total number of populations is also the same and is smaller as compared to other faculties. So, all the undergraduate students from FOA has been taken for research purpose.

Levels of TK, CK, and TCK Among Undergraduate Students

Objective 1: To measure the current level of technological knowledge, content knowledge, and technological content knowledge among undergraduate students.

RQ 1: What are the undergraduates' current level of technological knowledge, content knowledge, and technological content knowledge?

Table 4.3

Undergraduate Students Mean Score Analysis for Technological Knowledge (TK)

Sr. No	Statements	Mean Score
1	I know about a lot of different technologies (i.e; computer, mobiles, ICT)	3.97
2	I can troubleshoot issues with commonly used software like MS Word on my laptop's Operating System	3.76
3	I can learn technology easily	3.95
4	I stay updated with new educational technologies such as Moodle and collaboration tool (like; Google Workspace)	3.78
5	I can frequently use educational technology	3.89
6	I have the technical skills that I need to use technology	3.88
7	I can easily use tools like Power Point or specialized softwares to teach subject content	4.02
8	I have sufficient opportunities to work with different technologies (i.e; computer, ICT)	3.77
9	I know how to operate different programs (i.e; word, power point, excel)	4.15
	Cumulative Mean Score	3.90

Table 4.3 shows the mean score analysis for the construct of Technological Knowledge. Mean score of (4.15) shows that undergraduate students are good enough in operating programs of word, power point and excel. They are pretty shore that they can operate these programs easily. Mean score of (4.02) depicts that undergraduate students are sure about using the power point and related softwares for teaching the content. This means that they are good in using the software of power point. The mean

score of (3.97) and (3.95) for the statement one and three respectively shows that undergraduate students are good in learning about different technologies and they also update themselves with new technologies. The mean score of (3.89) and (3.88) respectively on the fifth and sixth statements shows that majority of undergraduate students are good in using the educational technology and are having technical skills of using the technology. This shows their interest level in using and understanding he technology. The cumulative mean score of 3.90 shows that the undergraduate students from different academic faculties are good at the construct of technological knowledge. They can use it frequently and easily. They also update themselves with new technological advancements. Else they show high agreement for using the softwares of word, power point and excel easily and frequently.

Table 4.4

Undergraduate Students Percentage Analysis for Technological Knowledge (TK)

S.N	Intervals	Frequency	Percentage	Decision
1	19 – 27	27	10%	Low Level
2	28 – 36	113	41.85%	Moderate Level
3	37 – 45	130	48.15%	High Level
	Total	270	100%	

Table 4.4 shows the percentage analysis of undergraduate students from different faculties at IIUI on the construct of Technological Knowledge. This analysis was done by calculating sum for each respondent and then making intervals keeping in view the lowest and the highest achieved scores by the respondents. There were total nine statements for TK construct upon which technological knowledge was measured from undergraduate students of varied academic disciplines of IIUI. The analysis depicts that 10% of undergraduate students were at low level for Technological Knowledge. While, 41.85% undergraduate students were at moderate level as well as, 48.15% undergraduate students were at high level for the construct of Technological Knowledge.

Table 4.5

Undergraduate Students Mean Score Analysis for Content Knowledge (CK)

Sr No	Statements	Mean Score
1	I have sufficient knowledge about different concepts discussed in the subject of **Computers**	3.99
2	I have sufficient knowledge about different terminologies used in the subject of **Computers**	3.88
3	I know about basic theories and concepts related to the subject of **Computers**	3.82
4	I know about various applications of ICT in Science and Technology	3.79
5	I know about the difference between input devices (mouse, keyboard) and output devices (printer, monitor)	4.33
6	I have knowledge about the hardware and software storage devices	4.21
7	I can easily differentiate between the uses of LAN, WAN, and MAN	3.98
8	I can explain the functions of CPU and Mother board in processing computer operations	4.05
9	I have basic knowhow that HTML and URL are related to web browsing	3.82
10	I have knowledge about maintaining data and making hierarchy of data	3.77
	Cumulative Mean Score	3.96

Table 4.5 shows the mean score and cumulative mean score analysis for the construct of Content Knowledge among undergraduate students. For CK construct the

subject of “Applications of Information and Communication Technologies” was selected as this course is been studied by all the undergraduate students among varied academic disciplines. The results show that majority of undergraduate students are having sufficient knowledge about the subject of computer. The mean score (4.33) shows that undergraduate students from different disciplines have knowledge about what the input and output devices are. They are good in differentiating between different input and output devices. The mean score of (4.21) depicts that the undergraduate students are good at differentiating between hardware and software storage devices. They have high mean scores for this statement. It unfolds that they have the ability to explain and differentiating about basic terms related to computer subject. The mean score of (4.05) at statement seven explains that undergraduate students are good at explaining the functions of CPU and Mother board. It means they are having great knowledge about the basics of the subject of computer. Majority of undergraduate students are having high scores for differentiating among the LAN, WAN and MAN, explains that they are good in different terminologies and concepts discussed in the subject of computer being studied by all the undergraduate students. The mean score of (3.99), (3.880 and (3.82) respectively for first, second and third statements shows that undergraduate students have sufficient knowledge about the terms, concepts and terminologies discussed in the subject of computer being studied by undergraduate students. Majority of undergraduate students from varied academic disciplines are good enough for the construct of Content Knowledge. The cumulative mean score of (3.96) depicts that undergraduate students are good in the construct of content knowledge (CK).

Table 4.6

Undergraduate Students Percentage Analysis for Content Knowledge (CK)

S. N	Intervals	Frequency	Percentage	Decision
1	10 – 23	05	1.83%	Low Level
2	24 – 37	73	27.03%	Moderate Level
3	38 – 51	192	71.11%	High Level
	Total	270	100%	

Table 4.6 depicts the percentage analysis among undergraduate students from varied academic disciplines at IIUI for the construct of Content Knowledge. The analysis was done by calculating cumulative score for each respondent and then making intervals keeping in view the lowest and the highest achieved scores by the respondents. There were total ten statements for CK construct upon which content knowledge was measured from undergraduate students of varied academic disciplines at IIUI. The table shows that 1.83% of undergraduate students were at low level for CK. While, 27.03% undergraduate students were at moderate level as well as, 71.11% undergraduate students were at high level for the construct of Content Knowledge.

Table 4.7

Undergraduate Students Mean Score Analysis for Technological Content Knowledge (TCK)

Sr. No	Statements	Mean Score
1	I know which software tools can help me understand computer science concepts	3.55
2	I know about computer applications related to my subject knowledge	3.9
3	I can use the technologies to enhance my understanding of concepts and terms in the subject knowledge	3.85
4	I can use tools like MS Power Point or Google Slides to develop presentation materials efficiently	4.07
5	I can use software and hardware technologies to enhance understanding of subject of computer	3.96
6	I can use relevant software to create documents or slides that help explain computer science concepts	4.01

7	I can use different search engines as learning tool for searching material related to computer science concepts	3.87
8	I can select suitable technologies for understanding different concepts related to computer science subject	3.89
9	I use communication technologies (i.e; Slack, Google Meet, Snapchat, Email) for discussing computer related topics with peers	3.59
10	I use social media platforms to explore and understand computer related topics through videos, posts and discussions	3.56
	Cumulative Mean Score	3.82

Table 4.7 depicts the mean score and cumulative mean score analysis for the construct of Technological Content Knowledge (TCK) among undergraduate students at IIUI. The mean score of (4.07) and (4.01) on statements four and six respectively depicts that undergraduate students are excellent in using and dealing with Microsoft power point software as well as they can easily make slides and word documents on computer as well. Mean score (3.96) depicts that majority of undergraduate students are also good in using the software and hardware technologies in enhancing their understanding regarding computer subject. Mean score (3.9) shows that majority of undergraduate students know about different applications of computer related to their subject area and knowledge. While mean score of (3.89) presents that undergraduate students are capable of choosing relevant technologies for understanding the concepts of computer subject. For statement nine and ten, undergraduate students are at high mean scores that they discuss computer education content with peers on emails and google meet. As well as, they use social media to promote and post different computer related concepts. Majority of undergraduate students are also having high mean score of (3.87) for the statement that they use different search engines as a learning tool for searching the concepts and terms related to the subject of computer. The cumulative mean score of 3.82 depicts that undergraduate students are at high scores for the construct of Technological Content Knowledge. They are good at intermingling the technology within the content of computer science.

Table 4.8

Undergraduate Students Percentage Analysis for Technological Content Knowledge (TCK)

S. N	Intervals	Frequency	Percentage	Decision
1	10 – 23	7	2.6%	Low Level
2	24 – 37	93	34.44%	Moderate Level
3	38 – 51	170	62.96%	High Level
	Total	270	100%	

Table 4.8 presents the percentage analysis for Technological Content Knowledge (TCK) among undergraduate students at IIUI. This analysis was done by calculating cumulative score for each respondent and then making intervals keeping in view the lowest and the highest achieved scores by the respondents. There were total ten statements for TCK construct upon which technological content knowledge was measured from undergraduate students of varied academic disciplines of IIUI. The table shows that 2.6% of undergraduate students were at low level for TCK. While, 34.44% undergraduate students were at moderate level as well as, 62.96% undergraduate students were at high level for the construct of Technological Content Knowledge.

4.9 Factors Influencing Technological, Content and Technological Content Knowledge

Objective 2: To explore the factors influencing the technological knowledge, content knowledge and technological content knowledge among undergraduate students.

RQ 2: What factors do influence the technological knowledge, content knowledge and technological content knowledge among the undergraduate students?

4.9.1 Internal Factors Hindering in Technological Knowledge, Content Knowledge and Technological Content Knowledge

This portion of the study is premised on the responses from the undergraduate students for the open-ended question related to internal factors hindering in technological knowledge, content knowledge, and technological content knowledge given in the questionnaire. Under this heading all the responses their thematic analysis and their percentages will be presented given by undergraduate students. Internal factors are the factors related to the person that hinders in TK, CK, and TCK among undergraduate students. Responses given by undergraduate students for this question includes following factors.

- Personal Characteristics
- Learning Challenges/Obstacles
- Curriculum Related Barriers

Thematic Analysis for Internal Factors

A. Personal Factors

Undergraduate students were of the view that a lot of internal factors influence their levels of Technological Knowledge, Content Knowledge and Technological Content Knowledge. These included;

- Lack of confidence in using technology
- Lack of institutional support
- Lack of motivation to integrate technology

As presented by respondents *"lack of motivation, lack of interest, and lack of confidence acts as influencing factor".* One other respondent said that *"personal interest effects our learning, if we are not interested we can't learn anything".* Another respondent was of the view that *"lack of motivation, knowledge, and lack of experience act as hindrance".* Another respondent reported that *"prior limited experience with use of technology and subject matter, make it difficult for me to learn effectively".* Beside this, the undergraduate students were also influenced by insufficient resources provided to them. As undergraduate students reported *"lack of resources, limited technological environment, outdated knowledge tools and minimum exposure to technology influences TK, CK, and TCK".* Another respondent reported that *"lack of devices, issue of interest, and outside distractions when available with device is also an issue".* Some others were of the view that self-perceptions also hinder in learning, as presented by some respondents *"personal interest, prior negative experience with technology use, and self-efficacy also effects the levels of TK, CK, and TCK".* With this, another respondent reported that *"fear of failure or self-doubt is a hindrance".*

B. Learning Challenges/Obstacles

When undergraduate students were asked for internal factors hindering in their TK, CK and TCK, they reported that learning problems and challenges were a hinderance for them. These include the following;

- Lack of access and resources
- Cognitive overload
- Difficulty in content understanding, and
- Struggle with integration of technology and content

The undergraduate students frequently cited limited access to technological tools, internet connectivity, and updated learning materials as primary barriers to developing TK and TCK. As reported by respondents *"infrastructural challenge restricts my ability to engage with technology and its integration with subject knowledge".* With this, the dual demand can lead to cognitive overload, reducing learning effectiveness and contributing to negative attitudes toward both TK and TCK. *"I find it difficult to focus when I have to switch between apps, tabs, and notes during a single lecture"*. Many students reported struggling to grasp complex theoretical or practical concepts, which affected their CK development. As reported by respondents *"the lack of foundational understanding of subject matter creates pressure and cognitive overload".* Some others were of the view that *"lack of critical thinking and problem-solving skills hinders a lot in TK, CK, and TCK".* Some others were of the view that *"lack of resources, limited technological environment, outdated technological tools and minimum exposure to technological devices influences TK, CK, and TCK".* Some students found it particularly challenging to connect technological tools with their academic content. As reported *"we are told to use apps and platforms, but no one explains how they actually works"*. This indicates a gap in instructional support and students' ability. These factors collectively impact an individual's ability to learn effectively and integrate technology with subject content.

C. Curriculum Related Barriers/Obstacles

Curriculum-related factors emerged as significant barriers in the development of TK, CK, and TCK. Through thematic analysis, three main sub-themes were identified:

- Outdated curriculum content
- Lack of technology integrated environment, and
- Rigid teaching approaches

As described by undergraduate students the lack of technology enriched environment create hindrance in achieving TK, CK and TCK. As reported by some of the respondents *"the absence of deliberate technology-based tasks in assignments and projects limits opportunities to develop TCK by applying technical tools to real problems".* Some other reported that *"there is no any provision of training and workshop regarding use of different new introduced softwares that's why we are not capable of using them".* Some other were of the view that *"lack of using technological tools and resources by the teachers during lessons may also develop hinderance in developing TK, CK, and TCK capabilities".* In conclusion, curriculum-related challenges significantly hinder the development of TK, CK, and TCK among undergraduate students. Addressing these barriers requires systematic curriculum reforms that emphasize relevance, technological integration, and practical application. Without such changes, students may leave educational programs underprepared for modern, technology-driven professional environments.

Percentage Analysis for Internal Factors

a. Personal Factors

From the undergraduate students 60% were of the view that lack of motivation, lack of interest, lack of confidence and lack of resources act as hindrance for achieving these knowledge levels. Beside this, 10% were of the view that limited personal experience such as minimal exposure to technology or reliance on outdated knowledge, as well as techno phobias can create foundational gaps. 15% of the undergraduate students express that personal interest, prior negative experience, and self-efficacy also play a significant role in hindering TK, CK, and TCK; without curiosity or a connection to the subject, engagement diminishes. Other than these, remaining 15% undergraduates did not report personal factor as a hindrance in their learning.

b. Learning and Cognitive Challenges

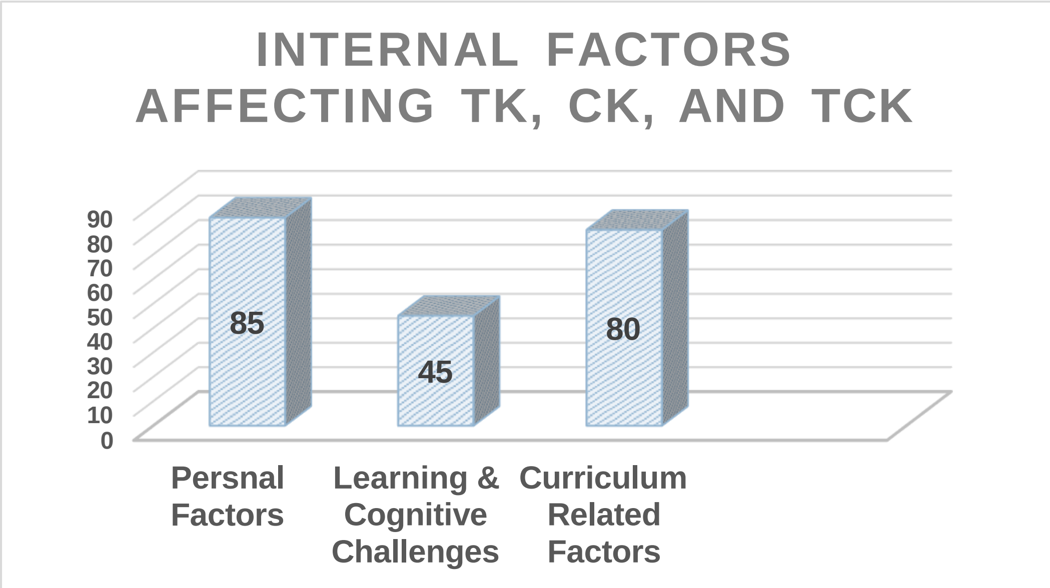
From undergraduate students 15% of the respondents express that cognitive challenges like difficulty with abstract thinking, problem-solving, or adapting to new tools and concepts hinder learning process. 10% of undergraduate students also relates that lack of critical thinking and problem-solving skills also act as internal factors that hinders in learning TK, CK and TCK. From the undergraduate students 20% express cognitive overload as a challenge to engage with complex concepts. These factors collectively impact an individual's ability to learn effectively and integrate technology with subject content. Other than these, remaining 55% undergraduates did not report learning &cognitive challenge as a hindrance in their learning.

c. Curriculum Related Factors

The outdated curriculum expressed by 5% of the undergraduate students is also a factor hindering in achieving TK, CK and TCK. Although the curriculum has been newly updated and revised there might be non-availability of resources and student full engagement. Beside this, the curriculum has been updated but the practical execution has still under process. These might be the reasons for listing outdated curriculum as a hindering factor. According to 10% of the respondents the university is not providing technology enriched environment that act as a factor influencing these knowledge levels. Lack of internet facilities as well as lack of connectivity issues hinders in learning as expresses by 40% of the undergraduate students. In view of 20% of undergraduate students there is no any provision of training and workshop regarding use of different new introduced softwares that's why undergraduate students are not capable of using them. Else, lack of using technological tools and resources by the teachers during lessons may also develop hinderance in developing TK, CK, and TCK capabilities as defined by 5% of the undergraduate students. Remaining 20% undergraduates did not report curriculum related factor as a hindrance in their learning process.

Figure 4.1

Internal Factors Influencing TK, CK, and TCK



4.9.2 External Factors Hindering in Technological Knowledge, Content Knowledge, and Technological Content Knowledge

This section is premised on the responses of undergraduate students for the open-ended question related to external factors hindering in technological knowledge, content knowledge, and technological content knowledge given in the questionnaire. Under this heading all the responses, their thematic analysis and their percentages was presented given by undergraduate students. External factors are the factors related to the institution that hinders in TK, CK, and TCK among undergraduate students. Responses given by undergraduate students for this question includes following factors.

- Institutional Factors
- Environmental Factors
- Limited Technology Integration
- Lack of Innovation and Change

Thematic Analysis for External Factors

(A) Institutional Factors

Institutional barriers act as external factor hindering the TK, CK, and TCK among undergraduate students. The sub themes emerged from this factor are as under;

- Limited access to technological resources
- Inadequate faculty training in technology integration
- Lack of institutional support and policy

The undergraduate students were of the view that limited access to up-to-date hardware, software, and stable connectivity reduces opportunities to practice modern tools, directly affecting TK and TCK. As reported by undergraduate students that *"the computer lab has old systems that can't run the latest software we need for projects".* Another reported that *"internet speed is so slow that we can't even download programming tools during lab sessions".* With this, undergraduate students also reported that faculty who are not well-trained in technology integration fail to merge technology with subject content, affecting TCK development and engagement with current CK. As reported by some respondents *"some teachers just use PowerPoint slides without showing how to use the latest programming frameworks, that effects negatively".* Along this, without well-defined policies, adequate funding, and strong partnerships, institutions are unable to foster an environment that effectively supports the development of TK, CK, and TCK through meaningful, hands-on learning experiences. As reported by respondents *"there are no workshops or seminars on new technologies".* Another was of the view that *"the university doesn't have partnerships with IT companies to give us practical exposure".* Some others were of the view that *"limited access to resources, such as outdated or insufficient technological tools and softwares also contributes in hindering learning".* All these barriers reflect hindrance in achieving TK, CK, and TCK.

(B) Environmental Barriers

Environmental barriers refer to external conditions in the physical or social learning environment that limit students' ability to develop technological, content, and integrated knowledge. These includes the following;

- Infrastructural issues
- Poor internet connectivity
- Electricity issues
- Overcrowded or inadequate learning space
- Lack of conducive learning environment
- Distracting campus environment

The undergraduate students were of the view that unstable electricity supply and weak internet connectivity interrupt continuous learning and make it difficult to access online resources essential for TK and TCK. As reported by respondents *“frequent power interruptions disrupt our online coding classes and lab work"*. Another reported that *“sometimes the internet is so slow that I can’t even open an online link or class"*. With this, undergraduate students were of the view that overcrowding reduces opportunities for individual practice, which is critical for mastering TK and applying CK in practical tasks. As reported by respondents *“the computer lab is always full, so I rarely get enough practice time"*. Another reported that *“no provision of internet, no environment, lack of resources, lack of labs and materials, lack of exposure to labs and resources also contribute towards it”*. Along this, noisy or distracting environment reduces focus and hinders in development of both conceptual understanding (CK) and skill-based knowledge (TK, TCK). As reported by respondents that *“surrounding noise makes it difficult to follow online lectures"*. Another reported that *“rigid policies and overloaded curricula discourage creativity and leave little time for exploring new technologies”*. Some others were of the view that *“ineffective leadership and a lack of vision for integrating technology in education prevents individual from developing their knowledge and skills and integrating technology with in the content”*. These factors collectively produce hindrance in achievement of TK, CK, and TCK.

(C) Limited Technology Integration

Limited technology integration refers to the inadequate use of digital tools, platforms, and resources into teaching, learning, and assessment practices. This external constraint prevents students from fully engaging with technological applications, understanding subject content in innovative ways, and developing the skills to integrate both. These involves the following;

- Minimal use of technology in teaching
- Irrelevant tools in curriculum
- Lack of hands-on projects

The undergraduate students were of the view that when technology is not meaningfully incorporated into teaching, opportunities to develop TK and TCK through real-world applications are lost. As reported by the respondents *“Most of our lectures are still delivered on the board without using any software or multimedia"*. Other problems included were *"a rigid curriculum that doesn't accommodate diverse learning styles or integrate technology effectively can create barriers to acquiring technological, content, and technological-content knowledge"*. On the other hand, language also act as barrier, as described by respondent *"language barrier, and tough and difficult wording and terminologies acts as a hindrance toward leaning and integrating technology"*. With this *"limited funding approved for technology integration creates hindrance in achieving TK, CK, and TCK"*. So, without structured opportunities to apply technology in solving content-related problems, students' TCK remains underdeveloped despite theoretical understanding that effects their future learning as well.

(D) Lack of Innovative Method and Change

The absence of modern teaching methods, along with reluctance to try new approaches, limits the use of technology in teaching content. These issues often arise from slow institutional change, old-fashioned teaching practices, or a lack of training for teachers, which reduces students' chances to experience creative and technology-based learning. These includes the following;

- Reliance on traditional teaching approaches
- Resistance to adopting new technologies
- Limited experimentations in curriculum delivery

The undergraduate students were of the view that over-reliance on traditional methods limits opportunities for students to engage with TK and TCK through interactive, real-world learning activities. As reported by them *"teachers as well as the students are reluctant to use the newly launched softwares independently"*. With this they also reported that *"classes are mostly lecture-based, and teachers rarely try new teaching methods"*. Besides this, resistance to change blocks the inclusion of modern technological practices in CK-focused teaching, which is vital for developing TCK. As reported by the respondents *"some teachers avoid using new software seeing this useless"*. Without providing opportunities for experimentation, undergraduate students miss on connecting TK with CK through innovative, problem-solving tasks. These problems in general produce hindrances in achievement of TK, CK, and TCK.

Percentage Analysis for External Factors

a. Institutional Factors and Infrastructure

The external factors related to institutions that hinder Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK) as described by 40% of undergraduate students include; insufficient access to modern resources, inadequate resource allocation to be used by the undergraduate students as a hindrance in achieving TK, CK, and TCK. 30% of undergraduate students were of the view that there is lack of infrastructure related to technology and integration of technology. 15% of undergraduate students also reported limited access to resources, such as outdated or insufficient technological tools and softwares also contributes in hindering learning. Remaining15% of undergraduate students did not find infrastructure as a problem in their learning.

b. Environmental Factors

The environmental factors also hinder in TK, CK, and TCK. As illustrated by 50% of the undergraduate students an unsupportive learning environment, lack of technology enriched environment contribute towards it. No provision of internet, no environment, lack of resources, lack of labs and materials, lack of exposure to labs and resources also contribute towards it. With this, outdated infrastructure, such as unreliable internet or tools, further limits technological growth. Rigid policies and overloaded curricula discourage creativity and leave little time for exploring new technologies. Additionally, according to 5% of the undergraduate students' ineffective leadership and a lack of vision for integrating technology in education prevents individual from developing their knowledge and skills and integrating technology with in the content. 45% of remaining undergraduate students did not report for environment as a factor influencing their learning.

c. Limited Technology Integration

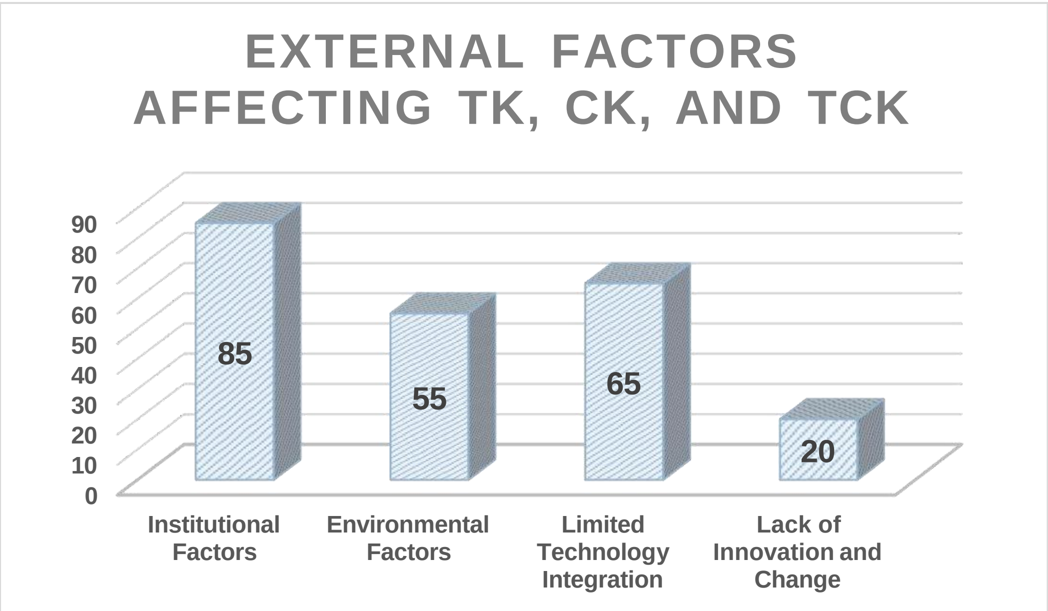
Limiting the integration of technology hinders in achieving the technological knowledge, content knowledge, and technological content knowledge. As described by 20% of undergraduate students a rigid curriculum that doesn't accommodate diverse learning styles or integrate technology effectively can create barriers to acquiring technological, content, and technological-content knowledge. With this, 15% of undergraduate students also reported language barrier, and tough and difficult wording and terminologies as a hindrance toward leaning and integrating technology. 10% undergraduate students were of the view that there is also limited funding given to integration of technology that create hindrance in achieving TK, CK, and TCK. Limited access to use of devices also contributed towards limiting technology integration as defined by 15% of the undergraduate students. With this, 5% of the undergraduate students reported that lack of technical support by the experts and teachers in using and operating technology is also a big issue. 35% of remaining undergraduate students did not report for limited technology provision as a factor influencing their learning.

D. Lack of Innovative Methods and Change

From the respondents 20% reported that resistance to change and lack of using innovative teaching methods acted as an external factor that is hindering in achieving TK, CK, and TCK. They reported that the teachers as well as the students are reluctant to use the newly launched softwares independently. They reported that, the rigid curriculum that doesn't accommodate diverse learning styles or reluctance to integrate technology with content effectively also create barriers to acquiring technological, content, and technological-content knowledge. Remaining 80% of undergraduate students did not find lacking in innovation provided.

Figure 4.2

External Factors Influencing TK, CK, and TCK



4.10 Problems Faced in Achieving TK, CK, and TCK

Objective 3: To explore the problems that undergraduate students face in achieving technological knowledge, content knowledge, and technological content knowledge.

RQ 3: What problems do undergraduate students face in achieving technological knowledge, content knowledge, and technological content knowledge?

4.10.1 Problems Faced by Undergraduate Students in Achieving Technological Knowledge

This section is premised with the responses provided by undergraduate students from varied academic disciplines regarding the problems they face in achieving Technological Knowledge. Under this heading all the responses are categorized in two ways, their thematic analysis and their percentages will be presented given by undergraduate students. Responses given by undergraduate students for this question includes following problems;

- Problems in Technological Knowledge
- Problems in Content Knowledge
- Problems in Technological Content Knowledge

(A) Thematic Analysis for Problems in Achieving Technological Knowledge

Undergraduate students reported several challenges that hinder their ability to acquire and effectively use technological knowledge. These challenges reflect both skill-related gaps and resource limitations. These includes;

- Limited access to technological resources
- Lack of hands-on practice
- Poor internet connectivity
- Outdated and insufficient softwares and tools
- Inadequate opportunities for training

Many students struggle to develop TK due to a lack of access to up-to-date devices, software, and reliable internet. Without proper resources, their ability to learn, practice, and apply technology remains limited. As reported by respondents *“our internet connection is too slow to run software or watch online tutorials."* This limited access to technology directly impacts students’ opportunities to enhance their TK through independent learning and practical engagement. Besides this, undergraduate students also reported that lack of practical application prevent from translating theoretical technological knowledge into actual skills. As reported by respondents *"we study about the software in theory, but rarely get a chance to use it in real tasks".* This hindered the learning mostly. Another respondent reported *"limited access to devices, unreliable infrastructure like poor internet connectivity, and outdated tools are hindering in achieving technological knowledge".* With this, low motivation, lack of interest, and low confidence in using technology reduce students' willingness to engage with technology-related learning. As reported by respondents *"I don't feel motivated to learn technology unless it's part of the exam."* Another reported that *"I am not such motivated to use technology by myself".* Along this, institutional gaps in training and infrastructure limit the development of students' technological competence as well. As reported by respondents *"lack of training opportunities and challenges in understanding complex software complicates the learning process".* Furthermore, another response was *"inadequate training and support for understanding specific software and technologies is also a problem".* Another reported that *"we don't have workshops or training sessions to learn about new technologies."* All these problems collectively hinder them in achieving their technological knowledge.

(B) Percentage Analysis for Problems in Achieving Technological Knowledge

From the undergraduate students 55% reported that achieving **Technological Knowledge (TK)** is often hindered by limited access to devices, unreliable infrastructure like poor internet connectivity, and outdated tools. A lack of training opportunities and challenges in understanding complex software further complicate the learning process as well as, inadequate training and support for understanding specific software and technologies is also a problem as described by 25% of the undergraduate students. With this, time constraints due to workload, insufficient technical support, and financial barriers, such as the high cost of devices and software, also contribute to these difficulties as described by 10% of the undergraduate students. These factors collectively make it challenging to develop technological proficiency effectively. Frequent technical issues, such as device malfunctions and software glitches, disrupt learning, while balancing time for practice and other responsibilities adds to the challenge. Additionally, 10% of undergraduate students also reported lack of institutional support and reliance on outdated tools further limit opportunities for technological skill development among undergraduate students from varied academic discipline at IIUI.

4.10.2 Problems Faced by Undergraduate Students in Achieving Content Knowledge

This section describes the responses provided by undergraduate students from varied academic disciplines regarding problems they face in achievement of content knowledge. The responses are categorized thematically and percentage wise.

(A) Thematic Analysis for Problems Faced in Achieving Content Knowledge

Undergraduate students reported several challenges that hinder their ability to acquiring content knowledge effectively. These challenges reflect both skill-related gaps and resource limitations. These includes;

- Insufficient learning materials
- Overloaded curriculum
- Time constrains
- Connectivity issues
- Limited teaching strategies for deep learning
- Lack of academic support and guidance
- Language barrier

The undergraduate students were of the view that overloaded curriculum discourages in-depth learning and leads to surface-level understanding of content. As reported by respondents *"we have too many subjects in one semester, so we just study to pass, not to understand"*. Likewise, *"insufficient or outdated and laborious educational resources, and lack of opportunities for professional development and training in specific subject areas hinders in learning content"*. So, heavy course loads and short semesters reduce the time students can dedicate to understanding subject content deeply. Along this, the teaching methods often focus on rote memorization rather than conceptual understanding, making it hard for students to grasp complex ideas. As the respondent report that, *"most teachers just read from slides; they don't explain with real-life examples"*. Beside this one report that, *"we are told to memorize definitions instead of learning how to apply concepts"*. Along this, the absence of structured academic support reduces students' chances to strengthen their understanding of core subject concepts. As reported *"there is lack of opportunities for professional development and training in specific subject areas".* Another report that, *"there is absence of a supportive learning environment that complicate the knowledge acquisition".* Respondents also reported that, *"lack of connectivity issues, lack of concentration, lack of engagement with subject matter, and certain distraction with in technology and outside form technology also create hindrance in content knowledge achievement".* These barriers collectively slow the process of mastering subject content.

(B) Percentage Analysis for Problems Faced in Achieving Content Knowledge

From undergraduate students 50% reported that achieving content knowledge is often hindered by insufficient or outdated and laborious educational resources, and lack of opportunities for professional development and training in specific subject areas. Along this, 20% of undergraduate students reported challenges in understanding complex concepts and the absence of a supportive learning environment that complicate the knowledge acquisition. These barriers collectively slow the process of mastering subject content. Sometimes, poor teaching methods or unengaging instruction can make it difficult to grasp concepts effectively. With this, 25% of the undergraduate students were of the view that low level of teacher's knowledge, less motivated teachers and lack of feedback also contributed towards it. The barrier of language also contributed a lot toward it. Lack of connectivity issues, lack of concentration, lack of engagement with subject matter, and certain distraction with in technology and outside form technology also create hindrance in content knowledge achievement. From the undergraduate students 5% were of the view that social media is a hindrance in content knowledge and concentration. Along this, difficult and outdated softwares also create hindrance in content knowledge achievement as described by the undergraduate students.

4.10.3 Problems Faced by Undergraduate Students in Achieving Technological Content Knowledge

This section describes the responses provided by undergraduate students from varied academic disciplines regarding problems they face in achievement of technological content knowledge. The responses are categorized thematically and percentage wise.

(A) Thematic Analysis for Problems in Achieving Technological Content Knowledge

Undergraduate students reported several challenges that hinder their ability to acquiring technological content knowledge effectively. These challenges reflect both skill-related gaps and resource limitations. These includes;

- Difficulty integrating technology with subject content
- Limited access to subject specific digital tools
- Insufficient hands-on practice opportunities
- Outdated teaching approaches in technology integration

Undergraduate students were of the view that a gap in instructional strategies linking technology with content reduces students' ability to apply TCK in practical scenarios. The students struggle to combine technological tools with their subject-specific knowledge due to limited guidance and practice. As reported by undergraduate students that *"we learn technology separately and content separately, but not how to connect both."* This reduces their ability to apply both effectively. Alongside they also reported that *"difficulty integrating technology with subject-specific content due to a lack of training or resources".* It is also said that, without adequate access to subject-relevant technologies, students cannot fully develop their TCK skills. As reported by respondents *"some tools are expensive and not provided by the university so we don't have access to subject-related software in our labs".* Beside this, *"insufficient guidance on using technology effectively for content delivery or exploration may create gaps in understanding".* It has been seen that the students have theoretical knowledge of technology but lack practical, content-linked application experience. As reported that *"labs are not scheduled often enough to practice with actual data or content".* And that, *"limited access to relevant tools and software that align with the content also hinder practical application".* With these problems, undergraduate students also reported that *"they face inadequate integration of technology with subject matter, lack of relevant digital resources, and insufficient training on technology-enhanced instructional methods that affect their ability of achieving technological content knowledge".* All these obstacles hinder and produce problems in achieving technological content knowledge.

(B) Percentage Analysis for Problems in Achieving Technological Content Knowledge

From the undergraduate students 65% reported that problems in achieving Technological Content Knowledge (TCK) include difficulty integrating technology with subject-specific content due to a lack of training or resources. Limited access to relevant tools and software that align with the content also hinder practical application as reported by 30% of the undergraduate students. Insufficient guidance on using technology effectively for content delivery or exploration may create gaps in understanding. Additionally, some undergraduate students 05% also reported that the technical issues, such as software complexity or hardware limitations, and a lack of collaboration or support from peers or instructors can further complicate the development of TCK. These challenges make it difficult to combine technological and subject knowledge effectively. Problems may also include difficulty in integrating technology with subject matter expertise, and limited access to resources and training on effective technology-enhanced instructional strategies. With these problems, undergraduate students also reported that they face inadequate integration of technology with subject matter, lack of relevant digital resources, and insufficient training on technology-enhanced instructional methods that affect their ability of achieving technological content knowledge.

4.11 Possible Solutions Provided by Undergraduate Students in Achieving Technological Knowledge, Content Knowledge, and Technological Content Knowledge

The possible solution provided by the undergraduate students in achieving technological knowledge, content knowledge and technological content knowledge includes the following;

- Ensuring access to modern devices, reliable internet, and providing affordable tools can help address technological issues. Regular training sessions and technical support, improving technical problems as well can further enhance technological skills. Along this, proper regular maintenance of devices is necessary. Provision of appliances to all undergraduates and regularly updating newly introduced softwares is also necessary. Provision of internet facility to all students is also necessary to deal with technology related problems. Integrating Moodle, Google Classroom, and MS Teams within course work is also beneficial. With this, increasing technological awareness among undergraduate students and providing them with technological projects is also important to increase their technological capabilities.

- For content-related problems, improving access to quality learning materials, using diverse teaching methods, and fostering a supportive learning environment, and providing feedback are key solutions. With this, inviting professional and experts to share their content related knowledge with undergraduate students is also beneficial. Side by side, softwares and content should be updated regularly according to student's needs. Providing better and easy learning material to the students can also be a great solution. Along this, there should be support of teachers as well. Solving these issues can solve content related problems regarding undergraduate students.
- To overcome technological content challenges, offering training on integrating technology with subject content, using user-friendly software, and promoting collaboration among peers and instructors could effectively fulfill the gap between technology and content. Fostering critical thinking, and problem solving also contribute towards it. Faculty technology enriched training sessions can also be a good solution improving the integration aspect among undergraduate students. There should also be provided supportive feedback for improving overall TCK. Programs should also be included that involve practicing the technology.

By implementing these technological, content, and technological content knowledge strategies, IIUI can enhance the TK, CK, and TCK among undergraduate students.

4.12 Comparison of Technological Knowledge, Content Knowledge and Technological Content Knowledge Among Undergraduate Students at IIUI

Objective 4: To compare the levels of technological knowledge, content knowledge, and technological content knowledge among undergraduate students enrolled in different faculties of IIUI.

H_o: There is no significant difference between the technological knowledge, content knowledge, and technological content knowledge levels among undergraduate students enrolled at different faculties of IIUI.

For comparison of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among undergraduate students at different faculties of IIUI the inferential statistics was applied. One Way ANOVA was used for comparison.

Table :4.9

Table Showing Mean Scores of TK, CK, and TCK for Different Faculties at IIUI

Faculties	TK	CK	TCK
Faculty of Education	3.83	3.89	3.85
Faculty of Arabic	3.7	3.96	3.69
Faculty of Sciences	3.69	3.78	3.62
Faculty of Management Sciences	4.07	4.19	3.98
Faculty of Social Sciences	3.77	3.85	3.85
International Institute of Islamic Economics	4.25	4.18	3.97
Faculty of Ussuluddin	3.93	3.83	3.69

For the analysis null hypothesis was made. The null hypothesis Ho was that there is no significant difference between Technological Knowledge, Content Knowledge, and Technological Content Knowledge among undergraduate students at IIUI. For comparison Alpha value was determined, that was 0.05%. After that table for ANOVA was run on Excel to find the difference among TK, CK, and TCK among different faculties of IIUI.

Table: 4.10 (1)

Table showing Sum, Average, and Variance of TK, CK, and TCK

Groups	*Count*	*Sum*	*Average*	*Variance*
TK	7	27.24	3.891429	0.042948
CK	7	27.68	3.954286	0.027895
TCK	7	26.65	3.807143	0.020424

Table: 4.10 (2)

ANOVA						
Source of Variation	***SS***	***f***	***S***	***F***	***P-value***	***F crit***
Between Groups	0.07	2	0.03	1.25	0.30	3.55
Within Groups	0.54	18	0.03			
Total	0.62	20				

4.13 Results of ANOVA

A one-way ANOVA was conducted to compare the mean scores of Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK) among undergraduate students.

As shown in Table 4.10 (2), the results indicated that there was no statistically significant difference among the mean scores of the three groups, the *p-value* (0.30) is greater than alpha value 0.05, we fail to reject the null hypothesis. The calculated F-value (1.25) was also less than the critical F-value (3.55), confirming that the observed differences in mean scores were not statistically meaningful. The calculated P value is not significant because of which post hoc cannot be applied.

CHAPTER 5

SUMMARY, FINDINGS, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The main theme for the study was the comparison of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among undergraduate students at International Islamic University Islamabad. The study involves comparing seven faculties and twenty departments under these faculties for TK, CK and TCK. The constructs of TK, CK and TCK were taken from TPACK model described by Mishra and Kohler. The aspect of Pedagogy has been skipped for this study because the study involves varied academic disciplines and pedagogical aspect is related to the students of education. So, the study was designed to compare the current levels of TK, CK, and TCK among undergraduate students from varied academic disciplines of IIUI. The objectives of the study involve to; (a) measure the current level technological knowledge, content knowledge, and technological content knowledge among undergraduate students. (b) compare the levels of technological knowledge, content knowledge, and technological content knowledge among different faculties at IIUI. (c) explore the factors influencing TK, CK, and TCK among undergraduate students. (d) explore the problems undergraduates face in achieving TK, CK, and TCK. This study has followed mixed methods research design including collection of quantitative and qualitative data simultaneously from the respondents. The target population comprised of all undergraduate students of second semester studying the course of "Application of Information and Communication Technologies" during their semester Fall 2024. Using stratified random sampling to ensure maximum representation from varied academic disciplines a sample of 297 students were selected as sample of the study. Self-developed questionnaire was used for collection of data from the undergraduate students. An MCQ test was also added to counter check their self-reported content knowledge. The instrument consisted of indicators as; Technological Knowledge, Content Knowledge, and Technological Content Knowledge. Some open-ended questions were also added in the questionnaire regarding the factors and problems undergraduate students face in achieving these knowledge levels. Data were collected through personal visit of the researcher and also through google forms. The data were analyzed using descriptive statistics; (frequency, percentage, mean score, and cumulative mean score analysis) to assess the levels of TK, CK, and TCK among undergraduate students. ANOVA was applied to compare the faculties for TK, CK, and TCK. The open-ended questions were also analyzed through thematic analysis and percentage analysis.

5.2 Findings

Findings of the research were categorized as follows;

1. Findings from levels of Technological Knowledge, Content Knowledge and Technological Content Knowledge
2. Findings from comparison analysis among different faculties.
3. Findings from internal and external factors analysis.
4. Findings from problems undergraduate students face in technological knowledge, content knowledge, and technological content knowledge.
5. Findings from possible solutions provided by undergraduate students for technological knowledge, content knowledge, and technological knowledge.
6. Findings from overall mean scores of different faculties at IIUI.

5.2.1 Findings from Levels of TK, CK, and TCK

The results of the study revealed that undergraduate students from various academic disciplines at the International Islamic University Islamabad (IIUI) demonstrated high levels of Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK). Specifically, the mean score for TK was 3.90, indicating that students possess a strong understanding and familiarity with technology relevant to their academic context. The mean score for CK was 3.96, reflecting a good grasp of subject-specific knowledge across disciplines. Similarly, the mean score for TCK was 3.82, suggesting that students are also capable of meaningfully connecting technology with their subject matter, demonstrating a solid foundation in integrating content with appropriate technological tools. These findings collectively indicate that IIUI undergraduate students are well-equipped in terms of knowledge across these domains.

5.2.2 Findings from Comparative Analysis among Different Faculties

The comparative analysis conducted to examine differences in Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK) among undergraduate students from varied academic faculties at the

International Islamic University Islamabad (IIUI) revealed no statistically significant differences across the groups. The results showed a p-value of 0.30, which is greater than the alpha level of 0.05, and the calculated F-value was less than the F-critical value. Based on these results, the null hypothesis was accepted, indicating that there are no significant differences in TK, CK, and TCK among undergraduate students from different faculties at IIUI. Consequently, the research hypothesis was rejected, suggesting that students across faculties possess relatively similar levels of technological, content, and technological content knowledge.

5.2.3 Findings from Influencing Factors Analysis for TK, CK, and TCK

The findings from influencing factors analysis was further divided in to internal factors and external factors undergraduate students face in achieving technological knowledge, content knowledge, and technological content knowledge.

(A) Findings from Internal Factors

i. The associated internal factors by the undergraduate students included personal factors hindering TK, CK and TCK. These included; lack of motivation, lack of interest, lack of confidence and lack of resources. Beside this, they also reported limited personal experience, prior negative experience, such as minimal exposure to technology or reliance on outdated knowledge, as well as techno phobias acted as personal hindrances in TK, CK, and TCK. The undergraduate students also expressed that personal interest, prior negative experience, and self-efficacy also plays a significant role in hindering TK, CK, and TCK.

ii. The undergraduate students also reported learning and cognitive challenges like difficulty with abstract thinking, problem-solving, or adapting to new tools and concepts as a hinderance in learning process. They also relate lack of critical thinking and problem-solving skills as internal factors that hinders in learning TK, CK and TCK.

iii. The undergraduate students reported curriculum related factors as hindrance in TK, CK, and TCK. These included; lack of internet facility, issues in connectivity, no any training sessions for introduction and use of newly introduced softwares. Besides this, they reported that university is not providing technology enriched environment that act as a hindering factor. Likewise, they expressed that lacking in internet facility and connectivity is an issue. The lacking in using technological tools and resources by the teachers during lessons also produce hindrance in integrating technological and content knowledge.

(B) Findings from External Factors

i. The undergraduate students reported institutional factors as a hindrance in achieving TK, CK, and TCK. These included; insufficient access to modern resources, inadequate resource allocation, and limited access to resources etc.

ii. The undergraduate students reported environmental factors as hindrance in TK, CK, and TCK. These included an unsupportive learning environment, lack of technology enriched environment, no provision of internet, lack of resources, lack of labs and materials, lack of exposure to labs and resources.

iii. They reported limited technology integration as a hindrance in achieving TK, CK, and TCK. These included a rigid curriculum that doesn't accommodate diverse learning styles, difficult and tough terminologies, and limited access to use of devices that limits technology integration. Beside this, the language barrier is also a hindrance toward leaning and integrating technology.

iv. They also reported resistance to change and lack of innovation in teaching learning methods and change as an external factor that is hindering achieving TK, CK, and TCK.

5.2.4 Findings from Problems Undergraduate Students Face in TK, CK, and TCK

The findings from the problems undergraduate students face in achieving in technological knowledge, content knowledge and technological content knowledge includes the following;

i. The undergraduate students reported that achieving **Technological Knowledge (TK)** is often hindered by limited access to devices, unreliable infrastructure like poor internet connectivity, and outdated tools. A lack of training opportunities and challenges in understanding complex software further complicate the learning process as well as, inadequate training and support for understanding specific software and technologies is also a problem. Additionally, lack of institutional support and reliance on outdated tools further limit opportunities for technological skill development among undergraduate students from varied academic discipline at IIUI.

ii. The undergraduate students reported that achieving **Content Knowledge** is often hindered by insufficient or outdated and laborious educational resources, and lack of opportunities for professional development and training in specific subject areas. Along this, undergraduate students also reported challenges in understanding complex concepts and the absence of a supportive learning environment further complicate knowledge acquisition. These barriers collectively slow the process of mastering subject content. The respondents also reported social media as a hindrance in content knowledge and concentration. Along this, difficult and outdated softwares also create hindrance in content knowledge achievement.

iii. The undergraduate students reported that problems in achieving **Technological Content Knowledge** (TCK) include difficulty integrating technology with subject-specific content due to a lack of training or resources. Limited access to relevant tools and software that align with the content can also hinder practical application. Insufficient guidance on using technology effectively for content delivery or exploration may create gaps in understanding. Additionally, they also reported technical issues, such as software complexity or hardware limitations, and a lack of collaboration or support from peers or instructors can further complicate the development of TCK. These challenges make it difficult to combine technological and subject knowledge effectively.

5.2.5 Findings from Possible Solutions Provided by Undergraduate Students for TK, CK and TCK

The finding from possible solutions provided by undergraduate students from varied academic disciplines includes the following;

i. Ensuring access to modern devices, reliable internet, and providing affordable tools can help address technological issues.

ii. Regular training sessions and technical support, improving technical problems as well can further enhance technological skills.

iii. Provision of appliances to all undergraduates and regularly updating newly introduced softwares is also necessary.

Iv Integrating Moodle, Google Classroom, and MS Teams within course work is also beneficial.

v. Increasing technological awareness among undergraduate students and providing them with technological projects is also important to increase their technological capabilities.

vi. For content-related problems, improving access to quality learning materials, using diverse teaching methods, and fostering a supportive learning environment, and providing feedback are key solutions.

vii. Inviting professional and experts to share their content related knowledge with undergraduate students is also beneficial.

viii. There should be regular updation of softwares and content according to student's needs.

ix. Offering training on integrating technology with subject content, using user-friendly software, and promoting collaboration among peers and instructors can effectively bridge the gap between technology and content.

x. Faculty technology enriched training sessions can also be a good solution improving the integration aspect among undergraduate students.

xi. Provision of supportive feedback is also important for improving overall integration of technological and content knowledge.

xii. Fostering critical thinking, and problem solving also contribute towards integration of technological and content knowledge.

5.2.6 Findings from Overall Mean Scores of Different Faculties at IIUI

A review of the mean scores from various faculties at the International Islamic University Islamabad (IIUI) indicated no considerable differences in students' levels of Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK). Beside this, the Faculty of Islamic International Institute of Education (IIIE) reported the highest mean scores across all three domains, suggesting that its students demonstrate a stronger command of both their subject matter and the effective use of technology in learning, along with the ability to integrate the two.

Similarly, the Faculty of Management Sciences ranked second in mean scores for TK, CK, and TCK. This indicates that students from this faculty also show a good understanding of their academic content, technological tools, and how to blend these elements in educational settings.

In contrast, the Faculty of Sciences recorded the lowest average scores in all three areas. This could point to limited opportunities for students in this faculty to interact with or apply technology in ways that support their subject knowledge. It highlights a potential need for increased efforts to incorporate technology into the science curriculum more effectively.

5.3 Discussion

This study was set out to compare the levels of Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK) among undergraduate students at IIUI, with the aim of identifying levels across faculties and exploring the factors influencing these differences. The findings reveal high levels of TK, CK, and TCK among various faculties. These findings align with earlier research by Koh and Chai (2016), who reported that exposure to technology-rich learning environments enhances both technological and integrated knowledge domains in pre-service teachers. Similarly, Pamuk et al. (2015) found that consistent engagement with discipline-specific digital tools improves both CK and TCK competence. Alongside, the findings revealed notable problems and factors influencing their levels of TK, CK, and TCK. In this section, these results are discussed in relation to the existing literature, highlighting consistencies, discrepancies, and potential explanations for the observed trends.

The high TK scores observed in this study may be attributed to increased accessibility to personal devices, online resources, and social media platforms for academic purposes. Previous studies have confirmed that routine exposure to technology fosters greater confidence and proficiency in digital tools (Chai et al., 2016; Mishra & Koehler, 2006). This is further supported by Teo (2011), who found that positive attitudes toward technology significantly predict self-reported technological competence. However, despite high TK levels, qualitative responses revealed persistent issues such as outdated institutional infrastructure, limited access to licensed software, and unreliable internet connectivity. This contradiction reflects findings by Tondeur et al. (2017), who observed that even technologically confident students face constraints when institutional resources are insufficient.

The findings obtained from the percentage analysis revealed that the majority of undergraduate students were at moderate level for the construct of TK. Similar findings were found in the literature by Jalani et al. (2021). They revealed that prospective teachers rate their technological knowledge on third level as compared to other domains of TPACK. Similarly, the research findings by (Ningtyas et al., 2023) are in line with this research where it concludes that EFL students thought that their teacher pays least importance to technology integration aspect and are low on the domain of TK. Furthermore, Irum et al., 2018 also analyzed teacher educators' perceptions for TK domain of TPACK in Sindh context. They concluded low level of technological knowledge among majority of teacher educators.

Similarly, CK levels were found to be strong, reflecting students' mastery of discipline-specific concepts. This is consistent with earlier work by Shulman (1986) and reaffirmed by Koehler et al. (2013), who emphasized the foundational role of CK in enabling effective learning and professional readiness. The CK scores in the present study may be influenced by structured curricula and experienced faculty members. However, barriers such as outdated course materials, limited access to recent publications, and insufficient curriculum updates were identified. These challenges parallel the findings of Hennessy et al. (2010), who argued that content knowledge development become ineffective when educational resources and pedagogical materials are not regularly revised to reflect evolving disciplinary trends.

The strong TCK scores suggest that students are capable of effectively integrating technology to represent, explore, and communicate content-specific concepts. These results are in line with Voogt et al. (2013), who found that TCK proficiency develops when learners engage with digital tools in meaningful, subject-oriented tasks. In the Pakistani context, this integration appears to be facilitated by both formal instruction and informal learning through online communities. Nevertheless, the study also revealed TCK-related issues such as the inability to apply advanced or specialized technological tools due to insufficient institutional training programs. This gap is comparable to findings by Javed and Arif (2019), who noted that while basic technological integration is common, advanced TCK applications require targeted capacity-building initiatives.

Similarly, Yanti et al. (2019) assessed the TCK of Mathematics Education Students among Teacher Training and Education Faculty, after completion of mathematics course. The results show that the students of Mathematics have good Technological Content Knowledge. Their mean score for TCK is 3.52 that indicates their understanding for technology integration in mathematics. Similar findings were concluded in case of undergraduate students for this study.

The findings from comparative analysis finds no significant difference among different faculties. In contrast, Simsek and Yazar (2019) in the context of Turkey, assessed TPACK self-efficacy of prospective teachers for technology integration from nineteen different departments of eighteen state universities, and reported that different departments are viewing TPACK in different manners. So, the self-efficacy of prospective teachers for integrating technology significantly differentiate.

Demographic variables (e.g., prior technology exposure, socioeconomic background) and institutional factors (e.g., availability of ICT facilities, supportive faculty) were found to influence TK, CK, and TCK levels. These results mirror findings by Sang et al. (2010), who highlighted the role of both personal and contextual factors in shaping technology integration competencies. Furthermore, peer collaboration and informal learning were reported as significant enhancers of technological integration skills, echoing the observations of Ertmer and Leftwich (2010) that professional learning communities accelerate TPACK-related growth.

Similarly, findings pertaining to internal and external factors related to TK, CK, and TCK included; lack of access to resources, lack of infrastructure, lack of devices, lack of motivation, no provision of internet and no good environment as well. The similar findings were presented by (Mumtaz et al., 2023; Kozlova & Pikhart, 2021) when it comes to infrastructure and lack of maintenance.

Saleem and Zahra (2017) found that Pakistani schools often lacked adequate ICT tools, reliable labs, and internet connectivity, factors that hinder both content delivery and technology. These results are in line with results of this study where students struggled to develop TK due to resource constraints and limited hands-on exposure.

In Turkey, Atabek in 2019 reported that inadequate in-service/pre-service training, poor content support, and weak incentives were major factors to integrating technology in education not the absence of hardware alone. These results support the findings that resistance to change and outdated instructional approaches directly effects TCK development even when technology is available.

Harell and Bynum (2018) also assessed internal and external “Factors Affecting Technology Integration in the Classroom” affecting technology integration. The results indicated poor infrastructure, inadequate technology, lack of sufficient technological tools, effective professional development as (external factors) limiting technology integration, and low teacher self-efficacy and teacher perceptions as (internal factors) that affect technology integration in PK-12 schools. Similar findings were concluded from this research.

Rudhumbu (2020) also investigated the obstacles and elements involved in incorporating technology into the classroom. The results indicated the availability of technical support, time allotted for the technology integration, ongoing staff development, instructor involvement in integration planning phase, the type of curriculum being integrated with technology, and the availability of infrastructure are a few examples of these factors. The similar findings were drawn from this research.

Pérez-Juárez et al. (2024) highlighted that while technology enables learning, it also introduces significant digital distractions reducing students' focus and performance during lab sessions. Same findings were from thematic analysis where students expressed difficulties concentrating in technology heavy learning environments, impacting TK and TCK acquisition.

The TPACK model (Mishra & Koehler, 2006) emphasizes that effective integration of technology with content and pedagogy (TCK) requires alignment across all three domains. Studies in Pakistan have underscored challenges such as outdated resources, lack of lab access, faculty training gaps, and financial limitations all as key obstacles to achieving TCK within TPACK. Same results were seen in case of this study, where students reported lack of resources, lack of access to labs, financial constrains and training gaps as major factors hindering in achieving TK, CK, and TCK.

Overall, the findings of this study highlight that undergraduate students’ development of Technological Knowledge, Content Knowledge, and Technological Content Knowledge is significantly shaped by a combination of institutional and environmental factors. Consistent with prior research (e.g., Gayyur, 2021; Pérez-Juárez et al., 2023), barriers such as limited access to resources, lack of innovative teaching practices, and resistance to change restrict meaningful technology integration in higher education. While individual motivation and digital literacy play important roles, it is evident that systemic improvements such as sustained professional development for educators, and supportive institutional policies are essential to fostering these competencies. Addressing these challenges requires a holistic approach where stakeholders collaboratively work to create a technology-rich learning environment that bridges theoretical knowledge with authentic, hands-on experiences.

Demographic variables (e.g., prior technology exposure, socioeconomic background) and institutional factors (e.g., availability of ICT facilities, supportive faculty) were found to influence TK, CK, and TCK levels. These results mirror findings by Sang et al. (2010), who highlighted the role of both personal and contextual factors in shaping technology integration competencies. Furthermore, peer collaboration and informal learning were reported as significant enhancers of technological integration skills, echoing the observations of Ertmer and Leftwich (2010) that professional learning communities accelerate TPACK-related growth.

In conclusion, from a theoretical perspective, these findings reinforce Mishra and Koehler's (2006) assertion that TK, CK, and TCK are interdependent yet contextually shaped domains. Practically, the results suggest that while student competencies are strong, sustained investment in infrastructure, updated curricula, and advanced training opportunities is critical for maximizing TPACK potential in higher education. Policymakers and institutions should prioritize resource allocation to address the identified barriers, ensuring that competence translates into effective practice.

5.4 Conclusions

On the basis of findings following conclusions have been drawn;

i. It was concluded that the current levels of Technological Knowledge (TK), Content Knowledge (CK) and Technological Content Knowledge (TCK) were high among undergraduate students from varied academic disciplines.

ii. Comparison of TK, CK, and TCK among undergraduate students from varied academic disciplines revealed that there is no significant difference between the technological knowledge, content knowledge, and technological content knowledge among different faculties of IIUI. As the p-value is greater than alpha value, so null hypothesis was accepted.

iii. From internal factors and problems influencing technological, content and technological content knowledge it was concluded that; lack of motivation, lack of interest, lack of confidence and lack of resources, limited personal experience, personal interest, prior negative experience, and self-efficacy, difficulty with abstract thinking, problem-solving, or adapting to new tools and concepts, lack of using technological tools and resources by the teachers during lessons are hinderances in developing TK, CK, and TCK capabilities in undergraduate students.

iv. From external factors and problems influencing technological, content and technological content knowledge it was concluded that; insufficient access to modern resources, inadequate resource allocation, lack of infrastructure related to technology and integration of technology, no provision of internet, no environment, lack of resources, lack of labs and materials, lack of exposure to labs and resources, rigid curriculum that doesn't accommodate diverse learning styles or integrate technology effectively creates barriers to acquiring technological, content, and technological-content knowledge.

v. From problem analysis, it was concluded that undergraduate students identified several key challenges hindering the acquisition of Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK). For TK, the primary issues included limited access to devices, unreliable internet, outdated tools, and inadequate institutional support. CK-related challenges involved outdated or insufficient learning materials, limited professional development, and an unsupportive academic environment. Additional barriers such as difficulty in understanding complex concepts, distractions from social media, and use of difficult software were also noted. Regarding TCK, students reported a lack of training, insufficient resources for integration, software and hardware limitations, and minimal collaborative or instructional support. Collectively, these challenges significantly affect students' ability to develop and integrate technological and content knowledge effectively.

vi. From the possible solutions provided by undergraduate students from varied academic disciplines it was concluded that; for solving technology related problems ensuring access to modern devices, reliable internet, and providing affordable tool are best solutions. Improving access to quality learning materials, using diverse teaching methods, and fostering a supportive learning environment, and providing feedback are key solutions for dealing with content related problems. Offering training on integrating technology with subject content, using user-friendly software, and promoting collaboration among peers and instructors can effectively bridge the gap between integration of technology and content related problems.

vii. From the overall mean scores among varied academic faculties it has been concluded that the faculty of IIIE ranked higher in all domains of TK, CK, and TCK. The Faculty of Management sciences ranked next to IIIE. While on the other hand the Faculty of Sciences ranked low on all three domains.

5.5 Recommendations

On the basis of conclusions following recommendations were given.

i. Although the findings revealed that undergraduate students demonstrated relatively high levels of TK, CK, and TCK, it is recommended that these competencies may be further strengthened. Maximum use of ICT in the teaching–learning process may be ensured by both students and teachers. Moreover, the adoption of effective instructional strategies by teachers is recommended to facilitate students' comprehension of concepts, terms, and content. In addition, the practical application of ICT in teaching and learning may be emphasized so that undergraduate students may develop stronger skills in integrating technology with content.

ii. Internal and external challenges were identified as barriers to the development of technological, content, and technological–content knowledge. To address these issues, it is recommended that adequate infrastructure and modern software and hardware resources may be provided, so that the learning experience of undergraduate students may be enhanced.

iii. Based on the findings, it is recommended that reliable and high-speed internet access may be provided to undergraduate students. For this purpose, the existing network infrastructure of the university should be upgraded to meet current academic and technological requirements.

iv. In light of the solutions suggested by undergraduate students, it is recommended that adequate access to modern technologies and resources may be ensured by the administration. The provision of projectors and the upgrading of computer laboratories are suggested as effective measures to create a technology-enriched learning environment for undergraduate students.

v. On the basis of mean scores across different faculties, it is recommended that the curriculum may be revised by policymakers and faculty to incorporate courses focused on technology integration, particularly for the Faculty of Sciences (FoS), as students from this faculty recorded the lowest scores in TK, CK, and TCK compared to other faculties. The inclusion of such courses is expected to support future learning and improve students' competence in applying technology to discipline-specific content.

5.6 Limitations of the Study

The study has following limitations.

This study focuses on three components from the TPACK framework: Technological Knowledge (TK), Content Knowledge (CK), and Technological Content Knowledge (TCK). Pedagogical Knowledge (PK) has been skipped for certain reasons. PK is generally related to people who are either teaching or being trained to become teachers.

Another reason is that, this research is about undergraduate students, especially those studying in general degree programs and not only in teacher education department. These students usually do not take part in teaching or receive training in teaching methods. Because of this, they are not likely to have much knowledge about pedagogy. Therefore, the study only includes TK, CK, and TCK—areas that are more suitable and relevant to what undergraduate students know and experience during their studies.

5.7 Recommendations for Future Studies

For future studies following recommendations were given;

i. This study has followed mixed methods approach to study phenomena further qualitative and in-depth study may be conducted.

ii. This study was particularly delimited to the different faculties of International Islamic University Islamabad; hence future researches may include any other university or comparison with any other university.

iii. This study has taken computer science subject as a core subject of undergraduate students; hence further research may target any other core subject for comparison.

iv. This study was limited to TK, CK, and TCK constructs from TPACK framework; further research may involve all aspects of TPACK as well.

v. This study has only used questionnaire and open-ended questions as instrument; future research may also involve observations and interviews as a technique for data collection.

vi. Faculty wise comparison was added in this study; future study may involve gender-based comparison as well.

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APPENDICES

APPENDIX (A)

Questionnaire

Comparison of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among Undergraduate Students at International Islamic University Islamabad

Technology is a broad concept that can involve a lot of different things. For this questionnaire technology refers to all the digital technologies. That involve the digital tools like computers, laptops, handhelds, and software programs etc. Read the statements below and rate your selves according to given scale.

PART (A)

Technological Knowledge (TK)

Sr. No	Statements	SA (5)	A (4)	UD (3)	DA (2)	SDA (1)
1	I know about a lot of different technologies (i.e; computer, mobiles, ICT)					
2	I can troubleshoot issues with commonly used software like MS Word on my laptop's Operating System					
3	I can learn technology easily					
4	I stay updated with new educational technologies such as Moodle and collaboration tool (like; Google Workspace)					
5	I can frequently use educational technology					
6	I have the technical skills that I need to use technology					

7	I can easily use tools like Power Point or specialized softwares to teach subject content					
8	I have sufficient opportunities to work with different technologies (i.e; computer, ICT)					
9	I know how to operate different programs (i.e; word, power point, excel)					

Content Knowledge (CK)

Sr. No	**Statements**	**SA (5)**	**A (4)**	**UD (3)**	**DA (2)**	**SDA (1)**
1	I have sufficient knowledge about different concepts discussed in the subject of Computers					
2	I have sufficient knowledge about different terminologies used in the subject of Computers					
3	I know about basic theories and concepts related to the subject of Computers					
4	I know about various applications of ICT in Science and Technology					
5	I know about the difference between input devices (mouse, keyboard) and output devices (printer, monitor)					
6	I have knowledge about the hardware and software storage devices					
7	I can easily differentiate between the uses of LAN, WAN, and MAN					

8	I can explain the functions of CPU and Mother board in processing computer operations					
9	I have basic knowhow that HTML and URL are related to web browsing					
10	I have knowledge about maintaining data and making hierarchy of data					

Technological Content Knowledge (TCK)

Sr. No	**Statements**	**SA (5)**	**A (4)**	**UD (3)**	**DA (2)**	**SDA (1)**
1	I know which software tools can help me understand computer science concepts					
2	I know about computer applications related to my subject knowledge					
3	I can use the technologies to enhance my understanding of concepts and terms in the subject knowledge					
4	I can use presentation tools to effectively present computer science concepts					
5	I can use software and hardware technologies to enhance understanding of subject of computer					
6	I can use relevant software to create documents or slides that help explain computer science concepts					

7	I can use different search engines as learning tool for searching material related to computer science concepts					
8	I can select suitable technologies for understanding different concepts related to computer science subject					
9	I use communication technologies (i.e; Slack, Google Meet, Snapchat, Email) for discussing computer related topics with peers					
10	I use social media platforms to explore and understand computer related topics through videos, posts and discussions					

PART (B)

Open Ended Questions

1. What are the internal factors (related to person) that hinders in Technological Knowledge, Content Knowledge, and Technological Content Knowledge?

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2. What are the external factors (related to institution) that hinders in Technological Knowledge, Content Knowledge, and Technological Content Knowledge?

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3. Identify the problems which you face in Technological Knowledge.

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4. Identify the problems which you face in achieving Content Knowledge.

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5. Identify the problems you face in achieving Technological Content Knowledge.

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6. Identify possible solutions for encountering the Technological Knowledge, Content Knowledge and Technological Content Knowledge.

APPENDIX (B)
MCQ TEST FOR CONTENT KNOWLEDGE

Table of Specification:

Topics	**Number of Items from Knowledge Level of Cognitive Domain**	**Percentage of Items**
Basics of Computer	07	46.67%
Input Devices	03	20%
Output Devices	03	20%
Software	02	13.33%
Total	15	100%

Directions: Read each statement carefully and choose the best answer from the following. Cutting and over writing is not allowed. Total time for completion of test is 15 minutes.

Encircle the best option for the following statements.

1. The full name of CPU is -----------------

A. Computer Processing Unit

B. Computer Principle Unit

C. Central Processing Unit

D. Control Processing Unit

2. Which of the following is the brain of Computer?

A. Central Processing Unit

B. Memory

C. Arithmetic and Logical Unit

D. Control Unit

3------------------------is the smallest unit of data in a computer?

A. Bit

B. KB

C. Nibble

D. Byte

4. Which of the following is an input device.

A. Keyboard

B. Mouse

C. Light Pen

D. VDU

5. Which of them is an output device?

A. Plotter

B. Printer

C. VDU

D. Mouse

6. The Central Processing unit is located in the…………

A. Hard Disk

B. System Unit

C. Memory Unit

D. Monitor

7. Which of the following is binary number?

A. 1 and 2

B. 0 and 0.1

C. 0 and 2

D. 0 and 1

8. Which of the following is an example of browsing software.

A. Microsoft Word

B. Notepad

C. Internet Navigator

D. Internet Explorer

9. What does RAM stands for ……………...

A. Random Access Memory

B. Reallocate Automatic Memory

C. Remote Access Memory

D. None of the above

10. A portable computer is called……………

A. Laptop

B. Bookshop

C. RAM

D Computer

11. Any signals that come in to the computer are called………

A. Input

B. Output

C. Processing

D. None of the above

12. What is full form of CD…………

A. Compact Disk

B. Common Disk

C. Compact Directory

D. Compact Drive

13. What is WAN…...

A. Wide Area Network

B. Wide Arena Network

C. What A Network

D. Wacky Area Network

14. The software application that is used the most often is…...

A. Spreadsheet

B. Databases

C. Word Processing

D. Presentations

15. Input refers to when a computer takes in information?

A. True

B. False

C. None of Above

D. Both of Above

16. Which of the following is not a type of software?

A. System Software

B. Application Software

C. Driver Software

D. Utility Software

CERTIFICATE OF VALIDATION

Research Title: Comparison of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among Undergraduate Students at International Islamic University Islamabad

By: Qudsia Shami

MS Research Scholar

This is certified that the attached research instrument developed by Qudsia Shami, MS Scholar in Teacher Education Department from International Islamic University, Islamabad, have undergone through validation by me. It is affirmed that the instrument designed is aligned with research objectives. The research instrument includes;

1. Questionnaire for Technological Knowledge, Content Knowledge and Technological Content Knowledge
2. General Knowledge MCQ Test

The above tools have successfully passed the examination and proven substantially helpful for my thesis.

CERTIFIED BY:

Name: Dr. Muhammad Sher Baz Ali

Designation: Assistant Professor

Institution: IIUI

Department: ELM

Signature:

Date: 13-12-2024

CERTIFICATE OF VALIDATION

Research Title: Comparison of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among Undergraduate Students at International Islamic University Islamabad

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The above tools have successfully passed the examination and proven substantially helpful for my thesis.

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Name: Dr. Humaira Akram
Designation: Assistant Professor
Institution: Teacher Education IIUI
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Date: 04-11.2024

CERTIFICATE OF VALIDATION

Research Title: Comparison of Technological Knowledge, Content Knowledge, and Technological Content Knowledge among Undergraduate Students at International Islamic University Islamabad

By: Qudsia Shami

MS Research Scholar

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The above tools have successfully passed the examination and proven substantially helpful for my thesis.

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Designation: Assistant Professor

Institution: IIUI

Department: Teacher Education

Signature:

Date: 15/11/2024