Title: Educators' and Learners' Perceptions of Information and Communication Technology (ICT) Integration in Mathematics Education: A Qualitative Study in Malaysian Private Schools

Abstract

The integration of Information and Communication Technology (ICT) has transformed educational practices globally, particularly in mathematics education where visualization, interactivity, and digital resources can enhance teaching and learning experiences. This qualitative study explored educators' and learners' perceptions regarding the integration of ICT in mathematics education within Malaysian private schools. Guided by Constructivist Theory and Engagement Theory, the study adopted an interpretive research paradigm to examine participants' experiences and perceptions of ICT-supported mathematics instruction. Data were collected through semi-structured interviews and classroom observations involving four mathematics educators and four learners from two private schools in Selangor, Malaysia. Thematic analysis was employed to analyse the data. Four major themes emerged: (1) ICT enhances student engagement, (2) ICT improves conceptual understanding, (3) ICT positively influences learners' perceptions of mathematics, and (4) ICT creates expanded learning opportunities. Findings revealed that ICT-supported learning environments increased learner participation, motivation, and confidence while facilitating visualization of abstract mathematical concepts. Educators reported that digital technologies enriched instructional practices and provided access to diverse educational resources. However, challenges related to teacher readiness, infrastructure, and effective implementation remain important considerations. Recent literature similarly indicates that technology-enhanced mathematics learning promotes

engagement, conceptual understanding, and personalized learning when implemented effectively. The study contributes to the growing body of research on ICT integration in mathematics education and provides practical implications for educators, school leaders, and policymakers seeking to strengthen technology-enhanced learning environments.

Keywords: ICT integration, mathematics education, learner engagement, educator perceptions, qualitative research, Malaysia

1.0 Introduction

The rapid advancement of digital technologies has significantly influenced educational systems worldwide. Schools are increasingly adopting Information and Communication Technology (ICT) to improve teaching effectiveness, enhance learner engagement, and develop twenty-first-century competencies. Within mathematics education, ICT has emerged as a powerful instructional tool capable of transforming traditional pedagogical approaches into more interactive, learner-centred experiences.

Mathematics is frequently perceived by learners as one of the most challenging academic subjects. Many students experience difficulties in understanding abstract concepts, solving complex problems, and maintaining motivation during lessons. Traditional instructional approaches often emphasize procedural learning and examination performance, limiting opportunities for conceptual exploration and meaningful engagement. Consequently, educators continue to seek innovative approaches that can improve learners' understanding and attitudes toward mathematics.

ICT offers numerous possibilities for addressing these challenges. Interactive whiteboards, mathematical software, online learning platforms, virtual manipulatives,

educational videos, simulations, and artificial intelligence-supported learning tools provide opportunities for learners to visualize mathematical concepts, engage in collaborative learning, and receive immediate feedback. Recent research suggests that technology integration can improve student engagement, support conceptual understanding, and facilitate personalized learning experiences.

The educational landscape in Malaysia has also undergone significant digital transformation. The Ministry of Education Malaysia has consistently emphasized the importance of integrating technology into teaching and learning processes to prepare learners for an increasingly digital society. Despite substantial investments in educational technology, successful implementation depends largely on educators' readiness, institutional support, infrastructure availability, and learners' perceptions of technology-enhanced learning environments.

While numerous studies have examined the effectiveness of ICT in education, fewer studies have explored the perceptions of both educators and learners simultaneously within the context of mathematics education. Understanding these perceptions is important because attitudes toward technology often influence its successful adoption and implementation. Positive perceptions may encourage greater use of ICT tools, whereas negative experiences may create resistance and limit educational benefits.

This study therefore investigates how educators and learners perceive the integration of ICT in mathematics education within Malaysian private schools. By exploring their experiences and perspectives, the study seeks to contribute to a deeper understanding of how technology influences teaching and learning practices in mathematics classrooms.

2.0 Literature Review

2.1 ICT in Mathematics Education

Information and Communication Technology (ICT) refers to a broad range of digital technologies used to create, store, process, communicate, and manage information. Within educational contexts, ICT includes computers, tablets, interactive whiteboards, learning management systems, educational software, online resources, simulations, and emerging technologies such as artificial intelligence and augmented reality.

The integration of ICT into mathematics education has attracted considerable scholarly attention over the past two decades. Technology has shifted from being viewed merely as a supplementary resource to becoming an essential component of contemporary mathematics instruction. The National Council of Teachers of Mathematics (NCTM) identifies technology as a critical element of effective mathematics teaching and learning because it influences both the content being taught and the ways in which students learn mathematical concepts.

Research consistently demonstrates that ICT can enhance mathematics learning by providing dynamic representations of abstract concepts. Technologies such as GeoGebra, Desmos, virtual manipulatives, graphing applications, and interactive simulations allow learners to visualize relationships between variables, explore mathematical patterns, and test hypotheses in real time. These tools support deeper conceptual understanding compared to traditional static representations.

Recent systematic reviews further suggest that technology-enhanced mathematics learning environments improve student engagement, motivation, and conceptual understanding. Emerging technologies such as artificial intelligence, augmented reality, and adaptive learning systems are increasingly being incorporated into

mathematics classrooms to provide personalized learning experiences and immediate feedback.

However, technology integration is not without challenges. Studies have identified barriers including inadequate infrastructure, limited teacher competence, insufficient professional development, and unequal access to digital resources. These challenges may hinder the successful implementation of ICT despite its potential educational benefits.

2.2 Educators' Perceptions of ICT Integration in Mathematics Education

Educators play a critical role in determining the success of ICT integration within mathematics classrooms. Their beliefs, attitudes, technological competencies, and willingness to adopt innovative pedagogical approaches significantly influence how technology is implemented and utilized in educational settings. Research has consistently shown that positive educator perceptions towards ICT contribute to more frequent and effective technology integration practices.

Previous studies indicate that educators generally perceive ICT as a valuable instructional tool that enhances lesson delivery, facilitates student engagement, and supports differentiated instruction. Digital technologies provide opportunities for educators to present mathematical concepts through multiple representations, including animations, simulations, videos, and interactive applications. Such tools allow educators to simplify complex mathematical concepts and make learning more accessible to diverse groups of learners.

According to recent studies, educators believe that ICT enables them to create more learner-centred learning environments where students actively participate in constructing knowledge rather than passively receiving information. Technology-

supported learning activities encourage collaboration, inquiry-based learning, and problem-solving, which are essential components of effective mathematics instruction. Furthermore, educators report that digital technologies help them monitor learner progress, provide immediate feedback, and adapt instructional strategies to meet individual learning needs.

Despite these perceived benefits, several challenges continue to influence educators' attitudes towards ICT integration. One commonly reported challenge involves inadequate professional development and insufficient technological training. Many educators acknowledge the educational value of ICT but express concerns regarding their ability to utilize technology effectively within mathematics instruction. Limited confidence and technological competence may reduce the frequency and quality of ICT implementation.

Additionally, educators often encounter challenges associated with infrastructure limitations, technical difficulties, and time constraints. Preparing technology-enhanced lessons frequently requires additional planning time, resource development, and troubleshooting. Consequently, successful ICT integration depends not only on educators' positive perceptions but also on institutional support, professional development opportunities, and access to reliable technological resources.

Within the Malaysian educational context, studies have highlighted the importance of continuous professional development programmes that equip educators with the necessary technological and pedagogical knowledge required to effectively integrate ICT into mathematics instruction. As educational technologies continue to evolve, educators must continually adapt their instructional practices to maximize the educational potential of digital learning environments.

2.3 Learners’ Perceptions of ICT Integration in Mathematics Education

Learners represent the primary beneficiaries of ICT integration in educational settings. Their perceptions, experiences, and attitudes towards technology-enhanced learning significantly influence learning outcomes, engagement levels, and academic achievement. Understanding learners' perspectives is therefore essential when evaluating the effectiveness of ICT integration in mathematics education.

Research suggests that learners generally hold positive perceptions towards the use of ICT in mathematics classrooms. Digital technologies often make mathematics lessons more engaging, interactive, and enjoyable. Interactive applications, educational games, simulations, and multimedia resources provide opportunities for learners to actively participate in learning activities while receiving immediate feedback on their performance.

One of the most frequently reported benefits of ICT integration is enhanced learner engagement. Traditional mathematics instruction has often been criticized for emphasizing procedural learning and repetitive exercises. ICT-supported learning environments, however, introduce dynamic and interactive experiences that capture learners' attention and sustain motivation throughout lessons. Interactive technologies allow learners to manipulate mathematical objects, explore patterns, and visualize abstract concepts that may otherwise be difficult to understand.

Furthermore, ICT contributes to increased learner autonomy and self-directed learning. Online learning platforms, educational applications, and digital resources provide learners with opportunities to access learning materials beyond classroom hours. Such accessibility allows learners to review concepts independently, practise mathematical skills at their own pace, and seek additional support when needed.

Recent studies have also reported improvements in learners' confidence and attitudes towards mathematics following the integration of ICT. Students who previously perceived mathematics as difficult and intimidating often develop more positive attitudes when technology is incorporated into instruction. The visual and interactive nature of digital resources can reduce anxiety and improve learners' willingness to engage with challenging mathematical concepts.

Nevertheless, learner perceptions are not universally positive. Some students experience challenges associated with technological distractions, excessive screen time, and technical difficulties. Additionally, disparities in access to digital devices and internet connectivity may create inequalities in learning opportunities. Consequently, educational institutions must ensure equitable access to technological resources while promoting responsible and purposeful use of ICT within learning environments.

Overall, existing literature suggests that ICT has the potential to transform learners' experiences of mathematics by making learning more engaging, accessible, and meaningful. However, effective implementation requires careful planning, appropriate technological infrastructure, and ongoing support for both educators and learners.

2.4 Constructivist Theory

Constructivism serves as one of the most influential theoretical foundations underpinning technology-enhanced learning environments. The theory proposes that learners actively construct knowledge through experiences, interactions, and reflection rather than passively receiving information from instructors.

The origins of constructivism can be traced to the works of educational theorists such as Jean Piaget and Lev Vygotsky. Piaget emphasized cognitive development and the active role learners play in constructing understanding through interaction with their

environment. Vygotsky, meanwhile, highlighted the importance of social interaction and collaborative learning in knowledge construction.

Within mathematics education, constructivist principles suggest that learners develop mathematical understanding through active exploration, experimentation, and problem-solving activities. Learning occurs when students engage meaningfully with mathematical concepts, test ideas, make connections, and refine their understanding based on new experiences.

ICT aligns closely with constructivist principles because technology enables learners to actively explore mathematical concepts rather than merely receiving explanations from educators. Interactive software, simulations, virtual manipulatives, and dynamic mathematical applications allow learners to investigate relationships, visualize patterns, and construct their own understanding of mathematical ideas.

For example, dynamic geometry software enables students to manipulate geometric figures and observe how changes affect mathematical relationships. Similarly, graphing applications allow learners to explore functions interactively and develop conceptual understanding through experimentation. Such experiences support knowledge construction by encouraging learners to actively engage with mathematical concepts.

The role of the educator within a constructivist classroom differs significantly from traditional instructional approaches. Rather than acting solely as a transmitter of knowledge, the educator serves as a facilitator who guides learners' exploration, encourages inquiry, and provides support when necessary. ICT enhances this facilitative role by providing diverse learning resources and opportunities for individualized learning experiences.

Therefore, constructivism provides an appropriate theoretical lens for understanding how ICT supports meaningful learning experiences within mathematics education.

2.5 Engagement Theory

Engagement Theory, developed by Kearsley and Shneiderman (1998), provides a framework for understanding how technology can enhance learner participation and involvement in educational activities. The theory argues that meaningful learning occurs when learners are actively engaged in collaborative, authentic, and purposeful activities.

According to Engagement Theory, effective learning experiences should incorporate three key components:

Relate

The "Relate" component emphasizes collaboration and interpersonal interaction. Learners should work together to solve problems, exchange ideas, and construct knowledge collectively. Collaborative learning encourages communication, critical thinking, and social interaction.

ICT supports collaborative learning through digital communication tools, online discussion platforms, collaborative applications, and shared learning environments. These technologies facilitate interaction among learners and promote cooperative learning experiences.

Create

The "Create" component focuses on meaningful learning activities that involve designing, producing, or solving authentic problems. Learners are encouraged to apply knowledge creatively and develop solutions to real-world challenges.

Within mathematics education, ICT provides opportunities for learners to create digital presentations, explore mathematical simulations, develop models, and investigate authentic mathematical problems. Such activities encourage higher-order thinking and active engagement.

Donate

The "Donate" component emphasizes the importance of contributing meaningful work to an audience beyond the classroom. Learners become more motivated when they perceive their work as valuable and relevant.

Technology enables learners to share their work with broader audiences through online platforms, digital portfolios, presentations, and collaborative projects. Such opportunities increase learner motivation and accountability.

Engagement Theory is particularly relevant to ICT integration because technology facilitates interactive learning experiences that may be difficult to achieve through traditional instructional approaches alone. The theory suggests that meaningful engagement promotes deeper learning, increased motivation, and improved educational outcomes.

In the context of this study, Engagement Theory provides a useful framework for understanding how ICT influences learners' participation, motivation, and perceptions of mathematics education.

2.6 Empirical Review

Recent studies have consistently demonstrated the positive impact of Information and Communication Technology (ICT) on mathematics teaching and learning. The rapid advancement of digital technologies has transformed educational practices,

particularly following the increased adoption of online and blended learning environments. Researchers have reported that ICT integration enhances learner engagement, conceptual understanding, problem-solving skills, and academic achievement in mathematics.

Several studies indicate that learners exposed to technology-supported instruction demonstrate higher levels of participation and motivation compared to those taught using traditional methods. Interactive technologies enable learners to visualise abstract mathematical concepts, manipulate variables, and receive immediate feedback, thereby improving conceptual understanding and retention. Furthermore, digital tools such as GeoGebra, virtual manipulatives, and educational applications have been shown to support active learning and encourage exploration of mathematical ideas.

Research has also highlighted the importance of educator readiness in successful ICT implementation. Educators who possess positive attitudes towards technology and receive adequate professional development are more likely to integrate ICT effectively into their instructional practices. Conversely, insufficient training, lack of confidence, and limited technological resources may hinder effective implementation.

Within the Malaysian educational context, studies have reported positive relationships between ICT integration and learner engagement, motivation, and achievement. However, challenges such as infrastructure limitations, unequal access to digital resources, and varying levels of technological competency continue to influence implementation effectiveness.

Although the literature generally supports the educational benefits of ICT, researchers emphasise that technology alone does not guarantee improved learning outcomes.

Rather, successful integration depends on pedagogically sound instructional strategies that encourage collaboration, inquiry, critical thinking, and meaningful learner engagement.

Overall, existing empirical evidence suggests that ICT can significantly enhance mathematics education when supported by appropriate infrastructure, professional development, and effective pedagogical practices.

2.7 Knowledge Gap

Despite the growing body of research examining ICT integration in mathematics education, several gaps remain evident within the literature. Much of the existing research has focused primarily on the effectiveness of ICT in improving academic achievement and learner performance. Comparatively fewer studies have explored the perceptions of both educators and learners simultaneously within the same educational context.

Furthermore, many previous studies have concentrated on quantitative measures of achievement while providing limited insights into participants' lived experiences and attitudes towards ICT-supported mathematics instruction. Understanding these perceptions is essential because attitudes towards technology often influence its successful adoption and implementation.

Within Malaysia, research exploring educators' and learners' perceptions regarding ICT integration in mathematics education remains relatively limited, particularly within private school settings. Most studies have focused on public schools or have examined ICT implementation from the perspectives of educators only.

Therefore, this study seeks to address this gap by exploring the perceptions of both educators and learners regarding the integration of ICT in mathematics education

within Malaysian private schools. By examining participants' experiences and perspectives, the study contributes to a deeper understanding of how ICT influences teaching and learning practices in mathematics classrooms.

2.8 Conceptual Framework

This study is guided by Constructivist Theory and Engagement Theory.

Constructivist Theory proposes that learners actively construct knowledge through interaction, exploration, and reflection. Within mathematics education, ICT provides opportunities for learners to engage with mathematical concepts through simulations, visualisations, and interactive learning experiences. These tools support knowledge construction by enabling learners to explore relationships, test ideas, and develop conceptual understanding independently.

Engagement Theory complements constructivism by emphasising active participation in meaningful learning activities. According to the theory, learning is enhanced when learners collaborate, solve authentic problems, and engage in purposeful tasks. ICT supports engagement by providing interactive learning environments that encourage collaboration, exploration, and communication.

The conceptual framework proposes that ICT integration influences educators' and learners' perceptions of mathematics education by enhancing engagement, improving conceptual understanding, fostering positive attitudes towards mathematics, and creating expanded learning opportunities.

ICT Integration

↓

Enhanced Engagement

↓

Improved Conceptual Understanding

↓

Positive Perceptions of Mathematics

↓

Expanded Learning Opportunities

This framework guided the development of the research questions, interview protocols, data collection procedures, and analysis processes.

3.0 Methodology

3.1 Introduction

This study aimed to explore educators' and learners' perceptions regarding the integration of Information and Communication Technology (ICT) in mathematics education. Given the exploratory nature of the research questions and the emphasis on understanding participants' experiences, a qualitative research approach was adopted.

This chapter outlines the research methodology employed in the study, including the research paradigm, research design, research setting, participant selection procedures, data collection methods, and data analysis processes.

3.2 Research Paradigm

The study adopted an interpretivist research paradigm. Interpretivism is appropriate for qualitative studies that seek to understand how individuals interpret and make sense of their experiences within specific social contexts.

The interpretivist paradigm aligns with the objectives of this study because it focuses on understanding educators' and learners' perceptions regarding ICT integration in mathematics education. Rather than measuring variables quantitatively, the study sought to explore participants' experiences, beliefs, attitudes, and interpretations.

Through interviews and classroom observations, participants were given opportunities to express their views openly, enabling the researcher to develop a comprehensive understanding of how ICT influences mathematics teaching and learning.

3.3 Research Design

A qualitative multiple-case study design was employed in this research. Qualitative research is particularly suitable for investigating complex educational phenomena involving human experiences, perceptions, and interactions.

The multiple-case study design enabled the researcher to examine ICT integration across two different educational settings while maintaining a detailed focus on individual participants' experiences. This approach provided rich descriptions and facilitated cross-case comparisons.

Data were collected through semi-structured interviews, classroom observations, and field notes. The use of multiple sources of evidence strengthened the credibility and trustworthiness of the findings.

3.4 Research Setting

The study was conducted in two private schools located in Selangor, Malaysia:

1. *Sri Kuala Lumpur International School*
2. *Sri KDU Private School*

Both schools had incorporated ICT into mathematics instruction through the use of interactive whiteboards, projectors, laptops, tablets, educational software, and online learning platforms.

These schools were selected because they provided information-rich environments where educators and learners had substantial experience with ICT integration in mathematics classrooms.

3.5 Participants and Sampling

Purposive sampling was employed to select participants who possessed direct experience with ICT integration in mathematics education. Purposive sampling is commonly used in qualitative research because it allows researchers to select participants who are knowledgeable about the phenomenon under investigation.

A total of eight participants participated in the study, comprising four mathematics educators and four learners.

Educators

- *Educator 1 – Year 6 Mathematics Teacher (Sri Kuala Lumpur International School)*
- *Educator 2 – Year 5 Mathematics Teacher (Sri Kuala Lumpur International School)*

- *Educator 3 – Year 4 Mathematics Teacher (Sri KDU Private School)*
- *Educator 4 – Year 6 Mathematics Teacher (Sri KDU Private School)*

Learners

- *Learner 1 – Year 6 Student (Sri Kuala Lumpur International School)*
- *Learner 2 – Year 6 Student (Sri Kuala Lumpur International School)*
- *Learner 3 – Year 4 Student (Sri KDU Private School)*
- *Learner 4 – Year 6 Student (Sri KDU Private School)*

Although the sample size was relatively small, it was considered appropriate for qualitative inquiry because the purpose of the study was to obtain in-depth insights rather than statistical generalisation. Data collection continued until sufficient thematic saturation was achieved, whereby no substantially new themes emerged from participant responses.

3.6 Data Collection Procedures

Data collection was conducted over several weeks to ensure sufficient opportunities for participants to share their experiences and for the researcher to observe ICT integration within authentic mathematics learning environments. Multiple methods of data collection were employed to enhance the depth, richness, and credibility of the findings.

3.6.1 Semi-Structured Interviews

Semi-structured interviews served as the primary method of data collection. This approach was selected because it provides flexibility while ensuring that all participants address the key research questions. Semi-structured interviews allow

researchers to probe further into participants' responses and explore emerging ideas in greater depth.

Separate interview protocols were developed for educators and learners. The interview questions focused on participants' experiences, perceptions, attitudes, and opinions regarding ICT integration in mathematics education.

The educator interview questions explored:

- *Perceived benefits of ICT integration*
- *Changes in student engagement and motivation*
- *Teaching experiences before and after ICT implementation*
- *Challenges encountered during ICT integration*
- *Professional practices related to technology use*

The learner interview questions explored:

- *Experiences of learning mathematics through ICT*
- *Perceived benefits and challenges*
- *Impact on understanding mathematical concepts*
- *Attitudes towards mathematics learning*
- *Suggestions for improving ICT integration*

Each interview lasted approximately 30 to 45 minutes and was conducted face-to-face within the participants' respective schools. Interviews were conducted in a comfortable and familiar environment to encourage open and honest responses.

With participants' consent, all interviews were audio-recorded and later transcribed verbatim for analysis. The use of audio recordings ensured accuracy and minimized the risk of information loss during data collection.

3.6.2 Classroom Observations

To complement the interview data, classroom observations were conducted during mathematics lessons where ICT was actively integrated into instruction.

Observation enables researchers to gather first-hand evidence of classroom practices and learner behaviours. Unlike interviews, which rely on participants' self-reported experiences, observations provide opportunities to examine actual interactions and teaching practices as they occur naturally.

The observation protocol focused on:

- *Types of ICT tools utilized*
- *Teacher-learner interactions*
- *Learner participation and engagement*
- *Collaborative learning activities*
- *Classroom management practices*
- *Learner responses to ICT-supported instruction*

Field notes were recorded throughout each observation session. Particular attention was given to how ICT influenced learner engagement, participation, communication, and understanding of mathematical concepts.

The observations served as an important source of triangulation, allowing the researcher to compare observational evidence with participants' interview responses.

3.6.3 Field Notes

Field notes were maintained throughout the data collection process.

These notes documented:

- *Classroom interactions*
- *Researcher observations*
- *Contextual information*
- *Emerging themes*
- *Reflections on participant responses*

Field notes provided additional context and assisted in interpreting the interview and observation data during the analysis phase.

3.7 Data Analysis

The data were analysed using thematic analysis. Thematic analysis is widely used in qualitative research because it provides a systematic approach for identifying, analysing, and reporting patterns within qualitative data.

The analytical process followed the six-phase framework proposed by Braun and Clarke (2006).

Phase 1: Familiarisation with Data

The researcher repeatedly reviewed interview transcripts, observation records, and field notes to develop a comprehensive understanding of the data.

This stage involved:

- *Reading transcripts multiple times*

- *Reviewing observation notes*
- *Identifying preliminary patterns*
- *Recording initial analytical reflections*

Phase 2: Generating Initial Codes

Meaningful segments of data were systematically coded.

Examples of initial codes included:

Participant Statement	**Initial Code**
Students enjoy learning mathematics more	Increased engagement
Visual demonstrations improve understanding	Conceptual understanding
Technology makes lessons interesting	Motivation
Access to online materials helps learning	Learning opportunities
Students collaborate more frequently	Collaboration

Coding enabled the researcher to organize large volumes of qualitative data into manageable categories.

Phase 3: Searching for Themes

Related codes were grouped into broader categories.

For example:

Codes	Category
Interest, enjoyment, participation	Student engagement
Visualisation, understanding, confidence	Conceptual understanding
Positive attitudes, reduced anxiety	Perceptions of mathematics
Resources, collaboration, independence	*Learning opportunities*

Phase 4: Reviewing Themes

Themes were reviewed and refined to ensure they accurately represented the data.

The researcher examined whether:

- *Themes were internally coherent*
- *Themes were distinct from one another*
- *Sufficient evidence supported each theme*

Phase 5: Defining and Naming Themes

Four final themes emerged:

1. *ICT enhances student engagement.*
2. *ICT improves conceptual understanding.*
3. *ICT changes learners' perceptions of mathematics.*
4. *ICT creates new learning opportunities.*

These themes captured the core experiences and perceptions reported by participants.

Phase 6: Producing the Report

The final stage involved interpreting the findings, integrating supporting quotations, and relating the results to existing literature and theoretical frameworks.

3.8 Trustworthiness of the Study

Trustworthiness is essential in qualitative research because it establishes confidence in the findings. This study adopted Lincoln and Guba's (1985) framework, which consists of credibility, transferability, dependability, and confirmability.

3.8.1 Credibility

Credibility refers to the extent to which findings accurately represent participants' experiences.

Several strategies were employed:

- *Prolonged engagement with participants*
- *Classroom observations*
- *Triangulation of data sources*
- *Member checking*

Triangulation involved comparing interview responses with observational evidence and field notes to ensure consistency.

3.8.2 Transferability

Transferability refers to the extent to which findings may be applicable to other contexts.

To enhance transferability, detailed descriptions of:

- *Participants*
- *School settings*
- *Research procedures*
- *Data collection methods* were provided.

These descriptions allow readers to determine the relevance of findings to their own contexts.

3.8.3 Dependability

Dependability concerns the consistency and stability of research procedures.

An audit trail was maintained throughout the study, documenting:

- *Research decisions*
- *Data collection procedures*
- *Coding processes*
- *Analytical decisions*

This documentation enables future researchers to understand how the findings were generated.

3.8.4 Confirmability

Confirmability refers to the extent to which findings are grounded in participant data rather than researcher bias.

The researcher maintained reflexive notes throughout the study and ensured that interpretations were supported by direct evidence from interviews and observations.

3.9 Ethical Considerations

Ethical principles were carefully observed throughout the research process.

Prior to data collection, approval was obtained from the participating schools. All participants were informed of the purpose of the study, research procedures, and their rights as participants.

For learner participants, parental consent and learner assent were obtained before participation.

Participation was entirely voluntary, and participants were informed that they could withdraw from the study at any stage without penalty.

Confidentiality and anonymity were maintained through the use of pseudonyms and participant codes. Personal identifiers were removed from transcripts and reports to protect participant privacy.

All interview recordings, transcripts, observation notes, and research documents were stored securely and accessed only by the researcher.

The study adhered to principles of:

- *Respect for persons*
- *Beneficence*

- *Non-maleficence*
- *Justice*

The researcher ensured that participation did not expose individuals to physical, emotional, professional, or psychological harm.

CHAPTER 4: FINDINGS

4.1 Introduction

This chapter presents the findings derived from interviews, classroom observations, and field notes collected from four mathematics educators and four learners from two private schools in Selangor, Malaysia.

Thematic analysis revealed four major themes:

1. *ICT enhances student engagement.*
2. *ICT improves conceptual understanding.*
3. *ICT changes learners' perceptions of mathematics.*
4. *ICT creates new learning opportunities.*

Together, these themes illustrate how both educators and learners perceive the role of ICT in supporting mathematics teaching and learning.

4.2 Theme 1: ICT Enhances Student Engagement

One of the most prominent themes emerging from the data was the positive influence of ICT on learner engagement. Both educators and learners consistently described technology-enhanced lessons as more interesting, interactive, and motivating than traditional approaches.

Educator 1 explained:

"Integrating ICT creates a more enjoyable learning environment. Students become curious and actively participate in activities. They are no longer passive learners."

Similarly, Educator 4 stated:

"When technology is used, students remain focused longer and contribute more frequently during discussions."

Observational data supported these perceptions. During lessons involving interactive whiteboards, mathematical simulations, and online activities, learners demonstrated high levels of participation. Students frequently volunteered answers, collaborated with peers, and remained actively engaged throughout instructional activities.

Learner 4 reflected:

"The smart board helps me focus. Mathematics becomes more interesting, and I enjoy participating in lessons."

These findings suggest that ICT functions as a motivational tool that stimulates learner interest and increases active participation within mathematics classrooms.

4.3 Theme 2: ICT Improves Conceptual Understanding

The second major theme that emerged from the data was the role of ICT in supporting learners' conceptual understanding of mathematics. Both educators and learners reported that digital technologies facilitated visualization, exploration, and comprehension of abstract mathematical concepts that were often difficult to understand through traditional instructional methods.

Educator 1 emphasized the importance of visual representations:

"Many mathematical concepts are abstract. When I use animations, videos, and interactive demonstrations, students can actually see what is happening. This makes understanding much easier."

Similarly, Educator 4 explained:

"Students often struggle with graphs and algebraic relationships. ICT allows them to observe changes instantly and understand how variables affect outcomes."

The classroom observations reinforced these perspectives. During lessons involving graphical simulations and interactive mathematical software, learners appeared more confident when solving problems. Students frequently referred to visual representations to justify their answers and explain mathematical reasoning.

Learner 4 shared:

"When I can see the diagrams moving and changing, I understand better. It helps me solve questions because I can picture the concept in my mind."

Another learner explained:

"Sometimes I do not understand from the textbook, but when the teacher shows videos or simulations, everything becomes clearer."

The findings suggest that ICT supports conceptual understanding by transforming abstract mathematical concepts into concrete visual experiences. This finding aligns with constructivist perspectives that emphasize active exploration and knowledge construction through meaningful learning experiences.

Furthermore, ICT appeared to support multiple learning styles. Visual learners particularly benefited from animations and graphical representations, while interactive activities allowed kinaesthetic learners to engage directly with mathematical concepts. As a result, technology-enhanced instruction created more inclusive learning environments that accommodated diverse learner needs.

Overall, participants perceived ICT as an effective tool for facilitating deeper understanding and improving learners' confidence in mathematics.

4.4 Theme 3: ICT Changes Learners' Perceptions of Mathematics

A third theme concerned the influence of ICT on learners' perceptions and attitudes towards mathematics. Several participants reported that prior to experiencing ICT-supported instruction, they viewed mathematics as a difficult, stressful, and uninteresting subject.

Educator 2 explained:

"Many students come into mathematics lessons already believing that mathematics is difficult. Technology helps change that perception because learning becomes more interactive and enjoyable."

Learner 4 described her previous experiences:

"I used to feel nervous whenever mathematics class started. I was afraid of getting answers wrong and did not enjoy the subject."

However, after participating in ICT-enhanced lessons, her perception changed considerably:

"Now mathematics is one of my favourite subjects. I understand more, and I enjoy learning because it feels easier and more interesting."

Another learner stated:

"Technology makes mathematics feel like other subjects. It is no longer something that I fear."

Educators also observed positive changes in learner attitudes.

Educator 1 remarked:

"Students show more confidence. They are willing to try solving difficult questions because they have tools that support them."

Classroom observations indicated that learners displayed greater willingness to participate, ask questions, and attempt challenging tasks during ICT-supported lessons compared to traditional instruction.

The findings suggest that ICT contributes significantly to reducing mathematics anxiety and fostering more positive attitudes towards mathematics learning. When learners experience success through visual supports, interactive activities, and immediate feedback, their confidence increases, leading to more positive perceptions of the subject.

This finding is particularly significant because attitudes towards mathematics often influence long-term achievement, subject selection, and future career aspirations in science, technology, engineering, and mathematics (STEM) fields.

4.5 Theme 4: ICT Creates New Learning Opportunities

The final theme highlighted the ways in which ICT expands learning opportunities for both educators and learners.

Participants consistently reported that technology provided access to a broader range of educational resources, instructional strategies, and learning experiences than would be possible through traditional classroom approaches alone.

Educator 1 explained:

"The internet gives access to thousands of resources. I can find videos, simulations, games, and activities that make lessons more meaningful."

Similarly, Educator 3 stated:

"Technology allows me to differentiate instruction. Some students need more support, while others need additional challenges. ICT helps me cater to both groups."

Learners also recognized the benefits of increased access to educational resources.

Learner 2 shared:

"If I do not understand something, I can watch videos at home and learn again."

Another learner noted:

"I can practise using online activities and get feedback immediately."

Observational data showed learners frequently collaborating with peers while using technology. Group activities involving digital resources promoted communication, discussion, and cooperative problem-solving.

Several educators also emphasized the importance of independent learning opportunities.

Educator 4 explained:

"Students are no longer limited to what happens during class. They can continue learning outside school through online resources."

The findings indicate that ICT extends learning beyond traditional classroom boundaries by facilitating:

- Independent learning
- Collaborative learning
- Access to diverse educational resources
- Immediate feedback
- Personalized learning experiences

As a result, ICT creates more flexible and learner-centred educational environments that support lifelong learning skills.

4.6 Summary of Findings

Four major themes emerged from the analysis of interview, observation, and field note data.

First, ICT enhanced learner engagement by increasing participation, motivation, and interest during mathematics lessons. Learners described technology-supported activities as enjoyable, interactive, and stimulating.

Second, ICT improved conceptual understanding through visualizations, simulations, and interactive representations that helped learners comprehend abstract mathematical concepts.

Third, ICT positively influenced learners' perceptions of mathematics by reducing anxiety, increasing confidence, and fostering more favourable attitudes towards the subject.

Finally, ICT created expanded learning opportunities by providing access to diverse educational resources, supporting independent learning, and facilitating collaboration.

Collectively, the findings suggest that both educators and learners perceive ICT as a valuable educational tool that enhances mathematics teaching and learning experiences.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter discusses the findings in relation to the research questions, theoretical framework, and existing literature. The discussion focuses on how ICT integration influences learner engagement, conceptual understanding, attitudes towards mathematics, and learning opportunities.

The findings are interpreted through the lenses of Constructivist Theory and Engagement Theory, both of which emphasize active participation, mea meaningful learning experiences, and learner-centred instructional practices.

5.2 ICT Enhances Learner Engagement

One of the most significant findings of this study is that ICT enhances learner engagement in mathematics education. Both educators and learners consistently reported increased participation, interest, and motivation when technology was incorporated into lessons.

This finding supports recent studies demonstrating that technology-enhanced learning environments promote active learner involvement and increase classroom participation. Interactive technologies create opportunities for learners to engage directly with mathematical concepts rather than passively receiving information.

The findings also align with Engagement Theory, which proposes that meaningful learning occurs when learners actively participate in collaborative and authentic learning activities. Through ICT-supported tasks, learners became more involved in classroom discussions, problem-solving activities, and collaborative learning experiences.

The increased engagement observed during classroom observations further reinforces the argument that technology serves as an effective motivational tool within mathematics education.

5.3 ICT Improves Conceptual Understanding

The findings indicate that ICT significantly contributes to learners' conceptual understanding of mathematics.

Educators and learners emphasized the importance of visual representations, simulations, and dynamic demonstrations in facilitating understanding of abstract mathematical concepts.

This finding is consistent with Constructivist Theory, which suggests that learners construct knowledge through active interaction with learning materials and experiences. ICT provides opportunities for learners to explore concepts, test ideas, and visualize relationships in ways that support deeper understanding.

The ability to manipulate variables and observe immediate changes appears particularly valuable in mathematics education, where abstract concepts often present challenges for learners.

5.4 ICT Changes Learners' Perceptions of Mathematics

A notable finding of this study was the positive influence of ICT on learners' perceptions and attitudes towards mathematics. Prior to the integration of ICT, several learners described mathematics as a difficult, stressful, and intimidating subject. Following exposure to technology-enhanced learning experiences, however, learners reported increased confidence, enjoyment, and willingness to engage with mathematical concepts.

These findings are consistent with previous studies that have highlighted the relationship between technology integration and improved learner attitudes. Traditional approaches to mathematics instruction often emphasize procedural knowledge and repetitive exercises, which may contribute to negative perceptions of the subject. In contrast, ICT provides opportunities for active participation, exploration, and immediate feedback, creating a more enjoyable learning experience.

The findings also support the work of researchers who argue that technology can reduce mathematics anxiety by making abstract concepts more accessible and understandable. When learners experience success through visual supports, simulations, and interactive activities, they develop greater confidence in their mathematical abilities.

From a constructivist perspective, positive perceptions emerge when learners actively construct knowledge and experience meaningful success in learning activities. ICT facilitates this process by providing engaging environments that support exploration, experimentation, and discovery.

Furthermore, positive attitudes towards mathematics have important long-term implications. Research suggests that learners who develop confidence and interest in

mathematics are more likely to pursue advanced studies and careers in STEM-related fields. Therefore, ICT may contribute not only to immediate learning outcomes but also to future educational and career aspirations.

5.5 ICT Creates New Learning Opportunities

The findings demonstrated that ICT significantly expands learning opportunities for both educators and learners.

Participants highlighted the ability of technology to provide access to diverse educational resources, online learning platforms, interactive applications, and multimedia materials. These resources enable educators to enrich instruction while allowing learners to continue learning beyond the classroom.

This finding supports contemporary research emphasizing the role of technology in facilitating personalized and flexible learning. Digital technologies allow learners to progress at their own pace, revisit difficult concepts, and access additional support when necessary.

The findings also align with Engagement Theory, which emphasizes authentic and meaningful learning experiences. ICT supports authentic learning by connecting classroom activities with real-world applications and providing access to current information and resources.

Moreover, technology facilitates collaborative learning through digital communication tools, online discussion forums, and group-based activities. Learners are able to share ideas, solve problems collectively, and learn from one another, thereby developing important communication and teamwork skills.

Another important finding concerns learner autonomy. ICT encourages self-directed learning by providing opportunities for independent exploration and inquiry. Such experiences are particularly valuable in preparing learners for lifelong learning in an increasingly digital society.

Overall, the findings suggest that ICT extends learning beyond traditional classroom boundaries and creates more dynamic, accessible, and learner-centred educational environments.

5.6 Implications for Practice

The findings of this study have several important implications for educational practice.

Implications for Educators

Educators should consider integrating ICT regularly into mathematics instruction to enhance learner engagement, understanding, and motivation. Technology should not merely serve as a presentation tool but should be utilized to facilitate active learning, collaboration, and problem-solving.

Teachers should also adopt learner-centred pedagogical approaches that leverage technology to encourage exploration and inquiry. Interactive activities, simulations, and digital investigations can support deeper conceptual understanding and improve learning outcomes.

Implications for School Leaders

School administrators play a critical role in supporting successful ICT integration. Educational leaders should ensure that schools possess adequate technological infrastructure, including reliable internet connectivity, digital devices, and access to educational software.

Additionally, school leaders should provide continuous professional development opportunities that enhance educators' technological and pedagogical competencies.

Implications for Policymakers

Educational policymakers should continue investing in digital learning initiatives while addressing issues related to equity and accessibility. Efforts should focus on ensuring that all learners have access to quality technological resources regardless of socioeconomic background.

Policy initiatives should also emphasize teacher training, curriculum integration, and sustainable technology implementation strategies.

Implications for Future Research

Future studies should explore ICT integration across different educational contexts, including public schools, rural schools, and secondary education settings. Larger sample sizes and mixed-methods approaches may provide additional insights into the effectiveness of technology-enhanced mathematics education.

Researchers may also investigate emerging technologies such as artificial intelligence, virtual reality, and augmented reality within mathematics learning environments.

5.7 Limitations of the Study

Several limitations should be acknowledged when interpreting the findings of this study.

First, the study involved only eight participants from two private schools in Selangor, Malaysia. While the sample size was appropriate for qualitative inquiry, the findings cannot be generalized to all educational settings.

Second, the study focused exclusively on participants' perceptions and experiences rather than objective measures of academic achievement. Consequently, the research does not establish causal relationships between ICT integration and learner performance.

Third, the study was conducted within schools that possessed relatively strong technological infrastructure. Different findings may emerge in contexts where access to technological resources is limited.

Fourth, the study relied primarily on self-reported data obtained through interviews. Although classroom observations were used to support the findings, participant responses may have been influenced by personal biases or social desirability.

Despite these limitations, the study provides valuable insights into how educators and learners perceive ICT integration in mathematics education and contributes to the growing body of literature on technology-enhanced learning.

5.8 Conclusion

This study explored educators' and learners' perceptions regarding the integration of Information and Communication Technology (ICT) in mathematics education within Malaysian private schools. Guided by Constructivist Theory and Engagement Theory, the study adopted a qualitative approach to examine participants' experiences and perspectives concerning technology-enhanced mathematics instruction.

The findings revealed four major themes. First, ICT enhanced learner engagement by increasing participation, motivation, and interest during mathematics lessons. Second, ICT improved conceptual understanding by enabling learners to visualize and interact with abstract mathematical concepts. Third, ICT positively influenced learners' perceptions of mathematics by reducing anxiety and fostering greater confidence and

enjoyment. Finally, ICT created expanded learning opportunities through access to digital resources, collaborative learning experiences, and independent learning pathways.

The study demonstrates that both educators and learners generally perceive ICT as a valuable educational tool that enhances teaching and learning experiences in mathematics classrooms. Technology provides opportunities for more engaging, interactive, and learner-centred learning environments that support both academic development and positive attitudes towards mathematics.

However, the successful integration of ICT depends on multiple factors, including educator competence, institutional support, technological infrastructure, and pedagogically sound implementation strategies. Educational stakeholders must therefore continue investing in professional development, infrastructure enhancement, and equitable access to technology.

As educational technologies continue to evolve, ICT will likely play an increasingly important role in shaping the future of mathematics education. By leveraging technology effectively, educators can create meaningful learning experiences that prepare learners for success in an increasingly digital world.

References

1. Bansal, S. K. (2007). *ICT and its impact on education*. APH Publishing Corporation.
2. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.
3. British Educational Communications and Technology Agency. (2003). *What the research says about ICT and motivation*. BECTA.
4. British Educational Communications and Technology Agency. (2007). *The impact of ICT in schools*. BECTA.
5. Chan, T. (2002). Constructivism and learning. Educational Research Journal, 17(2), 1–12.
6. Chrysanthou, I. (2008). The use of ICT in primary mathematics in Cyprus: The case of geometric concepts. *Educational Media International, 45*(2), 125–139.
7. Clements, D. H., & Sarama, J. (2014). *Learning and teaching early math: The learning trajectories approach* (2nd ed.). Routledge.
8. Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.
9. Denzin, N. K., & Lincoln, Y. S. (2005). *The Sage handbook of qualitative research* (3rd ed.). Sage.
10. Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25–39.
11. Fey, J. T. (1989). Technology and mathematics education: A survey of recent developments. *Educational Studies in Mathematics, 20*(3), 237–272.
12. Gagnon, G. W., & Collay, M. (2001). *Designing for learning: Six elements in constructivist classrooms*. Corwin Press.

13. Higgins, S. (2000). The impact of ICT on learning. *British Educational Research Association Conference Proceedings*.
14. Hohenwarter, M., & Jones, K. (2007). Ways of linking geometry and algebra: The case of GeoGebra. *Proceedings of the British Society for Research into Learning Mathematics, 27*(3), 126–131.
15. Jones, G., & Knezek, G. (2007). Mathematics and technology. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 151–168). Springer.
16. Kearsley, G., & Shneiderman, B. (1998). Engagement theory: A framework for technology-based teaching and learning. *Educational Technology, 38*(5), 20–23.
17. Kislenko, K., Grevholm, B., & Lepik, M. (2005). Mathematics is important but boring: Students' beliefs and attitudes towards mathematics. *Nordic Studies in Mathematics Education, 10*(1), 21–40.
18. Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.
19. Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. Jossey-Bass.
20. Moila, M. M. (2006). *The use of educational technology in mathematics teaching and learning: An investigation of a South African rural secondary school* (Master's thesis).
21. Moyer, P. S., Bolyard, J. J., & Spikell, M. A. (2002). What are virtual manipulatives? *Teaching Children Mathematics, 8*(6), 372–377.
22. National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. NCTM.
23. Pangani, G. B. (2013). *Use of ICT in schools: Exploring opportunities and challenges*. University of Dar es Salaam.

24. Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2009). What makes professional development effective? *American Educational Research Journal, 46*(4), 921–958.
25. Poudel, B. (2007). ICT in mathematics education: Opportunities and challenges. *Journal of Mathematics Education, 1*(1), 45–56.
26. Ruthven, K., & Hennessy, S. (2002). A practitioner model of the use of computer-based tools and resources to support mathematics teaching and learning. *Educational Studies in Mathematics, 49*(1), 47–88.
27. UNESCO. (2009). *ICT competency standards for teachers: Policy framework*. UNESCO.
28. Van den Heuvel-Panhuizen, M., & Drijvers, P. (2014). Realistic mathematics education. In S. Lerman (Ed.), *Encyclopedia of mathematics education* (pp. 521–525). Springer.
29. Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
30. Warschauer, M. (2006). *Technology and social inclusion: Rethinking the digital divide*. MIT Press.

APPENDIX I

Questions to guide educator participants.

1. What variations did you notice in your students' interest levels toward the class after integrating ICT?

2. In what ways does ICT assist you in facilitating student comprehension?

3. Are there reservations among teachers regarding the integration of ICT in teaching mathematics? If so, what are the reasons behind these hesitations?

4. When did you initiate the use of ICT in your classroom, and what impact has it had on your teaching since its implementation?

5. What disparities do you observe between teaching mathematics with and without the use of ICT?

6. What criteria guided your decision to incorporate ICT into your mathematics teaching approach?

7. How do your students respond to the use of ICT in your classroom? Can you share any anecdotes or feedback, whether positive or negative, from your students?

8. How do you prepare your lessons? Do your students contribute by sourcing materials from home and bringing them to class?

9. How does your teaching method contribute to altering students' accustomed learning approaches, particularly regarding problem-solving?

10. How do your fellow teachers perceive your classroom practices? Have they been influenced to adopt similar approaches?

11. What opportunities and challenges do you encounter when integrating ICT into mathematics instruction?

Questions to guide learner participants.

1. How do you feel about using technology, such as computers or tablets, in your Mathematics classes?

2. Do you think using ICT helps you understand Mathematics concepts better? Why or why not?

3. What are some of the benefits or challenges you've experienced when using ICT for learning Mathematics?

4. How do you think your peers perceive the use of technology in Mathematics education?

5. Are there any specific ICT tools or apps that you find particularly helpful for learning Mathematics? Why do you like them?

6. Do you think there are any areas where ICT could be improved or better utilized in Mathematics education?

7. How do you think educators could make ICT integration in Mathematics classes more engaging and effective for students?