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Teachers' Perspective and Challenges of Using Technology Tools in Teaching Science Subject at Secondary School

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Abstract

This study investigates the perspective of teachers and challenges they encounter while using technology into secondary school science instruction. Six science teachers from Putrajaya-area schools participated in interviews as part of the study which used qualitative approaches to learn more about their perspectives, experiences, and level of technology integration in the classroom. According to research, teachers are aware of how technology may improve science education by providing dynamic and captivating resources like instructional games, virtual labs, and simulations. These resources make it possible to visualize abstract scientific ideas, which improves student comprehension and engagement. Important challenges are noted in the study, such as a lack of resources, technological challenges, insufficient training, and differences in students' and teachers' degrees of digital literacy. These difficulties frequently cause disruptions to lessons and restrict the efficient use of technology in the classroom. Teachers underlined the need of infrastructure upgrades to enable smooth technology integration as well as the necessity of focused professional development to increase their digital competencies. The study highlights how technology can be both a strong facilitator and a cause of challenges for science teaching. It concludes with suggestions for providing skills and lack of resources, promoting broad access to technology, and putting in place strong support networks. A more engaging, inclusive, and productive teaching-learning environment can be achieved by resolving these problems and optimizing the use of technology in science education.

Keywords: ICT Integration in Education, STEM Learning Environment, Teacher Competency, Virtual Experiments, Student Engagement, Educational Technology Challenges

Introduction

Technology is the practical application of scientific knowledge, instruments, and techniques to solve problems or achieve specific objectives. It encompasses a wide range of advances across industries, including manufacturing, information technology, communication, healthcare, and education. In education, technology has evolved from being a supplementary teaching aid to becoming an integral component that supports and transforms learning. The implementation of information and communication technology (ICT) assists in improving and strengthening information delivery while fostering a student-centred learning environment (Heinonen et al., 2022). Innovative use of technology can enhance student literacy and engagement by promoting thinking, decision-making, problem-solving, and logical reasoning skills that are crucial in the information era. However, the full potential of technology in education can only be realized when there is a paradigm shift in teaching and learning practices, with teachers playing a central role as effective agents of change.

Understanding both the benefits and challenges of integrating technology into classrooms is essential for improving the quality of teaching and learning, especially given technology's growing influence on society and education. Teachers play a critical role in developing students' technological and cognitive competencies needed for national socioeconomic progress. As technology continues to shape modern education, the ability to retrieve, manage, and apply knowledge through digital means has become indispensable for both teachers and students (Heinonen et al., 2022). Although many teachers recognize the potential of technology, its effective adoption remains challenging due to resource limitations and varying degrees of digital literacy (Yuen et al., 2019; Jones, 2020).

In Malaysia, the Smart Schools Initiative (Sekolah Bestari) was introduced in 1999 as part of the Ministry of Education's broader goal to transform teaching and learning through ICT. The Malaysian Education Strategic Plan (2013–2025) continues to emphasize the integration of digital technologies to enhance learning quality and prepare students for the knowledge-based economy (Ministry of Education Malaysia, 1997). Through this initiative, schools are provided with computers, internet facilities, and ICT-based training programs for teachers and students. Nevertheless, despite these policies, many teachers still face obstacles in effectively implementing technology due to limited access to devices, inadequate infrastructure, and insufficient training (Bećirović, 2023; Wohlfart & Wagner, 2022). These challenges often lead to inconsistent use of digital tools, which reduces the overall effectiveness of ICT-based education. Science subjects such as Physics, Chemistry, and Biology particularly benefit from technology integration because digital tools such as virtual laboratories, simulations, and interactive visualizations which help students grasp abstract scientific concepts more effectively (Bhat, 2023). Studies have shown that the use of ICT in science education can enhance engagement, facilitate inquiry-based learning, and improve conceptual understanding (Turgut & Aslan, 2021; Alshehri, 2020). However, the extent to which these benefits are realized depends greatly on teachers' digital competencies, pedagogical approaches, and institutional support. Given these circumstances, it is crucial to investigate teachers' perspectives and the challenges they encounter when using technology tools in teaching science. While international research has explored ICT integration extensively, there remains a gap in localized studies focusing on Malaysian secondary school science teachers. Understanding their lived experiences can provide valuable insights for

developing more effective training and infrastructure support tailored to the Malaysian context.

Therefore, this study investigates teachers' perspectives and challenges in using technology tools in teaching science subjects at the secondary school level in Malaysia. The novelty of this research lies in its qualitative exploration of real-world classroom practices and contextual barriers, offering a comprehensive view of how teachers perceive and implement digital tools in science instruction. The study contributes to the social science and education fields by providing empirical evidence that can inform policy formulation, professional development programs, and strategies for improving ICT integration in Malaysian schools.

Problem Statements

Based on the expanding impact of a digitally driven culture, there is a great deal of interest in understanding how educational practice is altering. Many studies have shown that incorporating technology into education has favourable outcomes, such as raising student motivation and enhancing teacher feedback and evaluation (Jones, 2020). Furthermore, there is evidence that teachers are becoming more interested in incorporating technology into their courses (Yuen et al., 2019).

Despite the reported benefits of technology in education, several academics have expressed severe reservations. They claim that just using digital technology does not promote learning. There is a danger of employing new technology to teach old concepts in traditional methods, which may not assist student learning successfully (Timotheou et al., 2022). Knowing and using technology does not ensure good teaching practice (Akram et al., 2022). The current tendency appears to be for teachers to use technology as a delivery mechanism while continuing to employ traditional teaching approaches.

Furthermore, research has revealed that many teachers do not completely integrate technology into their teaching approaches (Bećirović, 2023). Teachers are frequently allocated responsibility for using electronic instructional approaches (Wohlfart & Wagner, 2022). Some teachers reported having problems using technology because of a lack of time to become acquainted with technology (Bećirović, 2023). Furthermore, teachers indicated a desire for more specific direction on how and why technology should be included into the lessons they teach.

Although there has been information of effective integration of technology into scientific education, there have also been instances when the implementation has been less than ideal. Science teachers who struggle to incorporate thinking into their lessons are a good example. Despite their preparation and enthusiasm, they struggle with actual usage of technology, and as a result, students lose interest in the class and instead of paying attention, they browse the internet. and have fun. Teachers' approaches to challenges are returning to conventional instructional materials and methodologies.

Objectives

This research aims to investigate teachers' perspective and challenges of using technology tools in teaching science subjects. The objectives of this research are

1. To figure out teachers' perspective on using technology tools to teach science in the

classroom.

- What is the teachers' perspective of implementing technology tools in teaching science subjects?

2. To figure out the challenges of implementing technology tools in the classroom to teach science subjects among school teachers.

- What are the challenges faced by the teacher in implementing technology tools in teaching science subjects?

3. To determine the extent to which teachers integrate technology tools in the classroom to teach science subjects.

- How do teachers use technology tools in teaching science subjects in the classroom?

Literature Review

Challenges in Using Technology Tools in Teaching Science Subjects

The use of technology tools into education has altered the teaching and learning process, particularly in scientific topics. Technology tools are digital resources, software, and platforms that make teaching easier by increasing interactivity, engagement, and content accessibility. However, using these tools into scientific teaching presents obstacles. Issues such as limited access to necessary devices, inadequate infrastructure, and insufficient teacher training frequently impede the efficient use of technology in classrooms. Understanding and addressing these obstacles is critical for fully realizing the benefits of technology in science education (Kalyani, 2024). Implementing technology into the teaching and learning process is a complicated undertaking that can be affected by a variety of obstacles referred to as "challenges." These obstacles can be described as situations that obstruct progress or the attainment of goals.

Limited Accessibility and Network Connection

Limited accessibility and inadequate network connectivity are important impediments to the successful use of technology in education. Accessibility refers to how easily students and teachers can get and use the digital tools, devices, and resources required for learning. Network connection, on the other hand, refers to the availability and dependability of internet services that facilitate online and technologically based educational activities. In many cases, socioeconomic inequities, limited infrastructure, and geographic limits all contribute to these problems, resulting in unequal possibilities for children to benefit from technology-enhanced learning (Russo & Emtage, 2023). Addressing these issues is crucial for ensuring fair access to quality education.

Some research studies have emphasised the difficult issue of teachers' restricted access to resources, particularly home access, which prevents them from efficiently incorporating modern technology into teaching. There are several causes for this lack of access to technology. Teachers cited challenges in having continuous access to computers. Booking computers in advance was sometimes overlooked, and they were unable to reserve them for consecutive periods, especially while working on various projects with kids. Because technology resources were often shared among teachers, this resulted in limited access to them.

According to Bećirović (2023), lack of access to technology resources may be caused by more than just a lack of hardware, software, or other technology assets neither school. It might also be the result of inadequate resource management, low-quality technology, incompatible software, or a lack of personal access for teachers. The issues associated with technology accessibility for teachers are not restricted to a single country; they are ubiquitous and vary by location. The most significant barrier, according to Mercenier and Voyvoda (2021), was a lack of accessibility, with teachers reporting numerous issues such as a lack of computers and suitable resources. According to Wireless Internet in Lower Secondary Schools in Europe 2018 (2019), internet access is still not found in 50% of European schools.

Several investigations from other nations found similar results. Turgut and Aslan (2021) discovered that a lack of computers, old or sluggish technology systems, and a paucity of instructional software were barriers to successful technology deployment in Turkish schools. According to Alshehri (2020), the absence of internet connection during school hours and hardware shortages are barriers to technology integration in Saudi schools. According to research conducted in United State schools, one of the biggest hurdles to technology integration in the classroom was a lack of computer resources (Dinc, 2019).

School with Limited Technical Support

Technical support in education is defined as the assistance and resources offered to maintain, troubleshoot, and maximize the usage of technology tools and infrastructure in schools. For many institutions, particularly those in less fortunate or rural areas, lack of technological support is a major barrier. This includes limited access to IT professionals, inadequate equipment upkeep, and technical issues that are not resolved on time. Without adequate support, educators and students may struggle to use technology successfully, resulting in disruptions in learning and a limited ability to properly integrate digital tools into the curriculum (Timotheou et al., 2022). Addressing this gap is critical to ensuring the successful adoption of technology in education.

Effective use of technology in education necessitates both strong technical assistance in the classroom and enough whole-school resources. Dovilė Stumbrienė et al. (2023) emphasized that without these crucial characteristics, teachers cannot be able to overcome the barriers that prevent them from adopting technology. Neumeyer et al. (2021) revealed that one of the most significant impediments to technology adoption in education, according to elementary and secondary teachers, was a lack of technical help.

Technical issues surfaced as a key barrier for teachers in Mercader and Gairín (2020) study. Slow-loading websites, internet access challenges, malfunctioning printers, and the usage of outdated and unreliable PCs were among the technological impediments. These technical difficulties hampered the seamless delivery of teachings as well as the natural flow of classroom activities (Mercader & Gairín, 2020). According to Technical Assistance and Support in the Planning of School Maintenance (2022), technology assistance or maintenance agreements in schools are crucial to supporting teachers in using technology in the classroom without wasting time troubleshooting software and hardware issues. According to Bećirović (2023) research, the absence of technical assistance in a school can lead to irregular technical maintenance, increasing the likelihood of technical breakdowns.

Several participants in the Bećirović (2023) survey expressed concern that technical difficulties would prohibit them from using technology in their teaching due to the possibility of equipment running out during a session. Numerous research studies related to education have discovered that a lack of technical help is a major barrier to efficient technology use. For example, emphasised that technology integration in education necessitates technical aid, and its lack might be a barrier. Similarly, Turgut and Aslan (2021) discovered that a lack of technical assistance was regarded as a major impediment to technology integration in scientific instruction in Turkish schools. Science teachers in Saudi Arabia were eager to include computers into their classrooms, but many were concerned about technical support or hardware concerns Alshehri (2020). Mercader and Gairín (2020) stated that technological issues create impediments to seamless class delivery for teaching professionals, regardless of their degree of expertise or the type of technical assistance and access they have.

Lack of Effective Training

Effective training in education refers to structured programs and tools that provide educators with the information and skills they need to effectively integrate technology into their teaching methods. A lack of such training might impede teachers' confidence and creativity in using digital resources, restricting their ability to improve learning experiences. This problem is frequently caused by a lack of professional development opportunities, obsolete training materials, or an emphasis on generic abilities over subject-specific applications. Addressing the training gap is critical for empowering educators and ensuring the successful implementation of technology in education (Gondwe, 2021).

The lack of appropriate teacher training in the use of technology in education is regularly noted in the literature as a difficulty. According to Neumeyer et al. (2021) research, there are insufficient training opportunities for teachers to use technology in the classroom. Similarly, Kaminskienė et al. (2022) cited a lack of training as one of the top three hurdles to teachers' use of technology in the classroom as one of the top three barriers. Current studies in Turkey discovered that the most significant barrier to using modern technology in education was a lack of ongoing training for the teachers, while Turgut and Aslan (2021) discovered that insufficient training for teachers in the application of technology in Turkish schools was a barrier.

Nisar Ahmed Dahri et al. (2024) realised that training is a complicated topic, and its efficacy is dependent on a variety of factors, including time for training, pedagogical training, skills training, and the use of technology in initial teacher training. Similarly, Handika et al. (2023) discovered that a lack of digital literacy training, pedagogic and didactic technology usage in the classroom training, and technology training for specific subject areas were barriers to the use of new technologies in classroom practice. Similar reasons for failures in using educational technology were cited in Saudi Arabian studies, such as a lack of teacher training in computer use, a focus on traditional "delivery" teaching rather than investing in modern technology, and a scarcity of teachers qualified to confidently use technology (Alshehri, 2020).

It is critical to provide pedagogical training for teachers rather than just technology tool usage (Heinonen et al., 2022). According to Haarala-Muhonen et al. (2023), in order to persuade teachers of the usefulness of utilising technology in the classroom, training should focus on

pedagogical difficulties. Teachers who attended technology professional development courses still lacked expertise on how to successfully incorporate technology into their classes; they only understood fundamental technology skills like running a computer and setting up a printer. This was due to the courses' emphasis on obtaining fundamental technology skills rather than improving technology pedagogical components.

Simply put, when new tools and teaching techniques are introduced, teacher training is required to enable them to effectively incorporate these technologies into their teaching (Christina Ioanna Pappa et al., 2023). However, according to Heinonen et al. (2022), poor or insufficient training leaves teachers unprepared and lacking confidence in properly integrating technology into the classroom. According to Sevgi Aydin-Gunbatar et al. (2023), teachers must not only be computer literate but also develop abilities in integrating computer use into their teaching and learning programmes.

Lack of Teachers' Competency

Teachers' competency refers to the knowledge, skills, and attitudes required by educators to perform their roles effectively, including the ability to integrate technology into teaching. Lack of competency in this area can result in underutilization of digital tools, reduced student engagement, and ineffective teaching practices. Contributing factors include limited exposure to technology, inadequate professional development, and resistance to adopting new methods (Mariscal et al., 2023).

Another barrier to teacher credibility is their ability to successfully integrate technology into their instructional practices (Handika et al., 2023). According to Sevgi Aydin-Gunbatar et al. (2023) research in Australia, many teachers lack computer knowledge and abilities and exhibit limited excitement for adopting computer-based supplemental learning into their teaching practices. The degree of this barrier varies by country. According to research, in poor nations, teachers' lack of technology ability is a key obstacle to their adoption and implementation of technology. (Neumeyer et al., 2021). For example, teachers' lack of technology ability has been cited as the main obstacle in the United State (Dinc, 2019). In a similar way, a lack of technology skills is a significant obstacle to incorporating technology towards science education in Saudi Arabia. (Alshehri, 2020).

Mercenier and Voyvoda (2021) published the research on technology used in the European schools, and data from 27 European nations revealed that teachers who do not use computers in classrooms frequently cite "lack of skills" as a barrier to adopting technology for teaching. In a global survey involving nationally representative samples of schools from 26 countries, researchers discovered that teachers' lack of knowledge and competencies posed a substantial impediment to installing technology in secondary schools (Neumeyer et al., 2021).

Heinonen et al. (2022) performed research that revealed various viewpoints in various nations. In Denmark, for example, many teachers avoid using technology and media in the classroom because they lack technology abilities, instead of pedagogical or practical reasons. In the Netherlands, however, teachers' technology knowledge and abilities were no longer viewed as the primary obstacle to technology usage. Thus, one of the major challenges to integrating technology into education is a lack of teacher competency. It might also be one of the elements influencing reluctance to change.

Theoretical Framework

A theoretical framework is a structured foundation that includes concepts, theories, and principles to help researchers understand and analyze a study subject. It serves as a contextualizing lens for the study, assisting in explaining correlations between variables and providing a reason for the approach used. In the context of educational research, a theoretical framework is essential for matching the study's aims with established knowledge, assuring clarity and consistency. Researchers can establish a more solid and believable method to answering research questions by rooting it in theory.

Davis et al. (1989) previously created the Technology Acceptance Model (TAM), that focused on 'activity linked to reasons.' Continuing their research, Venkatesh and Davis (2000) investigated the variables impacting people's computer usage and attitudes towards computers, resulting in the development of TAM 2. Figure 1 depicts the model, which connects perceived utility and ease of use with attitudes towards utilising technology and actual system utilisation. They put their model through its paces on 107 individuals who have been using the system for management for 14 weeks. The findings demonstrated that individuals' intentions to use the computer predicted actual computer usage, and perceived usefulness strongly affected these intentions.

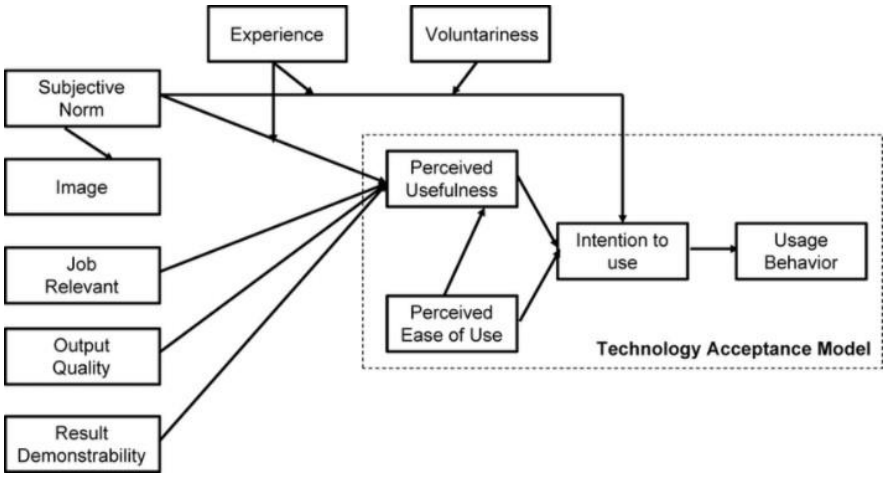

Figure 1: A theoretical extension of the technology acceptance model as TAM 2 (Venkatesh and Davis 2000)

When teachers are presented to a new technology, Venkatesh and Davis (2000) claimed that their decision to embrace and use it is impacted by two basic criteria, as well as other additional variables:

- External Variables: These are the difficulties that teachers experience when incorporating new technologies into their teaching and learning processes due to causes outside their control. Limited accessibility and network connectivity, schools with inadequate technology infrastructure, a lack of appropriate training, a lack of time, and insufficient teacher competency are examples of such issues.
- Perceived Usefulness (PU): This is the degree to which teachers feel that employing a certain technology would improve their work performance. Teachers are unlikely to employ technology tools if they do not feel a need to challenge or modify their professional practices. However, if they see technology as valuable for increasing their teaching and

students' learning, they are more likely to be enthusiastic about utilising technology in the classroom. Teachers' perceived utility of technology tools is influenced by factors such as the capacity to work more quickly, enhanced job performance, higher productivity, effectiveness, and general usefulness.

- Perceived Ease-of-Use (PEOU): This is the degree to which teachers feel that utilising a specific system or technology will involve little effort. Previous research has found a number of characteristics associated with perceived ease of use of technology, suchas ease of learning, clarity, accessibility, manageability, and ease of remembering (Worthington, 2021).
- Attitude Towards Use: Teachers' positive or negative views about utilising the target technology or system are referred to as their attitude towards use. Teachers' views towards these aspects will be influenced by how easily they see utilising technologies for personal use and in the classroom.
- Behavioural Intention: This shows the extent to which teachers have made intentional preparations to do or refrain from performing a certain future behaviour, such as employing a specific technology.

In addition, as factors influencing perceived usefulness and usage intentions, the updated version of TAM 2 includes social impact methods (subjective norm, voluntariness, and image) and conceptual instrumental methods (job relevance, output quality, results demonstrability, and perceived ease of use). These characteristics also contribute to teachers' acceptance and use of technologies.

Conceptual Framework

A conceptual framework for investigating teachers' perspectives and problems of employing technology tools in scientific subject at the secondary school level may be designed as follows:

Independent variables

Technology Competency of the Teacher: This comprises the teachers' knowledge, abilities, and confidence in utilising technologies to successfully teach science topics.

- Dependent variable:

Perceived Ease of Use: This variable assesses teachers' impressions of how readily they can incorporate technology tools into their present teaching techniques and practices.

- Mediating Factors

Teaching Method: This refers to the pedagogical approach and tactics utilised by the teacher when introducing technology resources into scientific education.

- Moderating Variable:

Teacher Experience: This variable evaluates the influence of teachers' years of experience on their desire and competence to use technologies in scientific instruction.

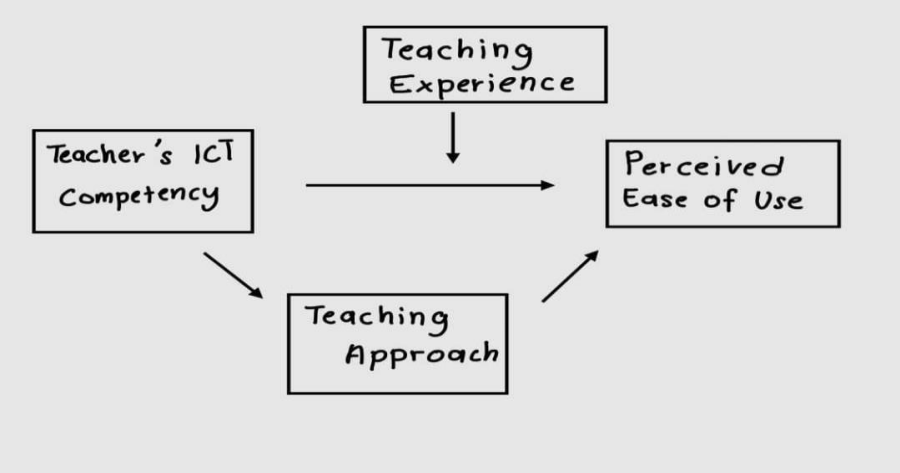

Figure 2: Conceptual framework of teachers' view and challenges of using technology tools in teaching science subjects at secondary school.

The conceptual framework aims to investigate how teachers' technology proficiency impacts their perceived ease of use while using technology tools in scientific instruction. It also looks at how teaching methods may help to moderate the link between independent and dependent factors. Furthermore, the moderating variables of teaching experience may impact the overall incorporation of technologies in secondary school scientific education.

Research Design

The main goal of this study was to figure out teachers' perspective on using technology tools to teach science in the classroom. Other than that, to figure out the challenges of implementing technology tools in the classroom to teach science subjects among school teachers. Moreover, this study also wants to determine the extent to which teachers integrate technology tools in the classroom to teach science subjects. To answer all of these research questions, a qualitative research method was adopted.

Research Method

This study uses a qualitative research approach to investigate science teachers' attitudes and experiences with using technology tools to teach science courses. Qualitative research is ideal for comprehending complicated phenomena in their natural setting, particularly when investigating personal experiences and perspectives. In this case, the researcher intends to investigate the attitudes, obstacles, and tactics used by science teachers when incorporating technology into their teaching practices.

A purposive sampling strategy was used to identify six (6) Science teachers with experience using technology tools in the classroom in SMK at Putrajaya. Because they are attractive and adaptable to the researcher, interviews are often utilised in qualitative research (Nathan et al., 2019). This selection strategy helps the researcher to choose participants who study issues, the researcher created a semi-structured collection of questions. The interview methodology was developed in response to the study's research questions. It covers questions concerning the teachers' views in implementing technology tools in teaching science subjects in the classroom, challenges of using technology tools in teaching science subjects in the classroom among school teachers as well as to what extent do the teachers

use technology tools in teaching science subjects in the classroom. In order to acquire relevant personal information from the respondents, demographic questions were also included in the interview. The researcher prepared a list of vital queries that would help in answering the study questions in order to build the interview questions. Table 3.1 is an illustration of the questions asked of the respondents, and Appendix A has a complete set of interview questions provided to the participants who were selected.

Table 3.1
Example of question listed in the Interview protocol (Ramli & Saleh, 2019).

Sample of items used In-Depth Interview
1) How many years of your experience in teaching?
2) What is your perception on using technology tools in science subjects?
3) What are the technology tools used in teaching science subjects?
4) Were there any challenges that you encountered when using technology tools in science subjects?
5) Is it possible that the chosen technology tools will help students learn specific science content?
6) To what level do teachers utilize technology tools in the classroom to teach science?

Population
The term "population" refers to the total group of people or components who share certain traits and are of interest to the researcher. It symbolises the bigger group to whom the study findings are intended to be generalised. The whole set of prospective participants or subjects from whom a sample is taken to conduct research is referred to as the population.

The population for this study were six teachers from SMK at Wilayah Persekutuan Putrajaya. There were some restricted criteria for this research where the respondents teach science subjects at the secondary school. The sample included six female responders in varying amounts. The location of the research sample was placed in the Putrajaya region.

Sampling
The process of selecting a selection of persons or items from a greater number of people for the purpose of conducting research is known as sampling. A sample is a subset of people picked from the population. Because it is sometimes difficult or impossible to investigate the complete population owing to its size, expense, or time limits, sampling is a vital aspect of research. There are numerous sampling strategies, and the method used is determined by the study objectives, demographic characteristics, and available resources. Convenience sampling, purposive sampling, quota sampling, accidental sampling, and snowball sampling are examples of non-probability sampling procedures. Purposive sampling is the most successful method for this kind of research. Purposive sampling, also known as judgemental or selective sampling, is a non-probability sampling approach used in research in which participants are chosen on specified criteria that correspond with the study aims. The researcher handpicks people or aspects from the population that have the necessary

features or experiences pertinent to the study in this technique. Purposive sampling is frequently used when a researcher wants to examine a specific subgroup or gather information from people who have specific knowledge, skills, or unique experiences connected to the research issue. Six teachers were chosen based on the subject taught which is science subject and are willing to participate in this research. The teachers' quality that been met is Science teachers at secondary school. The interview's goal is to dive thoroughly into the teacher perspective and the obstacles that teachers encounter while using technology tools in teaching science subjects.

Reliability and Validity

Reliability

In research, reliability relates to the consistency and stability of an instrument used to produce results from samples (Creswell, 2014). Three elements are considered to ensure the validity of this study work. First, all 25 samples answered the same questions. The samples were asked the identical questions in chronological order, giving them plenty of opportunity to respond. This proved consistency on the side of the investigator. Survey homogeneity in terms of response options, scales, and question types helps to reduce response bias and increase survey reliability. Test-retest reliability assesses stability by examining the consistency of responses over time after administering the survey to a subset of participants twice. The researcher can assess the data collected, boosting the reliability of the information received through the survey.

Validity

The validity of the interviews was maintained by connecting the interview questions with the study goals, with an emphasis on investigating teachers' perspectives and challenges in using technology tools in scientific instruction. Content validity was determined by engaging scientific education specialists and performing a thorough study of current research. In addition, a purposive sample strategy was employed to choose people with relevant experiences related to the research objective. Following data collection, chosen participants were requested to evaluate their interview transcripts for correctness and completeness, hence increasing the reliability and trustworthiness of the interview data.

Method of Data Analysis

As interviews were the only technique of data collection for this study, the information acquired is qualitative. The qualitative data was analysed by transcribing the audio recordings and doing theme analysis. Creswell (2013) defined thematic analysis as "identifying, coding, and categorising the themes present in the data to provide detailed descriptions of the phenomenon under study. To guarantee that no material was missed during transcription, the researcher attentively listened to the audiotapes numerous times while comparing them to notes obtained during the interviews. Following that, the interview replies were analyzed and coded into relevant components. The data was then categorized into topics using content analysis, with themes chosen based on quotes from respondents.

Finding and Results

The interviews were conducted with six science teachers from the same secondary schools in the Putrajaya area. These teachers, who volunteered for the interview, are currently utilizing various technology tools in their science classes. The researcher meticulously scheduled and

planned these interviews during her practical training session. The primary objective of the researcher was to delve into the teachers' perspectives and the challenges they encounter while integrating technology into their teaching methods. This exploration aimed to uncover insights into the effectiveness, hurdles, and overall impact of technology on science education.

Each interview lasted approximately 30 minutes and followed a consistent set of questions for all participants. This uniformity ensured that the data collected was comparable across all interviews, providing a comprehensive view of the teachers' experiences and viewpoints. The structured approach allowed the researcher to gather detailed information about how technology tools are being used in science classrooms, as well as the benefits and obstacles associated with their use.

Demographic Profile of Respondent

Demographic information describes a lot of groups and subgroups, and gives basic information about the population. It can be used to describe an entire nation, an area, a city, or the people who are supposed to be buyers of an item or service in question. A person's age, gender, type of work, education, and other details represent their basic demographic data (Wikipedia Contributors, 2024). Six science teachers voluntarily participated in the interview process after being informed about the objective and procedure of the study. At the beginning of each interview, a briefing session was conducted to outline the purpose of the research, the specific topics to be discussed, and the expectations from the participants. This ensured that all interviewees were fully aware of the process and felt comfortable sharing their perspectives and experiences.

The background information of each participant, including details such as teaching experience and subject being taught, is summarized in Table 4.2. This table provides an overview of the participants' profiles, offering context for their responses and helping to analyse variations in their views based on factors such as years of experience or prior exposure to technology. By presenting this demographic information, the study highlights the diversity of perspectives gathered, ensuring a comprehensive understanding of the challenges and opportunities associated with integrating technology tools in science education.

Table 4.2
Demographic profile of respondents

Respondent	Subject been teaching	Experience in teaching
Mrs. A	Physics and Mathematic	3 years
Mrs. H	Science	7 years
Mrs. I	Biology and Science	2 years
Mrs. A	Physics and Science	20 years
Mrs. S	Science	10 years
Mrs. A	Physics	5 years

Teachers' Perspectives on Using Technology Tools

Technology's implementation into education has greatly changed the way that lessons are taught and learned, providing resources that improve comprehension, accessibility, and engagement. Devices, software, and digital resources that enhance and support teaching methods are referred to as technology tools in education. These include platforms that facilitate individualized learning, educational apps, virtual simulations, and interactive whiteboards. These tools are not merely improvements for teachers; they are essential tools that influence how they plan, present, and assess their lessons. Since teachers' attitudes, experiences, and difficulties have a direct impact on the success of technology adoption in classrooms, it is crucial to understand how they see using these tools (Almuhanna, 2024). This section explores teachers' perspectives on integrating technology tools in education. The respondents highlighted several perspectives regarding the role of technology in science education and the advantages of using technology in teaching science. From their responses, it was evident that teachers recognized technology as a valuable resource for enhancing science education.

Perceptions of Technology's Role in Science Education

Science education is drastically changed by technology, which changes how students investigate, comprehend, and interact with scientific ideas. Digital tools, programs, and platforms that support science education are referred to as technology in this context. Virtual labs, simulations, interactive software, and data analysis tools are a few examples that enable students to conduct experiments, visualize abstract phenomena, and analyze outcomes in ways that are not possible with conventional approaches (Bhat, 2023). This section explores these views by looking at the advantages technology presents for science education, the difficulties encountered, and how it affects instructional strategies and student performance.

Table 4.3

Response 1 on "What is your perception on using technology tools in science subject?"

My perception on using technology tools in science subject is a good to be use as its help teaching and learning become more interesting. *Mrs. H*
With so many advantages that improve learning and engagement, the use of technology in science education is innovative. Science is made more interesting via interactive platforms, augmented reality, and educational games, and adaptable learning resources accommodate different learning preferences. Thus, I include technology in my teaching and learning session so I can produce a well-rounded and influential science curriculum by integrating technology with conventional hands-on approaches and updating resources to reflect new developments. *Mrs. S*
Technology has made my life easier as a teacher. It suits the need of these young generations as they are more engaged in learning when technology is utilized. Thus, I include technology in my teaching and learning session a lot. *Mrs I*

From the interview, the teachers often perceive technology tools as valuable facilitators that enhance the learning experience in science education by making lessons more interactive and

engaging (Khukalenko et al., 2022). When it comes to helping students picture abstract scientific processes and concepts that may otherwise be difficult to understand through traditional teaching techniques, tools like virtual labs, simulations, and multimedia presentations are crucial.

Table 4.4
Response 2 on "What is your perception on using technology tools in science subject?"

I honestly think technology helps deepen student understanding in visualising Physic concepts and law in daily life. With suitable gadget and material, my class sessions became more interactive with the help of visual aid from the technology. *Mrs. A*
I believe technology tools are transformative in science education. They not only make complex concepts easier to visualize and understand but also encourage student engagement and participation. Tools like simulations, virtual labs, and interactive presentations bring abstract scientific concepts to life. *Mrs. A*
I believe that technology tools have tremendous potential to improve science education. As we know, this generation has a bad perspective on STEM subjects. Technology can make it easier to visualize complex scientific concepts, engage students in interactive learning, and offer access to up-to-date information. However, the effectiveness of technology in education depends on how well it is integrated and how accessible it is to both. *Mrs. A*

According to the respondent in Table 4.4, teachers believe that using interactive simulations and visual representations, technology may effectively clarify these difficult concepts. 3D animations, for example, might depict planetary motions or molecular structures, giving abstract ideas a more concrete and understandable form (Teplá et al., 2022). Additionally, virtual experiments are useful substitutes for conventional laboratory sets, saving money and time without sacrificing the quality of experiential learning. Additionally, teachers value how technology reduces the hazards involved in handling potentially dangerous materials or equipment by offering a controlled and safe environment for conducting research. This capacity to make complex scientific ideas easier to understand and comprehend supports technology's function as an effective instrument for improving the teaching of science.

Benefits of Using Technology in Teaching Science

The use of technology in science education has become a vital component of modern education, providing instruments for improving the delivery and comprehension of complicated scientific concepts. In this context, "technology" refers to electronic gadgets, software, and applications created to enhance and support instructional strategies. Examples of dynamic and captivating learning experiences include online collaborative platforms, data visualization tools, interactive models, and virtual simulations (Esra Kabataş Memiş et al., 2023). This section examines the benefits of integrating technology into science instruction, highlighting how it can enhance student comprehension, encourage critical thinking, and get students ready for a technologically advanced future.

Table 4.5
Response on "Is it possible that the chosen technology tools will help students learn specific science content?"

Students can investigate complicated ideas that could be challenging to understand using only conventional approaches thanks to technological aids like interactive models, simulations, and virtual labs. For example, 3D molecular representations in chemistry or virtual dissections in biology can offer a more profound comprehension of structures and processes. Game-based tools and interactive quizzes, such as Kahoot! or Quizizz, make learning specific topics engaging while reinforcing knowledge retention.   *Mrs. S*
The right technology tools can make complex scientific concepts easier to understand by providing visualizations and interactive content. For instance, virtual labs allow students to experiment and observe phenomena that might be too costly, time-consuming, or dangerous to replicate in a classroom setting   *Mrs. A.*

According to the respondent, technology helps improve student engagement and enables a deeper comprehension of difficult subjects and makes its advantages in science education clear. Technology-enabled learning environments are vibrant and engaging, drawing students in and promoting active engagement. Lessons are made more interesting by elements like polls, quizzes, and gamified activities, which encourage students to participate and pay attention. Through simulations, animations, and virtual experiments such as PhET Interactive Simulations or Gizmos, technology also helps students visualize abstract scientific ideas and gives them access to processes that are otherwise challenging to illustrate in typical classroom settings. Simulations, for instance, can simulate planetary motions or chemical reactions, helping students better understand complex interactions and details (Yilmaz, 2023).

Challenges in Implementing Technology Tools

The use of digital tools in education has enormous potential for improving teaching and learning, but it is not without obstacles. In this context, technology tools are defined as digital resources, equipment, and software that support instructional methods, such as interactive platforms, learning management systems, and educational applications. While these tools have the potential to alter the classroom experience, successful technology implementation is sometimes associated with challenges (Guanzon et al., 2024). This section examines the challenges in implementing technology tools in education.

Teachers identified several obstacles that hinder the effective integration of technology into teaching practices. One of the main challenges highlighted was limited access to resources, including insufficient devices, outdated software, and unreliable internet connections. Teachers also pointed out the lack of technical support and training, which often leaves them unprepared to effectively utilize technology in the classroom. Additionally, some teachers mentioned student-related challenges, such as varying levels of digital literacy and difficulties in keeping students focused when using technology.

Resource Limitations and Accessibility

Resource constraints and accessibility refer to the issues associated with the availability and equitable distribution of educational materials, technologies, and infrastructure required to facilitate effective learning. In the context of education, resources include not only physical instruments such as computers and software, but also reliable internet connectivity, technical assistance, and professional development opportunities for teachers (Guanzon et al., 2024).

Table 4.6

Response on "Were there any challenges that you encounter when using technology tools in science subject?"

Yes, some challenges first are limited access to technology resources. Not all classrooms are equipped with modern tools such as projectors, smartboards, or computers, which are essential for delivering interactive and engaging lessons. This limitation can significantly affect the implementation of technology-driven teaching methods. *Mrs. A*
Yes, some challenges include limited access to resources due to budget constraints, technical issues with devices, and a lack of proper training for teachers on how to use technology effectively. Additionally, students' varying levels of familiarity with technology can sometimes slow down the teaching process. *Mrs. A*

From the interview session, accessibility issues and resource constraints continue to be major obstacles. Disparities in technology integration result from schools' frequent differences in device availability, internet connectivity, and necessary digital tools. While some classrooms have sophisticated equipment like computers, projectors, and smartboards, others could not have even the most basic setup, which makes it difficult to use technology-based teaching strategies effectively (Scholarworks & Brackett, 2024).

Technical Issues and Compatibility Problems

Technical issues and compatibility issues are challenges that develop when software, hardware, or systems fail to perform properly or cannot work together successfully. Bugs, crashes, hardware malfunctions, and incompatibilities between different versions or types of technology are all possible difficulties. Addressing these issues is crucial to maintaining consistent performance and user happiness (Rothhaupt et al., 2024). This section investigates common causes, potential consequences, and resolution techniques for various difficulties.

Table 4.7
Response on "Were there any challenges that you encounter when using technology tools in science subject?"

The challenge is the internet connection thus to use this kind of technology tools need to consider twice. *Mrs H.*
There are a number of issues with using technology in science teaching that need to be carefully considered. Although my school has projectors for each department and internet access, accessibility is still a major problem, underscoring the digital divide. Lessons usually will be disrupted by technical issues like internet connections or obsolete technology, which requires time. *Mrs. S*
Well, there are always issues about the internet connectivity. Sometimes, I encounter bad connection and have to make my students wait while I am setting up the slides. *Mrs. I*

From the interview session, teachers frequently deal with unpredictable internet access, all of which can interrupt classes and make it more difficult to provide educational materials effectively. In addition to taking up valuable class time, these technical issues irritate teachers and students alike (Timotheou et al., 2022).

Teacher Readiness and Training Gaps

Teacher readiness and training gaps relate to the mismatch between teachers' abilities, knowledge, and preparedness and the needs of today's classrooms. These gaps may result from insufficient professional development, a lack of access to training resources, or difficulties adjusting to new educational technologies and approaches (Talib et al., 2024). This section investigates the reasons, implications, and potential solutions to close these gaps and improve teaching effectiveness and student outcomes.

Table 4.8
Response on "Were there any challenges that you encounter when using technology tools in science subject?"

Another notable challenge is the lack of training for teachers. Many teacherss, including myself during the early stages of adopting technology, have experienced difficulties in learning how to effectively integrate these tools into teaching practices. Without adequate training or ongoing technical support, teachers may feel unprepared and hesitant to incorporate technology into their lessons. This highlights the need for professional development programs to equip teachers with the skills and confidence required for utilizing educational technology effectively. *Mrs. A*

The effective incorporation of digital tools in science education is significantly influenced by training gaps and teacher readiness. In order to give teachers the abilities and self-assurance they need to successfully integrate digital tools into their teaching methods, training programs must be adequate. Many teachers, however, believe that the training they receive is either too generalized or inadequate, making them ill-equipped to manage particular tools or troubleshoot technical problems (Alshorman, 2024). Teachers frequently have differing degrees of comfort and readiness as a result of this lack of focused professional development;

some feel creative and confident, while others find it difficult to put their ideas into practice. Teachers may also find it difficult to keep up with quickly changing technologies, which highlights the necessity of ongoing training programs that emphasize both fundamental skills and advanced applications.

Student Engagement and Classroom Management

Student engagement and classroom management are the tactics and procedures used to pique students' interest in learning while ensuring a disciplined and productive classroom environment. Engagement entails actively engaging pupils to participate in classes, whereas classroom management focuses on providing an environment in which effective teaching and learning may take place without interruption. This section delves into the issues at hand, approaches, and rewards of creating engagement and discipline to ensure the best educational outcomes.

Table 4.9

Response on "Were there any challenges that you encounter when using technology tools in science subject?"

Furthermore, it can also be difficult to integrate technology with curricula and assessment systems, necessitating more work and adaptation. Sometimes, the lesson might work well in theory but in practice, there are some issues such as difficulty in monitoring progress, students get distracted or misuse device by non-educational apps or websites during lessons. *Mrs. S*
Honestly, one of the challenges that I encounter is distraction. Students tend to focus on exploring non educational material when given the opportunity. *Mrs. A*

According to the respondent, students' digital literacy levels is a significant obstacle since some are proficient with technology, while others might not be, necessitating more time and assistance to guarantee fair participation. Before implementing digital technologies, teachers must offer instruction and direction because this discrepancy might impact learning speed and lead to comprehension gaps (Ndibalema, 2025). Additionally, there is a chance that students will become distracted when using internet-connected devices since they can be enticed to explore irrelevant content, utilize social media, or play online games during class.

Extent and Methods of Technology Integration

The amount and methods of technology integration refer to the degree and effectiveness with which digital tools, resources, and technologies are integrated into teaching and learning activities. This covers the extent to which technology aids curriculum delivery, increases student engagement, and enables innovative teaching practices. Integration methods vary greatly, ranging from the use of simple tools like slideshows to more complex strategies like interactive learning platforms and artificial intelligence (Adil et al., 2024).

This section examines the extent and methods of technology integration in teaching practices. It highlights how frequently and in what ways teachers incorporate technology tools into their instruction. The results show different degrees of technology use, from occasional additions to lessons to more regular and deep integration. While some teachers said they mostly used technology for presentations and demonstrations, others said they used it for virtual

experiments, interactive exercises, and simulations. Teachers used a variety of techniques to integrate technology, including collaborative tools, online resources, educational software, and multimedia presentations. To improve student engagement and comprehension, they also incorporated digital platforms for project-based learning, exams, and real-time feedback.

Types of Technology Tools Used in Teaching Science

The various forms of technological tools used in science education refer to the digital resources and equipment used to improve the teaching and learning of scientific subjects. These tools include virtual labs, simulations, data analysis software, interactive whiteboards, and instructional apps, among others. They are intended to promote hands-on learning, spark curiosity, and make complicated scientific phenomena more approachable and interesting. This section delves into the various types of technology tools, their use in science teaching, and their impact on student comprehension and participation.

Table 4.10

Response on "What are the technology tools used in teaching science subjects?"

I frequently use gamification tools like Kahoot and Quizizz when I need to evaluate my student. *Mrs. H*
There are a variety of technology tools that I use in teaching Science subjects, each tailored to enhance aspects of learning and engagement. The most common technology that I used is projector to present my slides to the students, interactive whiteboards, online video resources and virtual collaboration platforms such as Padlet, Jamboard and Google Workspace. *Mrs. S*
The most common technology that I used is projector to present my slides to the students. This saves a lot of time compared to writing on the whiteboard. *Mrs. I*
Smart TV and iPad. The iPad can wirelessly mirror its screen to a Smart TV. This allows me and students to display lessons, videos, presentations, and interactive apps from the iPad to a larger audience, making the learning experience more engaging and accessible. *Mrs. A*
Some of the commonly used tools include virtual lab simulations, interactive whiteboards, educational apps, data-logging sensors, and online platforms like Google Classroom and Kahoot. These tools facilitate experiments, assessments, and collaborative learning. *Mrs. A*
Common technology tools used in teaching science include digital simulations, virtual labs, interactive whiteboards, online educational platforms (such as Google Classroom, Quizizz, Kahoot), and multimedia resources like videos and animations. Additionally, data collection devices such as sensors and probes are also beneficial in experimental sciences. *Mrs. A*

Technological tools used in science education are essential for improving classroom instruction and making learning more dynamic and engaging. Data loggers provide real-time data collection and analysis, which helps students visualize patterns and trends during experiments; interactive whiteboards allow teachers to present dynamic lessons with multimedia content, annotations, and real-time demonstrations; online quizzes and games, like Kahoot, make assessments more engaging by incorporating elements of competition and instant feedback; and virtual labs and simulations allow students to conduct experiments

in a safe and controlled environment, allowing them to explore scientific concepts without the limitations of physical lab equipment (Godoy, 2022).

Instructional Strategies for Technology Integration

Instructional strategies for technology integration are the deliberate ways and approaches that teachers employ to effectively incorporate technology into their teaching and learning practices. These initiatives are intended to match technological tools with curriculum goals, increase student engagement, and improve the overall educational experience. Examples include blended learning, flipped classrooms, project-based learning using digital resources, and collaborative online activities. This section delves into numerous tactics, their implementation, and roles in maximizing the benefits of technology in education.

Table 4.11

Response on "How do these challenges impact your instructional methods and strategies?"

The difficulties of integrating technology into science instruction have a big impact on teaching strategies and tactics, frequently necessitating flexibility and preparation. Due to limited resources, I must find innovative ways to combine traditional teaching techniques with technology. In order to maintain learning continuity, technical problems and faults necessitate backup measures, such as creating alternate lessons or offline resources. Due to student distractions and gadget abuse, classroom management strategies including clear guidelines and monitoring tools are necessary to keep students' attention. Adapting classes to satisfy requirements and utilizing the advantages of digital tools frequently results from the necessity to match technology with curricula. *Mrs. S*
Due to the challenges, I always need to prepare myself with other backup plans. For example, if my online quiz I not showing, I need to switch with the traditional method which is giving quiz on a piece of paper. This actually reduced engagement since students cannot see the interactive visuals or collaborate online with their classmates. *Mrs I.*
These challenges force me to adapt my teaching strategies. For example, I often need to find alternative low-tech solutions when technology is unavailable. I also spend extra time preparing lessons to ensure that any technical issues won't disrupt the flow of the class. Additionally, I emphasize flexibility, adapting my lesson plans in case some students struggle with using certain tools. *Mrs. A*

To successfully integrate digital technologies into science education, instructional strategies for technology integration are necessary. One popular strategy is blended learning, which gives students a more flexible and individualized learning experience by fusing traditional in-person instruction with online materials and activities. The flipped classroom model is another successful tactic, in which students study new ideas at home using readings, videos, and simulations while class time is devoted to practical exercises, discussions, and problem-solving (Baig & Yadegaridehkordi, 2023).

Maximizing Available Resources

Maximizing available resources refers to the strategic use of existing tools, materials, and support systems to fulfil educational objectives in an efficient and effective manner. This entails using physical, digital, and human resources, such as classroom equipment, technology tools, and community knowledge, to improve teaching and learning experiences. Teachers can solve difficulties, reduce waste, and improve outcomes without making major

new costs. This section offers approaches, benefits, and examples for making the best use of educational materials.

Table 4.11
Response on "How do you maximize the use of available resources to support science education?"

Teachers can give priority to inquiry-based, hands-on learning that utilizes inexpensive resources and techniques in order to optimize the resources available in science education. To supplement real investigations, they can incorporate free online simulations, virtual labs, and instructional videos. *Mrs. S*
I will use variety of approach to deliver my lessons. I will be using slides, YouTube videos, online quiz and a lot of platforms to enhance my teaching. *Mrs I.*
Science education is most effective when students actively engage with the material. I often use the existing materials for inquiry-based learning where students experiment, ask questions, and seek solutions. Other than that, project-based learning is also one of the ways to incorporate scientific method while utilising school resources to foster a deep level of student understanding. *Mrs. A*
I ensure that resources are integrated purposefully into lessons rather than used as add-ons. For instance, I create flipped classrooms where students can explore concepts through videos and simulations before diving into discussions or practical experiments in class. *Mrs. A*

According to the respondents, in order to deliver high-quality learning experiences without having to pay for pricey software and equipment, teachers are increasingly depending on open-source materials and free online tools. Teachers can engage students in dynamic classes that might otherwise require expensive physical resources by using platforms that offer interactive learning activities, virtual labs, and simulations. As an example, open-source software offers free options for tasks like word processing, design, and video editing, while virtual science labs and math simulations allow students to conduct experiments and investigate difficult ideas online (Adil et al., 2024). Regardless of financial limitations, these tools assist teachers in developing dynamic, designed classes that improve learning outcomes and increase accessibility and interest in learning for all students.

Discussion

Research Question 1: What are teachers' perspectives on integrating technology tools in teaching science subjects?

The responses gathered from the interview sessions clearly highlight various perspectives shared by teachers regarding the use of technology tools. The respondents expressed different viewpoints, particularly concerning the role of technology in science education and the benefits of integrating technology in teaching science (Almuhanna, 2024). The following section provides a detailed discussion of the key points raised by the respondents, outlining their insights and experiences with technology in the classroom.

Perceptions of Technology's Role in Science Education

Technology tools are typically seen by teachers as transformative tools that improve science instruction and student learning. Numerous participants highlighted how resources like

simulations, virtual labs, and multimedia presentations enhance student engagement and facilitate the visualization and comprehension of abstract ideas (Asare et al., 2023). Teachers emphasized that these resources, which use platforms like Google Classroom, facilitate collaborative learning, better comprehension, and critical thinking (Jumadi et al., 2021).

Additionally, participants pointed out that technology updates instructional methods to meet the needs of students who are knowledgeable about technology. For example, students can better understand complex concepts like planetary motions and chemical structures when they use interactive simulations and visual models. In general, teachers thought that using technology to enhance lessons makes them more impactful, dynamic, and engaging (Yilmaz, 2023).

Benefits of Using Technology in Teaching Science

Improved student engagement, the ability to visualize abstract ideas, and chances for interactive learning are just a few advantages that technology tools provide in science teaching (Aslamiah, 2023). Participants said that by removing the dangers associated with traditional labs, tools like virtual labs and simulations enable students to conduct experiments safely and economically. Furthermore, it was noted that gamified activities like Kahoot and quizzes were useful for sustaining student attention while reinforcing learning (Kalogiannakis et al., 2021).

Differentiated education that takes into account different learning styles is also made possible by the integration of technology. Teachers realized that, particularly for kinesthetics and visual learners, interactive resources made science more approachable and understandable (Tsirulnikov et al., 2023). These advantages highlight how valuable technology is for enhancing the educational process.

Research Question 2: What challenges do teachers encounter when implementing technology tools in science education?

In response to the second research question, participants identified several challenges in implementing technology tools in education. Their feedback highlighted key barriers that affect the seamless integration of technology into teaching and learning processes. One significant issue mentioned was insufficient resources, including a lack of modern devices, outdated software, and inconsistent internet access (Guanzon et al., 2024). Respondents also expressed concerns about the limited technical support and training opportunities, which often left teachers feeling unprepared to effectively incorporate technology into their lessons. Additionally, some teachers pointed out student-related difficulties, such as differences in digital skills and distractions caused by technology use.

Resource Limitations and Accessibility

According to Bećirović (2023), resource constraints and accessibility concerns are important barriers to using technology in science education, as schools have variable levels of access to essential tools such as devices, internet connectivity, and digital materials. Some schools may have cutting-edge technology, such as desktop computers, projectors, and smartboards, allowing for a variety of interactive and innovative teaching methods. However, many other schools, particularly those in low-income areas, suffer with obsolete or insufficient infrastructure, making it difficult for teachers to properly employ technology-based lessons.

Students in these classrooms may not have access to the digital resources needed for hands-on virtual labs, simulations, or online research, limiting their capacity to fully participate in the learning process (Scholarworks & Brackett, 2024).

Furthermore, discrepancies extend outside the classroom, since children' home settings influence their access to technology. Some students may have dependable internet access and personal gadgets at home, whereas others, particularly those from low-income families, may lack even the most basic essentials, such as a solid internet connection or computer (Valdez et al., 2021). This digital divide not only affects students' capacity to complete assignments or participate in online learning, but it can also lead to wider accomplishment discrepancies, since individuals who lack proper technology tools are at a disadvantage compared to their peers. Students without internet access, for example, may miss out on essential instructional information, struggle with schoolwork that requires online research, or have difficulty participating in remote learning events. This circumstance exacerbates educational imbalances, making students from economically disadvantaged families more likely to lag behind in their studies, especially in technology-driven courses like science.

Technical Issues and Compatibility Problems

Lesson disruptions caused by technological issues are a serious impediment to effective technology integration in the classroom, frequently causing irritation for both teachers and students (Mercader & Gairín, 2020). Poor internet access, software malfunctions, and hardware failures are common concerns that can cause lessons to be delayed, interrupted, and disrupt the flow of learning (Basar et al., 2021). For example, a poor or unreliable internet connection may hinder students from accessing online materials, participating in virtual labs, or interacting with interactive simulations, resulting in wasted instructional time as teachers attempt to troubleshoot the problem. Similarly, gadget failures or software crashes can bring lessons to a standstill, forcing teachers to devote important class time to troubleshooting technological issues rather than teaching.

The difficulties extend beyond the classroom setting, with the integration of cutting-edge equipment being hampered by obsolete technology. Many schools, particularly in poor districts, struggle to keep their devices and systems up to date, making it difficult for teachers to use the most recent instructional apps, software, and resources (Mustafa et al., 2024). Older devices may lack the processing power or memory required to run newer apps or updates, so teachers may discover that some critical tools are no longer compatible with the technology in their classrooms. Furthermore, the rapid speed of software updates might result in compatibility concerns, as new versions of apps may not function effectively on older systems. In rare circumstances, the frequent updates required to keep software running properly might result in temporary inoperability, leaving teachers without access to critical resources until their systems are updated or repaired.

According to the research (Knyazeva et al., 2022), these technical disturbances not only take instructional time, but also have an influence on student participation. When lessons are disrupted due to technical challenges, teachers struggle to maintain a consistent and dynamic learning environment. Students may lose interest or become distracted, especially if they believe the class is not proceeding smoothly owing to technology issues. Over time, these difficulties can erode faith in the technology and make teachers and students hesitant to fully

embrace digital learning tools. In this setting, while technology has the potential to improve education, its usefulness is frequently hampered by technical constraints, especially when schools lack the resources to consistently maintain or upgrade their systems.

Teacher Readiness and Training Gaps

Many teachers think that the training programs offered nowadays are sufficient for utilizing technology in the classroom. Teachers may find it difficult to use digital tools, solve technical problems, and incorporate technology into their lesson plans if they are not properly trained (Knyazeva et al., 2022). In order to handle some technical issues that may come up during lessons, teachers frequently need extra specialized training. It's possible that general training sessions won't address how to use technology tools practically or offer solutions for typical problems. Teachers who receive specialized training may feel more competent and confident when using technology in the classroom. Teachers must receive training that explains how to use digital technologies to improve student engagement, customize learning, and encourage critical thinking. Effective technology use extends beyond simple operation. Programs for professional development should emphasize real-world technological applications that complement curriculum objectives and academic requirements (Kalyani, 2024). Furthermore, just as technology is always changing, so too are the educational resources and platforms that are accessible. Continuous professional development programs are vital to keep teachers updated on the newest innovations and best practices. Teachers who receive ongoing training are better equipped to adjust to new technologies and successfully incorporate them into their lesson plans (Kaminskienė et al., 2022). Lastly, teachers should have the abilities to resolve typical technological problems that may come up during instruction. Training programs should incorporate hands-on troubleshooting sessions to equip teachers with the skills they need to minimize disruptions and find speedy solutions to issues. Furthermore, when dealing with more complicated problems, having access to trustworthy technical help is essential.

Student Engagement and Classroom Management

Classroom dynamics can be greatly impacted by students' differing levels of digital literacy. The general pace of teaching may be slowed down by the fact that some students are very proficient with technology and can rapidly pick up new tools and platforms, while others may find it difficult and need more help. The difference calls for a diversified approach to education, in which teachers must ensure that more advanced students stay engaged and challenged while offering specialized support to those who require it (Audrin & Audrin, 2022).

Additionally, there is a chance of distractions when using internet-connected gadgets in the classroom. Students may abuse these gadgets for non-academic activities like social media browsing, gaming, or viewing objectionable material, which might interfere with the classroom setting and lower output. Using efficient classroom management techniques is crucial to overcoming these obstacles. Teachers can establish specific guidelines and rules for the use of devices in the classroom, outlining the appropriate times and methods for using technology. Enforcing these guidelines consistently contributes to a courteous and concentrated learning environment (Marise, 2024). Monitoring systems can also be used to keep tabs on students' internet activities and make sure they're utilizing their gadgets responsibly. Teachers can see students' screens, block access to specific websites, and give real-time feedback using tools like classroom management software.

Research Question 3: How do teachers utilize technology tools in delivering science lessons in the classroom?

The third research question was addressed by the respondents, who highlighted several key aspects related to the use of technology tools in teaching. Teachers identified specific technological tools incorporated into their lessons, such as multimedia presentations, interactive simulations, virtual labs, and online platforms. They also shared various instructional strategies for integrating technology into their teaching practices. These strategies included using digital resources for demonstrations, facilitating group activities, promoting collaborative learning, and conducting assessments through online tools (Adil et al., 2024). Additionally, respondents emphasized the importance of maximizing available resources by creatively adapting existing tools to address limitations and enhance lesson delivery. This approach aimed to improve student engagement and learning outcomes, showcasing teachers' efforts to make the most of the technology accessible to them.

Types of Technology Tools Used

The study's participants reported using a variety of technological tools to improve science instruction and learning. In addition to offering a hands-on experience that traditional labs might not always provide, virtual labs and simulations enable students to carry out experiments and visualize difficult concepts in a safe and economical way (Godoy, 2022). Data collection devices are used to collect real-time data during experiments, which students can analyze to gain more understanding into scientific phenomena. Interactive whiteboards serve as innovative teaching aids, enabling teachers to share multimedia content, remark on-the-fly, and actively involve students in engaging lessons (Khukalenko et al., 2022). These technologies offer a more visual and interactive technique to teaching, making abstract subjects easier to learn.

Because of their gamified approach to exams and quizzes, Kahoot and Quizizz are well-liked tools for evaluations. These platforms assist teachers and students find areas for growth by offering instant feedback in addition to making exams enjoyable and interactive. These technologies' competitive component can help increase student engagement and motivation. Google Classroom and other collaborative systems facilitate resource sharing and teamwork by enabling teachers to efficiently develop, distribute, and grade assignments. Within the platform, students can easily communicate, share materials, and work together on projects. This guarantees that every student has access to the resources and assistance they require while also promoting a collaborative learning environment (Yilmaz, 2023).

Instructional Strategies for Technology Integration

Teachers employed strategies such as blended learning and flipped classrooms to integrate technology into their lessons. Online learning activities and digital materials are combined with traditional in-person instruction to create blended learning. With this method, teachers may offer individualized, adaptable training that is catered to the needs of each student. Students may attend in-person classes in a mixed learning setting, where they participate in group projects, debates, and practical experiments. Outside of the classroom, pupils can simultaneously access digital materials including interactive simulations, movies, and online tests. Students may review difficult subjects, learn at their own pace, and continue their education outside of the classroom thanks to this combination (Han, 2023).

According to the research (Baig & Yadegaridehkordi, 2023), by using video lessons, simulations, and other digital materials, students can learn new concepts at home using the flipped classroom structure, which flips the conventional teaching methodology. This makes it possible to better utilize class time for interesting activities like group projects, discussions, and practical experiments. Students who view videos and do interactive tasks at home are better equipped to apply what they have learned in class. This method promotes critical thinking and active learning in addition to increasing student involvement. During class, teachers can offer more specialized help and direction, answering certain questions and promoting greater comprehension (Setren et al., 2020).

Maximizing Available Resources

Teachers used open-source and free web resources, which offered excellent instructional materials at no extra cost, to overcome resource constraints. In order to make the most of the tools and knowledge that were available, they also partnered with other schools to exchange training materials and hardware (Ahmad1, 2024). This cooperative strategy made it possible to distribute resources more fairly and guaranteed that every student had access to the resources they needed to learn. Teachers also showed ingenuity by making use of the resources at their disposal, recycling old equipment, and introducing commonplace things into their courses (Thambirajah et al., 2022). They maximized the impact of scarce resources by focusing on intentional integration and carefully crafting lessons to guarantee that technology was used efficiently and in line with learning objectives. Teachers were able to overcome financial limitations and deliver a quality learning experience because of this creative and planned approach (Adil et al., 2024).

Implication and Recommendation

This study highlights several important implications for integrating technology into science education. To strengthen the quality of science teaching, it is crucial to enhance teachers' confidence and proficiency in using digital tools through targeted training and continuous professional development programs. Schools and educational authorities should prioritize the creation of supportive environments for technology-enhanced learning by investing in reliable internet connectivity and up-to-date technological equipment. Addressing inequities in access to digital resources is also essential to ensure fairness and minimize the technological divide among schools with varying resource capacities. Incorporating technology-based strategies such as virtual laboratories and interactive simulations can make science lessons more engaging and help students better comprehend complex scientific concepts. Furthermore, establishing efficient technical support systems will enable teachers to resolve hardware and software issues promptly, minimizing classroom disruptions and promoting consistent technology use.

To achieve these goals, several recommendations are proposed. Teachers can be better supported through specialized training programs that focus on both basic and advanced digital competencies. Additional funding should be allocated to provide essential teaching technologies, including computers, projectors, and smartboards, for all classrooms. Collaborative learning should be further encouraged through platforms such as Google Classroom and Padlet to strengthen student-teacher and peer-to-peer interaction. Schools should also assign dedicated technical support personnel to ensure immediate troubleshooting of technological problems. Teachers are encouraged to incorporate

interactive tools like Kahoot and virtual laboratories to promote active, student-centered learning experiences and sustain engagement. Finally, to ensure lesson continuity during technical disruptions, educators should prepare contingency plans such as printed materials or offline learning modules. Implementing these measures will help overcome the challenges identified in the study and foster a more inclusive, effective, and technology-driven science education environment.

Conclusion

This study investigated the perspectives and challenges of secondary school science teachers in using technology tools for teaching. It revealed that while teachers recognize the potential of technology to enhance learning by making abstract scientific concepts more engaging and accessible, several challenges hinder its effective integration. These challenges include resource limitations, inadequate technical support, lack of training, and varying levels of digital literacy among both teachers and students. Teachers emphasized the transformative role of technology in making science lessons more interactive and fostering student engagement. Tools like virtual labs, simulations, and educational games were particularly praised for enabling experiential learning in a safe and cost-effective manner. However, issues such as unreliable internet, outdated devices, and insufficient access to resources often disrupted lesson delivery, reducing the effectiveness of these tools. Moreover, the study highlighted the need for targeted professional development to bridge the gaps in teachers' digital competencies. Training programs should not only focus on basic technical skills but also equip teachers with practical strategies to integrate technology into their pedagogy effectively. In conclusion, while technology holds immense promise for enriching science education, its successful implementation requires a holistic approach. Addressing infrastructure gaps, enhancing teacher training, and fostering supportive school environments are essential to overcoming the challenges and maximizing the benefits of technology in teaching. This study underscores the importance of ongoing research and development in educational technology to create a more inclusive, engaging, and effective learning environment.

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References

Adil, H. M., Ali, S., Sultan, M., Ashiq, M., & Rafiq , M. (2024). Open education resources' benefits and challenges in the academic AAC&U. https://www.aacu.org/oer/research/open-education-resources-benefits-and-challenges-in-the-academic-world-a-systematic-review?form=MG0AV3

Ahmad1, E. (2024). Revolutionizing Learning: Leveraging Social Media Platforms For Empowering Open Educational Resources. Revolutionizing Learning: Leveraging Social Media Platforms For Empowering Open Educational Resources International Journal On E-Learning And Higher Education, 19(1). https://ir.uitm.edu.my/id/eprint/91995/1/91995.pdf Akram, H.,

Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022, June 6). Teachers' Perceptions of Technology Integration in Teaching-Learning Practices: A Systematic Review. Frontiers; Shih-Yeh Chen. https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.920317/full

Almuhanna, M. A. (2024). Teachers' Perspectives Of Integrating AI-Powered Technologies In K-12 Education For Creating Customized Learning Materials And Resources. Education And Information Technologies. https://doi.org/10.1007/s10639-024-13257-y

Alshehri, K. G. (2020). Technology Adoption and Integration at a University in Saudi Arabia: A Descriptive Study.Vtechworks.lib.vt.edu. https://vtechworks.lib.vt.edu/items/03497217-cf3d-4689-a6bf-058d2257efb6

Alshorman, S. (2024). The Readiness To Use Ai In Teaching Science: Science Teachers' Perspective. Journal Of Baltic Science Education, 23(3), 432–448. https://doi.org/10.33225/jbse/24.23.432

Aslamiah. (2023, August 6). The 21 Benefits Of Technology In Education. Upm.edu.my. https://sgs.upm.edu.my/article/the_21_benefits_of_technology_in_education-72593?form=M G0AV3

Asare, S., Amoako, S. K., Biilah, D. K., & Apraku, T. B. (2023). The Use Of Virtual Labs In Science Education: A Comparative Study Of Traditional Labs And Virtual Environments 1,.Researchgate,Vol.04(Issue11),6563–6569. https://www.researchgate.net/publication/375963374_the_use_of_virtual_labs_in_science_ed ucation_a_comparative_study_of_traditional_labs_and_virtual_environments_1

Audrin, C., & Audrin, B. (2022). Key factors in digital literacy in learning and education: a systematic literature review using text mining. Education and Information Technologies, 27. https://doi.org/10.1007/s10639-021-10832-5

Baig, M. I., & Yadegaridehkordi, E. (2023). Flipped Classroom In Higher Education: A Systematic Literature Review And Research Challenges. International Journal Of Educational Technology In Higher Education, 20(1). https://doi.org/10.1186/s41239-023-00430-5

Basar, Z. M., Mansor, A. N., Jamaludin, K. A., & Alias, B. S. (2021). The Effectiveness And Challenges Of Online Learning For Secondary School Students – A Case Study. Asian Journal Of University Education, 17(3), 119–129. https://doi.org/10.24191/ajue.v17i3.14514

Bećirović, S. (2023). Challenges and Barriers for Effective Integration of Technologies into Teaching and Learning. Digital Pedagogy, 123–133. https://doi.org/10.1007/978-981-99-0444-0_10

Bhat, R. A. (2023). The Impact Of Technology Integration On Student Learning Outcomes: A Comparative Study. International Journal Of Social Science Educational Economics Agriculture Research And Technology (IJSET), 2(9), 592–596. https://doi.org/10.54443/ijset.v2i9.218

Christina Ioanna Pappa, Georgiou, D., & Pittich, D. (2023). Technology Education in Primary schools: Addressing Teachers' perceptions, Perceived barriers, and Needs. International Journal of Technology and Design Education, 34. https://doi.org/10.1007/s10798-023-09828-8

Davis, F. D., Bagozzi, R. P., and Warshaw, P. R. . (1989). User acceptance of computer technology: A comparison of two theoretical models. Management Science, 35(8), 982-1003. Retrieved from http://www.vvenkatesh.com/it/organizations/Theoretical_Models.asp#Con=structdefs

Dinc, E. (2019). Prospective Teachers' Perceptions of Barriers to Technology Integration in Education. Contemporary Educational Technology, 10(4), 381–398. https://doi.org/10.30935/cet.634187

Dovilė Stumbrienė, Tatjana Jevsikova, & Kontvainė, V. (2023). Key factors influencing teachers' motivation to transfer technology-enabled educational innovation. Education and Information Technologies, 29. https://doi.org/10.1007/s10639-023-11891-6

Esra Kabataş Memiş, Sümeyra Zeynep Et, & Elif Sönmez. (2023). Integration Of Technology Into Science Teaching: A Phenomenological Study On The Experiences Of The Pre-Service Teachers. Science Education International, 34(3), 166–176. https://doi.org/10.33828/sei.v34.i3.1

Godoy, C. H. (2022). A Review Of Augmented Reality Apps For An AR-Based STEM Education Framework. Arxiv, 3(1). https://doi.org/10.48550/arxiv.2203.07024

Gondwe, F. (2021). Technology Professional Development For Teacher Educators: A Literature Review And Proposal For Further Research. SN Social Sciences, 1(8). Https://Doi.Org/10.1007/S43545-021-00184-9

Guanzon, R., Kilag, O. K., Longa, G., Roche, M., Bolante, R., Suba, J., & Villarete, E. (2024). Digital Landscape: Key Challenges In Educational Technology Implementation. Risejournals.Org. Https://Risejournals.Org/Index.Php/Imjrise/Article/View/742

Haarala-Muhonen, A., Myyry, L., Pyörälä, E., Kallunki, V., Anttila, H., Katajavuori, N., Kinnunen, P., & Tuononen, T. (2023, September 8). The impact of pedagogical and ICT training in teachers' approaches to online teaching and use of digital tools. Frontiers. https://www.frontiersin.org/articles/10.3389/feduc.2023.1223665/full

Han, X. (2023). Evaluating blended learning effectiveness: an empirical study from undergraduates' perspectives using structural equation modeling. Frontiers in Psychology, 14. https://doi.org/10.3389/fpsyg.2023.1059282

Handika, R. F., Agustin, M., & Jakawali, G. (2023). TPACK Component Analysis (Technology, Pedagogics, Content Knowledge) in Elementary School Teachers as a Framework for Teacher Competence in 21st-Century Learning. International Conference on Elementary Education, 5(1), 545–551. http://proceedings.upi.edu/index.php/icee/article/view/3171

Heinonen, N., Katajavuori, N., Murtonen, M., & Södervik, I. (2022). Short pedagogical training in supporting university teachers' professional vision: A comparison of prospective and current faculty teachers. Short Pedagogical Training in Supporting University Teachers' Professional Vision: A Comparison of Prospective and Current Faculty Teachers, 51(2), 201–229. https://doi.org/10.1007/s11251-022-09603-7

Johansson, S., & Myrberg, E. (2019). Teacher specialization and student perceived instructional quality: what are the relationships to student reading achievement? Educational Assessment,Evaluation and Accountability, 31(2), 177–200. https://doi.org/10.1007/s11092-019-09297-5

Jones, B. D. (2020). Motivating and Engaging Students Using Educational Technologies. Handbook of Research in Educational Communications and Technology, 9–35. https://doi.org/10.1007/978-3-030-36119-8_2

Jumadi, J., Perdana, R., Hariadi, M. H., Warsono, W., & Wahyudi, A. (2021). The Impact Of Collaborative Model Assisted By Google Classroom To Improve Students' Creative Thinking Skills. International Journal Of Evaluation And Research In Education (IJERE), 10(2), 396. https://doi.org/10.11591/ijere.v10i2.20987

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A.-I. (2021). Gamification In Science Education. A Systematic Review Of The Literature. Education Sciences, 11(1), 22. https://doi.org/10.3390/educsci11010022

Kalyani, L. K. (2024). The Role Of Technology In Education: Enhancing Learning Outcomes And 21st Century Skills. International Journal Of Scientific Research In Modern Science And Technology, 3(4), 05-10. https://doi.org/10.59828/ijsrmst.v3i4.199

Kaminskienė, L., Järvelä, S., & Lehtinen, E. (2022). How does technology challenge teacher education? International Journal of Educational Technology in Higher Education, 19(1). https://doi.org/10.1186/s41239-022-00375-1

Khukalenko, I. S., Kaplan-Rakowski, R., An, Y., & Iushina, V. D. (2022). Teachers' Perceptions Of Using Virtual Reality Technology In Classrooms: A Large-Scale Survey. Education And Information Technologies, 27. https://doi.org/10.1007/s10639-022-11061-0

Knyazeva, N., Mikhailova, I., Usmanova, N., & Shindina, T. (2022). Overcoming Barriers In Developing Digital Skills For Higher Education Teachers: Challenges And Solutions. Review OfArtificial Intelligence In Education, 3, E024–E024. https://doi.org/10.37497/rev.artif.intell.educ.v3i00.24

Mariscal, L. L., Albarracin, M. R., Mobo, F. D., & Cutillas, A. L. (2023, May 1). Pedagogical Competence Towards Technology-Driven Instruction On Basic Education. ERIC. https://eric.ed.gov/?id=ed628659

Marise. (2024, December 19). Using Technology Effectively for Classroom Management: Strategies for Teachers - LearningMole. LearningMole. https://learningmole.com/using-technology-for-classroom management/?form=MG0AV3

Mercader, C., & Gairín, J. (2020). University teachers' perception of barriers to the use of digital technologies: the importance of the academic discipline. International Journal of Educational Technology in Higher Education,17(1). https://doi.org/10.1186/s41239-020-0182-x

Mercenier, J., & Voyvoda, E. (2021). On barriers to technology adoption, appropriate technology and European integration. Review of World Economics, 157(3), 669–702. https://doi.org/10.1007/s10290-021-00412-7

Mustafa, F., Thi, H., & Xuesong (Andy) Gao. (2024). The Challenges And Solutions Of Technology Integration In Rural Schools: A Systematic Literature Review. International Journal Of Educational Research, 126, 102380–102380. https://doi.org/10.1016/j.ijer.2024.102380

Nathan, S., Newman, C., & Lancaster, K. (2019). Qualitative Interviewing. Handbook of Research Methods in Health Social Sciences, 391–410. https://doi.org/10.1007/978-981-10-5251-4_77

Ndibalema, P. (2025). Digital Literacy Gaps In Promoting 21St Century Skills Among Students In Higher Education Institutions In Sub-Saharan Africa: A Systematic Review. Cogent Education, 12(1). https://doi.org/10.1080/2331186x.2025.2452085

Neumeyer, X., Santos, Susana. C., & Moris, Michael. H. (2021, December). Overcoming Barriers to Technology Adoption When Fostering Entrepreneurship Among the Poor: The Role of Technology and Digital Literacy. Ieeexplore.ieee.org. https://ieeexplore.ieee.org/document/9102422/metrics#metrics

Nisar Ahmed Dahri, Noraffandy Yahaya, Waleed Mugahed Al-Rahmi, Almogren, A. S., & Muhammad Saleem Vighio. (2024). Investigating factors affecting teachers' training through mobile learning: Task technology fit perspective. Education and Information Technologies. https://doi.org/10.1007/s10639-023-12434-9

Ramli, & Saleh. (2019). Frogvle Application In Science Teaching In Secondary Schools In North Malaysia: Teachers' Perspective. Education Sciences, 9(4), 262. https://doi.org/10.3390/educsci9040262

Rothhaupt, M., Vogt, L., & Urbas, L. (2024). Strategies For Software And Hardware Compatibility Testing In Industrial Controllers. Processes, 12(3), 580. https://doi.org/10.3390/pr12030580

Russo, K., & Emtage, N. (2023). The Digital Divide And Higher Education. Springer Ebooks, 81–97. https://doi.org/10.1007/978-3-031-30808-6_6

Scholarworks, S., & Brackett, S. (2024). Examining Barriers To Technology Integration Practices Of K-12 Examining Barriers To Technology Integration Practices Of K-12 Teachers Teachers. https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=17147&context=dissertations

Setren, E., Greenberg, K., Moore, O., & Yankovich, M. (2020). Effects of Flipped Classroom Instruction: Evidence from a Randomized Trial. Education Finance and Policy, 16(3), 1–54. https://doi.org/10.1162/edfp_a_00314

Sevgi Aydin-Gunbatar, Kaplan, N., & Fatma Nur Akin. (2023). The Integrations of Elementary Science Teachers' Technological Pedagogical Content Knowledge Components during COVID-19: Teaching Electric Circuits and Circuit Diagrams. Research in Science Education. https://doi.org/10.1007/s11165-023-10147-0

Talib, S., Alias, B. S., & Mohd Matore, M. E. @ E. (2024). Principal Competency, Teacher Readiness, And Teacher Commitment In STEM Education Implementation: A Qualitative Study. Deleted Journal, 20(4). https://doi.org/10.17576/ebangi.2024.2104.30

Technical assistance and support in the planning of school maintenance. (2022). Unesco.org. https://www.unesco.org/en/articles/technical-assistance-and-support-planning-school-mainten ance

Teplá, M., Teplý, P., & Šmejkal, P. (2022). Influence Of 3D Models And Animations On Students In Natural Subjects. International Journal Of STEM Education, 9(1). https://doi.org/10.1186/s40594-022-00382-8

Thambirajah, V., Md Yunus, M., & Mohd Said, N. E. (2022). Improving Students' Classroom Participation Through Creative Pedagogical Strategies. Jurnal Pendidikan Malaysia , 47(1). https://doi.org/10.17576/jpen-2022-47.01si-02

Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Monés, A. M., & Ioannou, A. (2022). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. Education and Information Technologies, 28(28). https://doi.org/10.1007/s10639-022-11431-8

Tsirulnikov, D., Suart, C., Abdullah, R., Vulcu, F., & Mullarkey, C. E. (2023). Game On: Immersive Virtual Laboratory Simulation Improves Student Learning Outcomes & Motivation. FEBS Open Bio. https://doi.org/10.1002/2211-5463.13567

Tu, M. M., Nazarudin, M. N., Noordin, Z., Tawan, A., & Watinin, N. (2020). Investigating The Relationship Between Teacher Attitude, Readiness, Integrity, And School-Based Assessment. International Journal of Education, Psychology and Counseling, 5(35), 306–320. https://doi.org/10.35631/ijepc.5350026

Turgut, Y. E., & Aslan, A. (2021). Factors affecting ICT integration in TURKISH education: a systematic review. Education and Information Technologies, 26. https://doi.org/10.1007/s10639-021-10441-2

Valdez, J. P. M., Datu, J. A. D., & Chu, S. K. W. (2021). Gratitude Intervention Optimizes Effective Learning Outcomes In Filipino High School Students: A Mixed-Methods Study. Computers & Education, 176, 104268. https://doi.org/10.1016/j.compedu.2021.104268 Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four ongitudinal filed studies. Management Science, 46, 186–204. Retrieved from http://www.vvenkatesh.com/it/organizations/Theoretical_Models.asp#Con=structdefs

Wikipedia Contributors. (2024, November 21). Demographic Profile. Wikipedia; Wikimedia Foundation. Https://En.Wikipedia.Org/Wiki/Demographic_Profile

Wireless internet in lower secondary schools in Europe 2018. (2019, March). Statista. https://www.statista.com/statistics/1086016/wlan-in-primary-schools-in-europe/

Wohlfart, O., & Wagner, I. (2022). Teachers' role in digitalizing education: an umbrella review. Educational Technology Research and Development,71 https://doi.org/10.1007/s11423-022-10166-0

Worthington, A. K. (2021, May 30). Technology Acceptance Model. Pressbooks.Pub; Pressbooks. https://ua.pressbooks.pub/persuasiontheoryinaction/chapter/technology-acceptance-model

Yilmaz, O. (2023). The Role of Technology in Modern Science Education. Academia.edu. https://doi.org/109743600/thumbnails/1

Yuen, C., Gurnam, F., Sidhu, K., Teknologi, U., Uitm, M., & Alam, S. (2019). Integrating Information and Communication Technology (ICT) into University Teaching and Learning: A Case Study. https://education.uitm.edu.my/ajue/wp-content/uploads/2019/04/Integrating-Information-and- Communication-Technology-ICT-into-University-Teaching-and-Learning-A-Case-Study.pdf