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Advancing Education 4.0 Through Leveraging Digital Technologies: An Empirical Evidence from Secondary Schools in Malaysia

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Abstract

Education 4.0 is a learning approach that aligns with the Fourth Industrial Revolution and emphasizes the transformation of education by using advanced and innovative technologies. Our research aims to investigate the utilization of Education 4.0 learning technologies by secondary school teachers and identify the challenges they encounter in integrating them into the learning process. Five semi-structured interviews were performed and then analyzed using the Nvivo program. The study identified five main themes: personalized learning, digital literacy, feedback mechanisms, technology integration, and teachers' professional development. The findings suggest that Education 4.0 is enhancing the importance of educational advancement and the development of high-tech skills using digital technologies, significantly transforming the education field.

Keywords: - Educations 4.0, technology, teachers, students, secondary school

1. Introduction

Education 4.0 is an innovative approach to learning that combines advanced technology and novel teaching theories. Traditional education models are enhanced using advanced technologies such as artificial intelligence, virtual reality, and data analytics in an environment that offers greater choices for learners. This idea extends beyond the simple application of technology in the classroom to building a completely new structure for education itself. Under Education 4.0, students are no longer passive knowledge consumers (Yousef, 2021). Instead, they actively involve themselves in their learning by means of immersive and interactive experiences that are tailored to suit the individual's requirements and preferred ways. According to Mukul & Büyüközkan (2023), this is the meaning of Education 4.0 for students in secondary school today, since they need to be furnished with basic competencies and information that will help them to adapt quickly (almost on a daily basis) to changing conditions or situations presented by modern society in the new century, ultimately not just to survive but perhaps even thrive.

This generation of students can be considered as digital natives, as technology infuses every aspect of the world they were born into. Their natural ease with digital technology makes them compatible with Education 4.0 (Wajda et al., 2022). It also arms individuals with key competencies such as analytical reasoning, problem-solving, teamwork, and flexibility. All of these are central to doing well in an information-based economy. However, we must foster a creative spirit in the coming generation of innovators and changers. First, is by including emerging technology into the learning process itself, and second, through the application of online platforms and joint technology in Education 4.0 education that can be made available on an equal basis to all high quality no matter where they are located or what their socio-economic backgrounds happen to be (Bonfield et al., 2020). Through this integration, of course, secondary school students from

all backgrounds can take a full curriculum and develop an international outlook.

Aside from the global view, the exponential expansion of the Industrial Revolution (IR) 4.0 has compelled Malaysian educational institutions to completely transform the existing education system and transition into the future education system 4.0. The use of digital technology in Education 4.0 for secondary schools in Malaysia signifies a substantial shift in the educational environment, motivated by the necessity to synchronize with the Fourth Industrial Revolution (4IR). Education 4.0 prioritizes individualized and adaptable learning, utilizing digital resources to improve the learning process. The transition is driven by Malaysia's overarching national policies, such as the Malaysian Education Blueprint 2013-2025, which seeks to enhance education using digital methods, with a focus on improving access, quality, equity, and efficiency (Ministry of Education Malaysia, 2013). The Blueprint emphasizes the imperative of using ICT in education to equip students for a technologically sophisticated and knowledge-based economy. Various efforts have characterized the progress of digital technology in Malaysian secondary schools. Key improvements include the implementation of smart classrooms, e-learning platforms, and digital textbooks. The Ministry of Education has implemented the Frog Virtual Learning Environment (Frog VLE), a cloud-based educational platform that provides students and instructors access to educational resources and collaboration tools (Ramli et al., 2018). Moreover, the implementation of hybrid learning models, particularly in response to the COVID-19 epidemic, expedited the integration of digital technology into educational practices.

Recent progress has been centered around integrating more advanced technologies like artificial intelligence (AI), augmented reality (AR), and big data analytics to provide dynamic and captivating learning environments. AI-powered solutions enhance individualized learning by examining students' advancement and customizing instructional materials to suit their specific requirements (Zulkifli et al., 2020). Augmented reality (AR) and virtual reality (VR) offer immersive educational experiences that can boost students' comprehension of intricate topics, so rendering learning more participatory and pleasurable. However, there are still obstacles to overcome to fully adopt Education 4.0 on a large scale. Significant obstacles include the digital divide, limits in infrastructure, and the necessity for ongoing professional development for instructors. Measures are being taken to tackle these difficulties, such as allocating government funds towards ICT infrastructure and implementing training initiatives to improve teachers' digital skills (Latip et al., 2020).

Essentially, the continuous process of incorporating digital technology into Education 4.0 for secondary schools in Malaysia seeks to fundamentally transform the educational system. The goal is to provide a more dynamic, individualized, and effective learning environment to equip students for the challenges and possibilities that lie ahead in a quickly changing technology world. Likewise, the impact on the education paradigm has led to future education 4.0 by considering the benefits of the new vision in learning skills and knowledge trends. Students must be trained, mentored, and facilitated in a different pedagogical approach to correspond with new possibilities. Digital learning is an instructional practice in any educational activity that uses technology to improve the student's learning experience, and it uses a wide range of technology-enhanced educational strategies that ultimately help students (Moraes et al., 2023). Digital learning is not only a very advanced form of technology, but it also gives students much freedom to study whenever they want without worrying about their schedules.

Despite significant efforts and investments by the Malaysian government, various issues persist in hindering the full realization of Education 4.0. One major issue is the digital divide, where disparities in access to digital tools and the internet between urban and rural schools result in unequal learning opportunities (Norazman et al., 2019). Additionally, infrastructure limitations, such as inadequate hardware and unreliable internet connectivity, particularly in rural areas, pose significant barriers to effective digital integration (Malaysian Communications and Multimedia Commission, 2020). Furthermore, teachers' readiness and proficiency in using digital technologies also remain critical challenges. Studies indicated that teachers recognize the potential of digital tools in enhancing learning, though, they are lack of necessary skills and confidence to integrate these technologies effectively into their teaching practices (Latip et al., 2020). Continuous professional development programs are essential but often insufficient, leading to a gap between policy intentions and classroom realities. Moreover, the sudden shift to online learning during the COVID-19 pandemic exposed the vulnerabilities of the current educational system. The abrupt transition highlighted issues such as inadequate digital infrastructure, lack of digital learning resources, and the varying levels of digital literacy among students and teachers (Shaharanee et al., 2016). These challenges underscore the urgent need for a comprehensive approach to strengthen the digital ecosystem within Malaysian secondary schools.

The Malaysian Education Blueprint 2013-2025 emphasizes the importance of ICT in education but acknowledges that achieving these goals requires addressing these persistent challenges (Ministry of Education Malaysia, 2013). Furthermore, recent reports by the Malaysian Communications and Multimedia Commission (MCMC) underlined the need for substantial improvements in digital infrastructure to support education (Malaysian Communications and Multimedia Commission, 2020). Thus, the objective of this paper is twofold. The first is to examine how teachers apply Education 4.0 learning technologies in teaching and the second is to identify what difficulties they face in applying Education 4.0 learning technologies to the learning process.

2. Theoretical Perspective

Self-determination theory (SDT) is a theory of motivation that employs empirical approaches to establish its principles and then uses them to guide its classroom applications. The theory, which has been in development for four decades, states that all students, regardless of their age, gender, socio-economic status, nationality, or background, have growth tendencies (e.g., intrinsic motivation, curiosity, psychological needs) that underlie their classroom engagement and help in promoting a positive school experience (Deci & Ryan, 1985). In most educational settings, research has shown that students fall on the extroversion and independence dimensions of extrinsic motivation (Deci et al., 1999). Teachers have a controlling influence on the learning environment; therefore, this might be the reason why students' creativity decreased (Kam & Umar, 2023). While students' motivation increases with control, this study also discovered that students who reported with higher motivation levels were incredible boredom and lower levels of effort and enjoyment in-class activities. The inverse relationship between self-motivation and focus, positive effect, and perseverance was shown among students who pursued integrated and intrinsic motivation (Cheng et al., 2023). While other motivation theories highlight students' expectations, beliefs, and objectives, SDT provides students with the resources they need to thrive in the classroom (Skinner et al., 2014). SDT describes inner motivational resources that every student possesses and may be used to guide teachers in engaging, nurturing, and vitalizing these resources to enhance students' engagement during the flow of teaching (Cahyati & Saputra, 2022). According to this notion, students may lack motivation, disdain their schoolwork, and behave irresponsibly. Students' motivational resources are supported in the classroom, but students display dissatisfaction with the way they are treated (Mystkowska-Wiertelak, 2022). Thus, SDT research uncovers the conditions in the school that uplift students' motivational resources and keep them vital, as opposed to neglect, undermine, and upset them (Deci & Ryan, 1985). The combination of SDT and Education 4.0 results in a teaching approach that prioritizes the needs and interests of students as it goes beyond just incorporating technology and instead focuses on providing a whole educational experience that fosters internal motivation and the development of lifetime learning abilities.

3. Methodology

This study is based on an interpretive philosophical approach designed to explore participants' subjective experiences of Education 4.0 learning technologies in their instructions. The inductive approach allows researchers to observe, collate, and deduce information by drawing inferences from occurring patterns during an event (Hennink et al., 2020). One benefit of adopting this qualitative research approach in the present study is that it offers greater scope for unraveling subjective and knowledge-oriented choices associated with a specific lived experience (Leenen-Young & Uperesa, 2023). Previous research on this subject has focused chiefly on quantitative methods, ignoring the subtleties of human decision-making. Specifically, the requirement to provide results that include a broad spectrum of individual behaviors, emotions, and sentiments associated with teaching secondary school students further supports our inductive approach.

The participants for this study were selected via purposive sampling, they incorporated digital technology in Education 4.0 in Malaysian secondary schools (Ho et al., 2024). This method ensures the inclusion of a varied and representative sample from the target population. The participants included secondary school teachers from both urban and rural schools in Malaysia. This strategy is selected to encompass a broad perspective on the digital divide and its effects on various educational environments. The selection of teachers was based on their diverse degrees of expertise and familiarity with digital technologies, encompassing technology-savvy early adopters and those with less proficiency. The presence of many perspectives will facilitate a comprehensive comprehension of the range of difficulties and accomplishments in incorporating digital technology. Teachers' participation in the study is based on their integration in digital infrastructure and access. The research team contacted school principals to elucidate the study's aims. Consent forms were provided to ensure that participation is voluntary and to ensure confidentiality.

Five participants eventually agreed to participate in the semi-structured interviews, and each of them was interviewed using a different digital technology platform (e.g., Zoom, Skype, and Microsoft Teams). Before the interviews, each participant received an email regarding the research questions, aims of the study, and the methodological strategy. It was a helpful starting point in establishing rapport with the participants and helping them to understand this research (Farooq & De Villiers, 2017). Our method also lent itself to creating a conducive environment to open and accessible discussion during interviews. This also allowed us to better schedule the interviews, in line with researchers' and respondents' personal preferences. Thus, one-to-one participant interviews were conducted by the first and second authors, and the five participants were labeled as CK1, CK2, CK3, CK4, and CK5. The interviews lasted 30 to 45 minutes for each participant and were conducted in English.

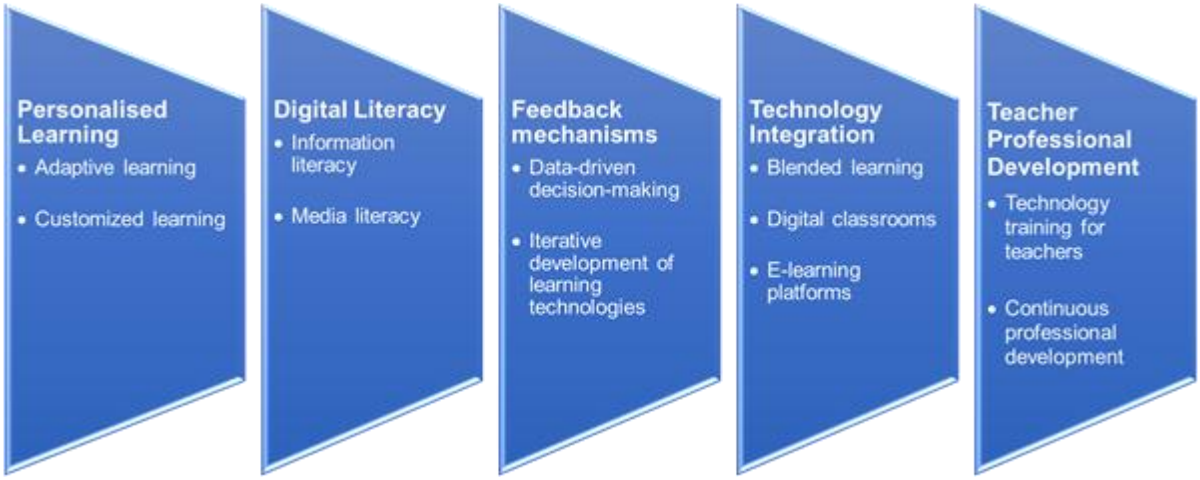

Fig. 1. Themes identified for enhancing education 4.0 learning

4. Results and Findings

The results of semi-structured interviews with five participants are presented here. Using the qualitative analysis Nvivo software, we inductively generated the categories from the data throughout the coding and analysis process. The theoretical concerns identified in the literature were also compared to the response patterns. Participants' answers are provided in the order of the detailed interview responses to each question, grouped by the thematic categories developed throughout the analysis to provide the data a degree of order. A total of five themes were identified. Fig. 1 illustrates the identified themes (i.e., personalized learning, digital literacy, feedback mechanisms, technology integration, and teachers' professional development) in enhancing Education 4.0 learning technologies for secondary school. In addition, to create a sense of order in the way the data is presented, the detailed interview responses to each question from each participant are listed in order with direct quotations to show the trends and to strengthen the interpretations of the discussion.

4.1 Personalized Learning

In view of Education 4.0, all five participants mentioned that personalized learning, mainly through integrating adaptive learning and customized learning strategies, represents a transformative force in advancing Education 4.0 learning technologies within secondary schools. Furthermore, the participants CK4 and CK2 also stressed on adaptive learning, driven by artificial intelligence and real-time data analytics, tailors educational content based on individuals' progress and needs. This dynamic adjustment makes the learning process more responsive and targeted, tailoring support to serve effectively where it matters the most. Together with adaptive learning, participant CK1 indicated that customized learning strategies are precisely what Education 4.0 needs to provide flexible resources and pathways of study to suit diverse individuals' preferences and styles in the same way proprietary systems can be adapted by integrating personal desires within an overall framework.

This approach values the individuality of each student's learning process. It empowers students and encourages them to get involved in their own education. Students can pursue content at their own pace, cover subjects that interest them in greater details than usual and receive assistance from teachers on complex topics. Combined, personalized, adaptive, and customized learning not only transforms the classroom experience but also develops important 21st-century skills such as critical thinking, problem-solving, and self-directed learning. Breaking the shackles of linear instruction by adopting these methodologies, secondary schools teachers not only recognize individual differences among students but are also teaching them how to prepare for a future in which even learning has gone digital. This integration establishes Education 4.0 as a vital, adaptive framework that allows students to succeed in an ever-changing educational environment. The following excerpts provided some insights into the selected participants:

"I understand is that the Industrial Revolution 4.0 uses a lot of AI and things related to computers. So, if we want to move towards the application of 4.0 in Education 4.0, they must master things related to ICT. So, in that sense, I think it's important and necessary". (Participant CK1)

"The whole process and methodology of learning will be updated and improved with the latest technology. It's about the benefits for teachers. Students will be more interested and will have more contact with teachers. If we look at it now, students use WhatsApp to communicate with teachers, ask about learning, ask about knowledge. So, this is a good development". (Participant CK2)

"In the internet, we see a lot of materials that students can access and more interesting and exciting learning experience. Students like gadgets and the internet. So,

when they use the Internet to find the materials to study, it becomes more effective. Besides that the technology in education is easier students can access the materials for study whenever they want at the shop or want to know something, they can just google it and get the materials they want. Technology is very helpful in personalized learning". (Participant CK3)

"Among the teachers, we are always progressive in this field of technology. Because if we want or not, we have to follow the change of time. We have to follow. We cannot just stay where we are all the time". (Participant CK4)

"Teachers are excited to teach through this thing because the students are interested in it and like it. Because when the students are interested, we are happy. When we are happy, we are really interested in knowing and want to know. But we are stuck with other subjects. We have a lot of desire to explore that. It's fun and interesting. The technology of the 4.0 platform will be continued. I agree, but we have a lot of constraints. We need to face a lot of challenges. We are also lacking in skills". (Participant CK5)

4.2 Digital Literacy

In the realm of Education 4.0, digital literacy includes information and media literacy, making Education 4.0 complete and adequate in secondary-level schools. According to participants CK2 and CK3, students are empowered through information literacy, which enables them to appraise, interpret, and employ information responsibly drawn from various digital avenues. These skills are essential in an age of plenty of information, yet one must evaluate what is true. However, participant CK3 argued that media literacy allows students to negotiate through the multicaulisin of the media messages, informing them on which types of media shape the perceptions and shape the society's narrative. Both participants CK4 and CK5 stated that these literacies strengthen education by helping students to make the best out of online data and steer clear of unreliable information.

This way, students are taught on producing information instead of merely consuming it as well as communicating effectively in multiple digital modes. Important to note, participant CK1 stressed that the multilayered approach fosters critical thinking, creative work, and responsible digital citizenship. Thus, secondary schools adopt these digital literacies because Education 4.0 needs to have a base from which it draws learners to be sensible, adaptable, and independent in future. The following excerpts provided some insights into the selected participants:

"This skill set is paramount in an era where information is abundant but discerning its reliability is crucial. Media literacy, on the other hand, empowers students to navigate the complex landscape of multimedia messages, fostering an understanding of how media shapes perceptions and influences societal narratives". (Participant CK4)

"Students learn not only to consume information but also to create and communicate effectively in diverse digital formats. This multifaceted approach nurtures critical thinking, creativity, and responsible digital citizenship". (Participant CK1)

"Education 4.0 learning technologies in secondary schools by enabling students to harness the vast potential of digital resources while navigating the pitfalls of misinformation". (Participant CK2)

"As secondary schools embrace these digital literacies, they fortify Education 4.0 with a foundation that prepares students for the challenges and opportunities of a digitally-driven world, ensuring they become discerning, adaptable, and empowered learners in the 21st century". (Participant CK5)

"Information literacy equips students with the skills to critically evaluate, analyze, and ethically use information from a multitude of digital sources". (Participant CK3)

4.3 Feedback Mechanisms

The integration of feedback mechanisms, particularly through data-driven decision-making and iterative development of learning technologies, plays a pivotal role in advancing Education 4.0 within secondary schools. According to the participants CK1, CK4 and CK5, data-driven decision-making utilizes insights gleaned from students' performance data, allowing educators to make informed choices about instructional strategies. This feedback loop ensures a targeted and responsive approach to addressing individual learning needs, optimizing the overall effectiveness of educational interventions. Furthermore CK 2 and CK3 explained that iterative development of learning technologies is a dynamic cycle in which feedback from educators, students or performance metrics leads to refinement. An iterative approach to the design of educational tools allows them to adjust continuously in response to changes within the learning environment. In this way, it can help to find strengths and weaknesses in the technologies used. Thus, there is room for ongoing improvement and development.

Meanwhile, these feedback mechanisms make up a dynamic educational environment with interventions not frozen in time but changing based on real-time data and user experiences. This adaptability means that Education 4.0 learning technologies in senior high schools stay up-to-date, receptive and on track with the changing face of education itself. To truly take advantage of the potential technology offer for education, we must create an agile system where students adopt data-driven decision making and carry it out along with iterative development. Making decisions based on data means using the information obtained from students' performance statistics to make better teaching judgments. The following excerpts provided some insights into the selected participants:

"One of the basic principles behind data-driven decision making is that student performance statistics are used to guide instructional strategies. By studying this information, teachers can make appropriate choices according to students 'learning needs". (Participant CK1)

"The iterative process of accumulated improvement, the creation of learning technology is based on feedback from educators and students as well as performance indicators. It allows for identification of strengths and weaknesses in technology". (Participant CK4 and CK5)

"These feedback mechanisms provide a dynamic educational environment that adapts to real-time data and user experiences. This flexibility, as we've discussed, is crucial for Education 4.0". (Participant CK3)

"Well, these mechanisms create a dynamic system where interventions aren't fixed but adapt in real-time based on data and user experiences. This adaptability ensures that the educational environment remains responsive to the evolving needs of students". (Participant CK2)

4.4 Technology Integration

Technology integration, specifically through the amalgamation of blended learning, digital classrooms, and e-learning platforms, stands at the forefront of enhancing Education 4.0 learning technologies within secondary schools. Blended learning, a symbiosis of traditional teaching and digital resources, fosters a diversified learning experience. It seamlessly combines face-to-face instruction with online elements, offering students flexibility in pace, place, and mode of learning. This dynamic approach accommodates diverse learning styles, promoting students' engagement and self-directed learning. According to participant CK1 and CK4, digital classrooms amplify the impact of technology by providing an immersive and interactive learning environment. The interactive whiteboards, educational apps, and collaborative tools transform traditional classrooms into hubs of technological innovation. Furthermore, real-time collaboration, multimedia resources, and instant access to information empower both educators and students, enriching the learning experience and preparing students for the digital demands of the future.

Despite this, participants CK2, CK3, and CK5 mentioned that e-learning platforms, serving as virtual classrooms, extend the boundaries of traditional education. They facilitate anytime, anywhere learning, allowing students to access resources and engage in discussions beyond the confines of the physical classroom. Such platforms also provide personalized learning paths, tests, and information. Educators can, therefore, customize instruction for each student according to his or her needs. Not only does this triumvirate of technological integration increase accessibility, but it also helps to develop 21st-century skills like digital literacy and collaborative effort. Positioning schools within the Education 4.0 framework as hubs of innovation equip students for this era's competitive edge and create an education that is just plain responsive, flexible, and engaging enough to improve educational effectiveness at all levels. The following excerpts provide some insights into the selected participants:

"Blended learning, by combining traditional teaching and digital resources, provides a diversified learning experience. It caters to various learning styles, fostering engagement and self-directed learning among students". (Participant CK1)

"Digital classrooms create an immersive and interactive learning environment. The use of interactive whiteboards, educational apps, and collaborative tools transforms traditional classrooms into centers of technological innovation". (Participant CK3 and CK5)

"e-learning platforms serve as virtual classrooms, allowing anytime, anywhere learning. Students can access resources and engage in discussions beyond the physical confines of the classroom". (Participant CK2)

"It's crucial to acknowledge both the advantages and challenges associated with technology integration. While it enhances accessibility and cultivates essential 21st-century skills, we must address concerns to ensure a balanced and effective educational landscape". (Participant CK4)

4.5 Teachers' Professional Development

Teachers' professional development, particularly through technology training and continuous learning initiatives, stands as a cornerstone in advancing Education 4.0 learning technologies within secondary schools. According to CK3, the integration of cutting-edge technologies in classrooms necessitates teachers to stay abreast of the latest developments. Technology training equips teachers with the skills to effectively leverage digital tools, enhancing their instructional methodologies and promoting interactive, student-centric learning experiences. Continuous professional development ensures that teachers remain adaptable and proficient in evolving technological landscapes. Participants CK2 and CK4 highlighted those workshops, online courses, and collaborative platforms facilitate the exchange of best practices and innovative strategies, fostering a culture of shared learning among teachers. This ongoing development empowers teachers to integrate Education 4.0 learning technologies seamlessly, ensuring they can maximize the benefits of digital tools for students' engagement and achievement.

Moreover, participants CK1 and CK5 illustrated that teachers become proficient in utilizing technology, they can tailor their teaching methodologies to cater to diverse learning styles, fostering a more inclusive and dynamic educational environment. Teachers' professional development, as a linchpin in the Education 4.0 paradigm, not only enriches the classroom experience but also ensures that students are guided by teachers who are adept

at harnessing the full potential of 21st-century learning technologies, preparing them for the challenges and opportunities of the digital age.

"Blended learning, by combining traditional teaching and digital resources, provides a diversified learning experience. It caters to various learning styles, fostering engagement and self-directed learning among students". (Participant CK3)

"Digital classrooms create an immersive and interactive learning environment. The use of interactive whiteboards, educational apps, and collaborative tools transforms traditional classrooms into centers of technological innovation". (Participant CK2 and CK4)

"It's crucial to acknowledge both the advantages and challenges associated with technology integration. While it enhances accessibility and cultivates essential 21st-century skills, we must address concerns to ensure a balanced and effective educational landscape. Thank you all for your thoughtful contributions". (Participant CK1)

"e-learning platforms serve as virtual classrooms, allowing anytime, anywhere learning. Students can access resources and engage in discussions beyond the physical confines of the classroom". (Participant CK5)

5. Discussion

The main aim of the study is to investigate the utilization of Education 4.0 learning technologies by secondary school teachers and identify the challenges they encounter in integrating them into the learning process. Overall, personalized learning, digital literacy, feedback mechanisms, technology integration, and teachers' professional development are the themes identified through interviewing the participants in the Education 4.0 learning process. Teachers from secondary schools were interviewed to investigate the utilization of Education 4.0 learning technologies.

According to the statements from participants CK1, CK2, and CK4, personalized learning does contribute to adaptive learning driven by artificial intelligence and customized learning strategies. It provides flexible resources and pathways to study and empowering students to be self-directed in their studies. This is supported by Latip et al. (2020) and Kizilkaya et al. (2021) that personalized learning embeds electronic learning (e-learning) and integration with several Artificial intelligence (AI) applications. Moreover, personalized learning will be the main content of Education that boasts adaptive learning. Learners are equipped with learning tools specific to their skills through personalized learning that makes it easy to understand complex subjects (Ulyawati & Sugito, 2022).

Next, technology development in education encourages creative approaches and digital literacy among students. Digital literacy is gaining access, understanding, and managing information through digital technologies. Digital literacy is vital in Education 4.0. According to all participants CK1, CK2, CK3, CK4, and CK5, digital literacy enables students to understand which media platform they can use to retrieve information and which media shapes information relevant to societal contexts. Besides, the participants also agreed that digital literacy empowered students through information literacy, and this skill helps them to improve their critical thinking and creativity and strengthens Education 4.0. According to C. Audrin & B. Audrin (2022), using digital tools and resources in Education 4.0 promotes digital competency through promoting information literacy, critical thinking, digital communication, and teamwork.

Besides, prior research also stated that in Education 4.0, digital literacy is crucial for students, teachers, and lifelong learners to navigate the digital world, engage with digital tools and resources, and adapt to the changing demands of the digital age (Bonfield et al., 2020). Feedback mechanisms is another theme identified from the interview with participants on data-driven decision-making, and iterative development of learning technologies. Out of standard educational models needed for Education 4.0, especially for teachers who take on the roles of teachers and access to learning facilitators are required to provide feedback on what has been learned, make recommendations, and take lessons from their students' learning (Barreiro, 2022). During the interview, participants CK1, CK4, and CK5 revealed that using the feedback mechanism is essential to their ability to take advantage of Education 4.0. Participants discussed how data-driven decision-making empowers teachers to make well-informed decisions about instructional practices based on students' performance data. In addition, they acknowledged that more effective educational interventions result from feedback mechanisms centered on each student's learning needs.

The next theme that influences teachers to utilize Education 4.0 is technology integration. The participants CK1 and CK4 brought up the idea that digital classrooms create more interactive learning. There is a technological innovation in digital classrooms that transforms traditional classrooms into better interactive learning through digital tools. The CK2, CK3, and CK5 participants mentioned that E-learning platforms, serving as virtual classrooms, allow students to assess resources and engage in discussion more actively, improve students' skills, and prepare students to face a competitive edge in the future. Integrating technology in Education 4.0 for secondary school students allows them to experience blended learning, such as face-to-face and virtual classrooms, which creates a more interactive teaching and learning process. Besides, a study stated that as a technology leader, principals play a crucial role in ensuring that technology integration for instruction is booming; the study will be beneficial to educators, particularly administrators as well (Ghavifekr & Wong, 2022). In addition, the school management is also responsible for equipping the classrooms with resources that can be utilized successfully to integrate technology into the teaching-learning process.

The final theme is teachers' professional development in utilizing Education 4.0 in secondary schools. Teachers' professional development in Education 4.0 is needed, especially in schools, because if digital tools are prepared but teachers lack knowledge in Education 4.0, the initiatives tend to fail. Therefore, teachers must be trained to operate and implement digital technologies in schools. The teachers' professional development can be conducted through training and continuous learning initiatives. The interview participants CK2, CK3, and CK4 shared that technology will help the teachers or educators master the skills to handle digital tools, enhance instructional methodology, promote interaction, provide student-centric learning experiences, and enhance students' engagement.

CK1 and CK5 mentioned that teachers become proficient in technology; they can implement diverse learning styles that give students a great experience learning from teachers who adopt the technology well. Equally, McChesney & Aldridge (2019) stated that although pre-service training gives teachers a strong foundation for improving their practice right away, in-service training enables teachers to continue growing and learning to stay current with pedagogical advancements. Teachers' professional development is commonly understood to include activities that enhance teachers' knowledge, skills, expertise, and attitudes. Besides, Boltsi et al. (2024) agreed that the foundational elements of Education 4.0, including active learning techniques, information and communication technologies, training by competencies, and infrastructure, are essential for creating innovative educational projects. The teachers' professional development will help in polishing their skills in Education 4.0 to perfectly integrate the technologies in schools.

The role of school management in teachers' professional development is pivotal in successfully integrating Education 4.0, as it involves providing the necessary support, resources, and training to equip teachers with the skills required to effectively use digital technologies in their classrooms. School management teams, including principals and management, are responsible for establishing an atmosphere favorable for ongoing learning and professional development among teachers. This entails coordinating frequent seminars, training sessions, and professional development programs targeting the most up-to-date educational technology and digital tools. The role of school management is crucial in promoting a culture of creativity and cooperation inside the school. Management fosters an environment where instructors feel encouraged and motivated to accept change by promoting innovative instructional techniques and digital technologies. This entails not just granting access to digital materials and infrastructure but also providing mentoring and peer support systems where instructors may exchange their experiences and exemplary methods.

The school management's endeavors towards Education 4.0 encompass acquiring financing and resources to improve digital infrastructure, including high-speed internet, interactive whiteboards, tablets, and other technical tools. In addition, management frequently engages in partnerships with external organizations, educational technology firms, and government entities to secure the services of skilled trainers and remain abreast of worldwide educational trends and advancements. An important responsibility of school administration is to guarantee that professional development programs are customized to meet individual requirements and are in line with the educational objectives of the school. This entails doing needs assessments to identify deficiencies in teachers' digital capabilities and developing focused training programs to rectify these areas. Management also oversees and assesses the efficiency of these initiatives, making any required modifications to guarantee ongoing enhancement. Within the framework of Education 4.0, school administration is also focusing on incorporating digital literacy into the curriculum and fostering interdisciplinary learning. Management fosters the development of students' critical thinking, problem-solving, and collaboration abilities, which are vital for the modern workforce, by promoting the utilization of digital technologies in different topics. In addition, the school's management guarantees that ethical issues and responsible utilization of technology are included into the institution's digital policies and procedures.

6. Conclusion

In conclusion, the study delved into using Education 4.0 learning technologies by secondary school teachers, shedding light on key themes such as personalized learning, digital literacy, feedback mechanisms, technology integration, and teachers' professional development. The findings reveal a positive correlation between personalized learning and adaptive learning driven by artificial intelligence, providing flexible resources and pathways for students. Additionally, digital literacy is a crucial component in Education 4.0, empowering students to critically engage with information and enhancing their creative thinking skills.

This study underscores the importance of feedback mechanisms in Education 4.0, emphasizing data-driven decision-making and teaching and learning through technology integration. Teachers, acting as facilitators and tutors, leverage feedback to tailor instructional practices to students' needs, fostering more effective educational interventions. Technology integration, particularly in digital classrooms and e-learning platforms, emerges as a transformative force, creating interactive learning environments and preparing students for a competitive future. Furthermore, the study highlights the vital role of teachers' professional development in successfully implementing Education 4.0. The findings emphasize that, despite the presence of digital tools, teachers must be adequately trained to harness the potential of these tools effectively. Continuous learning initiatives and training programs ensure educators master digital technologies, enhance instructional methodologies, and create student-centric learning experiences.

Prioritizing funding for extensive teachers' professional development programs emphasizing Education 4.0 technology should be a top priority for policymakers. These initiatives must be ongoing to ensure that teachers stay up to date on pedagogical innovations and can successfully incorporate technology into their lesson plans. Besides, schools should have access to a sufficient infrastructure, which includes support systems and technology resources, to enable the smooth integration of Education 4.0 technologies. This ensures that e-learning systems and virtual classrooms are functional and accessible. On the other hand, governments and educational institutions should collaborate to include personalized learning and digital literacy in the curriculum. This could entail using technology-enhanced instructional materials and techniques to prepare students for the digital age's demands. Continuous collaboration to build an environment that is conducive to technology integration amongst educational institutions, technology leaders, and school administration is very crucial. Through this collaborative effort, all parties involved in the educational system could integrate Education 4.0 as a comprehensive approach.

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