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RESEARCH ARTICLE

Leadership for Technology Integration in Teaching Mathematics: A Comparative Study Between Two Private Institutions

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ABSTRACT

The calling for technology integration in teaching mathematics has become louder as mathematics enables advanced understanding of concepts in other STEM subjects. However, technology integration in teaching mathematics has posed challenges for curriculum leaders and teachers. Hence, this study intended to investigate the curriculum change process involving technology integration from the principals' perspectives and their leadership approach to effective curriculum change management. The study adopted a qualitative research method. Data were collected via email interviews with two principals managing private institutions that offer the same math program for primary school students. The findings showed that Rogers' diffusion of innovation model supported the curriculum change process involving technology adoption in teaching mathematics. In addition, the principals were found to have distinct perspectives on curriculum change implementation and, hence, had adopted different leadership approaches in managing curriculum change. The findings of this study imply that future leadership development programs should focus on developing transformational leadership qualities that enhance curriculum change processes.

Contribution/Originality: This study contributes to the existing literature on curriculum change management and leadership models. The findings of this study explained how leadership affects technology integration as a curriculum change process and offered a direction for future leadership development programs focusing on developing transformational leadership qualities for better curriculum change management.

1. Introduction

The emerging educational landscape in the 21st century requires continuous improvement in curriculum to meet the changing societal needs. Globalisation, technological advancement, mobility, and the changing political and economic landscape are among the impetus for educational change. Education in the Fourth Industrial

Revolution (IR 4.0), or Education 4.0, should aim to develop graduates with the capabilities to operate under complicated and rapidly changing environments. Fullan and Scott (2014) concur that educators need "new pedagogies – powerful new learning modes steeped in real-world problem-solving." These new pedagogies suggested by Fullan and Scott (2014) are now made available with advancement in STEM education. STEM education is treated as an essential strategy for national development, and the Malaysia Ministry of Education has been working on reforming STEM education to meet the challenges and demands of a STEM-driven economy (Aspin et al., 2022). Ministry of Education Malaysia has developed a STEM education conceptual framework that clearly outlines the effort to produce qualified STEM graduates to fulfil the market's demand (Ministry of Education Malaysia, 2015).

Mathematics education needs more attention as it serves as a language for STEM education or as the enabler for the advancement of understanding concepts in other subjects (Fitzallen, 2015). While mathematics education has significant implications for STEM education in general, the mathematics curriculum needs a reform that brings teaching and learning to a whole new level. Technology integration in teaching and learning mathematics helps develop critical and scientific thinking (Das, 2019), improve analytical and problem-solving skills (Mulenga & Eickelmann, 2017, as cited in Kek & Maat, 2020), and facilitate interpretation of mathematical concepts (Ince-Muslu & Erduran, 2021). Given the significance of maths, educational leaders are expected to play essential roles in improving maths teaching. However, educational leadership is said to be complex and challenging due to the multifaceted roles played by the leaders (DeMatthews, 2014; O'Shea, 2021).

Gumus et al. (2016) asserted that educational leaders play multiple roles in leading and managing an educational institution, including monitoring, implementing, and improving curriculum, while DeMatthews (2014) described educational leaders as "*managers working with people and problems in highly complex and demanding environments*" (DeMatthews, 2014, p. 193), implying that leadership is a significant determinant for the institutional success. While there is literature on leadership and curriculum change (see Govindasamy & Mestry, 2022; Harris et al., 2020; Leong, 2022; Xiong et al., 2019), leadership and innovative teaching (see O'Shea, 2021), innovative teaching in mathematics education (see Ince-Muslu & Erduran, 2021), there are not enough studies that investigate the leader's roles in technology integration in math education.

1.1. Research Objectives

Hence, we must explore the roles a curriculum leader could play in ensuring effective technology integration in teaching mathematics to make teaching and learning effective and enable students to excel in STEM education. The research objectives of the present study included: 1) to investigate the curriculum leaders' perceptions of technology integration as part of the curriculum change in the two private education institutions; 2) to study and contrast the curriculum leadership of the two private education institutions in managing and leading the curriculum change; 3) to investigate the issues and challenges for curriculum change in the two private education institutions. Curriculum change could come in various forms, including modifications of contents, instructional practices, materials, and environments (Anderson, 2023). However, in the context of this study, only instructional practices using technology were covered. The present study's findings could enhance the leadership of implementing and managing curriculum

change involving technology, especially in teaching mathematics. In addition, students will benefit from the success of technology integration in math class, enhancing math and advancing their way to excel in STEM education.

2. Literature Review

2.1. Technology Integration in Teaching Mathematics

Technology in education is an idea far from new. It was first introduced by Finn in the 1960s under the concept of instructional technology. Since then, related concepts have been introduced, such as educational technologies, information technologies, and information and communication technologies (Ince-Muslu & Erduran, 2021). We are now in the final phase of it – Technology Integration, which is referred to the incorporation of technology and technology-based practices into all teaching and learning-related activities (Wachira & Keengwe, 2011, as cited in Ince-Muslu & Erduran, 2021). Educators and policymakers are urged to make use of technology in curriculum. As Hiefield (2023) puts it, "*Technology, when integrated seamlessly, should make teaching and learning easier to access for both teachers and students, and when it doesn't, then everyone suffers*".

Ince-Muslu and Erduran (2021) asserted that the integration of technology in math education is one of the most effective ways to facilitate students' understanding of mathematical concepts, and Kek and Maat (2020) argued that technology integration helps improve the teaching process, indicating the significance of technology in the teaching of mathematics. However, several factors affect the use of technology in math education, including teacher-driven and non-teacher-driven factors. Teacher-driven factors that influence technology integration in math education include teacher's beliefs and attitudes (Abdullah et al., 2016; Daher et al., 2018; Ince-Muslu & Erduran, 2021; Li, 2023); teachers' confidence in using technology (Abdullah et al., 2016; Ince-Muslu & Erduran, 2021), and teacher's technological, pedagogical, and content knowledge (TPACK) (Li, 2023). Non-teacher-driven factors include access to teacher training and professional development opportunities, access to resources and support required for technology integration (Abdullah et al., 2016; Das, 2019; Ince-Muslu & Erduran, 2021), and students' readiness and expectations (Ince-Muslu & Erduran, 2021).

2.2. Curriculum Change Process Guided by the Diffusion of Innovation Model

Exponential technological development in the 21st century is expected to create massive societal change (Penprase, 2018). In view of this, curriculum change is more than just a response to societal change but an inevitable process where education is expected to develop self-driven and self-organising learners who are capable and competent even under highly uncertain conditions (Fullan & Scott, 2014; Law, 2022; Penprase, 2018). Penprase (2018) pointed out that continuous evolution of curriculum is required to efficiently prepare future knowledge workers who can spearhead the development of an ever-more sophisticated interdisciplinary curriculum, especially in STEM education. Scholars argue that curriculum change is a colossal process which involves various stakeholders and requires continuous evaluation (DeMatthews, 2014; Endeley & Zama, 2021; Law, 2022).

Implemented curriculum is not the end of the curriculum process. In fact, it is part of the curriculum change process, as argued by Endeley and Zama (2021), who believe that

both processes are highly interwoven. Curriculum change is more than a change in the instructional process because curriculum change comes in various forms, including addition or deletion of the content, a modified pedagogical process, changed instructional design, differentiated learning modalities, instructional tools, and environments (Anderson, 2023; Endeley & Zama, 2021). Thus, technology integration in teaching mathematics requires more than just a change in the content of the curriculum. Using technology in mathematics teaching requires curriculum developers to consider many factors, including teacher-driven and non-teacher-driven factors (Ince-Muslu & Erduran, 2021). Rogers' Diffusion of Innovation theory offers an explanation of the teacher-driven factors in adoption decisions and is the most appropriate theory for investigating the adoption of technology in an educational environment (Azman et al., 2021). Rogers (2003, as cited in Sahin, 2006) argues that the rate of adoption of innovations is affected by the characteristics perceived by the individuals, not by what change agents or experts say about it. He defines the rate of adoption as the relative speed with an individual's adoption of the innovation (Roger, 2003, as cited in Drape et al., 2013), and innovation decision is made by members throughout the diffusion process, which refers to the process of communication about the innovation within the social system.

There are four main elements in the Diffusion of Innovations model, namely: 1) *innovation*, which refers to the idea, practice or project that is treated as a novel by an individual; 2) *communication channel*, which refers to a medium that allows participants create and share information to reach a mutual understanding; mass media and interpersonal communication are two communication channels in the Diffusion of Innovation model; 3) *time*, which is referred to as the duration of innovation-decision made by the individual to either adopt or not adopt the innovation; and 4) *social system*, which is referred to the interrelated units that are engaged in joint problem solving to attain a common goal (Rogers, 2003, as cited in Drape et al., 2013). Drape et al. (2013) quoted Roger's definition of innovation-adoption as:

the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to formatting an attitude toward the innovation, to a decision to adopt of reject, to implementation of the new idea and to confirmation of this decision. (Drape et al., 2013, p. 24)

The innovation-decision process, according to the model, is an information-seeking and information-processing activity to determine the innovation adoption's advantages and disadvantages, and the process involves five stages: 1) knowledge, 2) persuasion, 3) decision, 5) confirmation, and are usually happened in sequence. In the *knowledge stage*, individuals are aware of the existence of the innovation (awareness-knowledge), seek information about the operation of the innovation (how-to-knowledge), and understand why the innovation works (principles-knowledge). Individuals are exposed to innovative ideas, which will bring them into the *persuasion stage***,** where they will continue to seek more information about the innovation and develop a favourable or unfavourable attitude towards it. This attitude will influence the *decision stage***,** where the individuals decide to adopt or reject the innovation. Individuals will actively communicate within the social system, which might provide more information and contribute to discontinuance decisions even if they adopted the innovation earlier. The *implementation stage* is where the innovation is put into practice, but the decision can still be refutable if there is no effort to reduce uncertainty about the consequences. The final stage is the *confirmation stage*, where individuals seek support for their adoption

decisions, which can be reversed if conflicting messages about the innovation become visible (Rogers, 2003, as cited in Sahin, 2006).

According to Rogers (2003 as cited in Azman et al., 2021), the innovation-decision process is highly influenced by the attributes of innovations, namely:1) *Relative Advantage* refers to the degree to which a person perceives the adopted innovation outperforms the existing one (Azman et al., 2021); 2) *Compatibility*, refers to "the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters," (Rogers, 2003, as cited in Drape et al., 2013, p. 24); 3) *Complexity*, refers to "the degree to which an innovation is perceived as relatively difficult to understand and use," (Roger, 2003, as cited in Drape et al., 2013, p. 25); 4) *Trialability* is referred to "the degree to which an innovation may be experimented with on a limited basis" (Rogers, 2003, as cited in Drape et al., 2013, p. 25); 5) *Observability*, "the degree to which the results of an innovation are visible to others" (Rogers, 2003, as cited in Drape et al., 2013, p. 25).

Technology integration in education is found to be significantly influenced by teachers' perceptions of the technology used. They must perceive that the innovation to be integrated into their classrooms has a relative advantage to their teaching practices, is compatible with existing practices and values, is relatively easy to implement, can be tried before adoption, and offers visible results for usage (Azman et al., 2021; Drape et al., 2013). Curriculum change involving technology is a complicated and colossal process that requires leadership to ensure the changes are implemented successfully for the maximum benefit of all educational stakeholders, including the teachers and students. DeMatthews (2014) describes the curriculum change process in five steps highlighting the role of leaders, including 1) creating a well-developed plan with key stakeholders; 2) identify the right experts for the change process; 3) build consensus around the rationale of change; 4) manage change through guiding stakeholders; 5) make changes sustainable by fostering a culture of change. DeMatthews' (2014) five steps in managing curriculum change emphasised the roles of educational leaders in curriculum change.

2.3. Leadership in Curriculum Change

Leadership is defined as "*a person's ability to move others to want to do activities in accordance with what they are ordered*" (Prestiadi et al., 2020, p. 122). Educational leadership can be viewed as an individual's ability to direct others to carry out activities to achieve educational goals. DeMatthews (2014) posits that curriculum leadership comprises a significant portion of managerial and administrative work, and he proposed a five-step curriculum renewal process based on three prominent educational leadership theories: instructional, distributed, and social justice leadership. The first step in curriculum change, according to DeMatthews (2014), involves principals becoming the instructional leaders that bring a diverse group of stakeholders together who might have little or no ideas about what needs to change. The second step requires strategic and thoughtful distributed leadership from the leaders who put the right persons with the necessary skills and expertise into the position. The leaders must keep the communication channel open and keep the team focused on the area, scope, and scale of reform. Next, leaders are expected to build consensus among stakeholders on the school initiatives and foster a culture of collaboration and openness for meaningful engagement in the long term.

Prestiadi et al. (2020) highlighted the role of educational leaders in implementing digital learning, enabling teachers and learners to move towards digital learning in the Education 4.0 era. Prestiadi et al. (2020) believe that leaders in the modern educational landscape are essential in creating a teaching and learning system through technology and smart learning approaches. Transformational leadership is a model that emphasises the commitment and capacity of the organisation's members, which explains curriculum leadership. Transformational leadership was introduced in 1985 by Bass, who described transformational leadership as a process where the leader becomes the source of inspiration in boosting followers' confidence and expanding their interests (Brown et al., 2019; Holst, 2021). Transformational leadership has four sub-dimensions, including idealised influence, inspirational motivation, intellectual stimulation, and individualised consideration. According to Bass (1999), *idealised influence* and *inspirational motivation* are displayed when the leader "envisions a desirable future, articulates how it can be reached, sets an example to be followed, sets high standards of performance, and shows determination and confidence" (Bass, 1999, p. 11). *Intellectual stimulation* is displayed when the leader facilitates innovative and creative thoughts in followers. Lastly, *individualised consideration* is displayed when leaders pay attention to the developmental needs of followers and provide support for their development through the delegation of tasks as opportunities for growth.

Transformational leaders are needed in Education 4.0 to transform the "*work climate and adjust the development of science and technology for the advancement of the educational institutions*" (Prestiadi et al., 2020, p.123). The four dimensions of transformational leaders are the key to effective curriculum change implementation, working alongside the Diffusion of Innovation model, explained in the conceptual framework of the present study.

2.4. Conceptual Framework

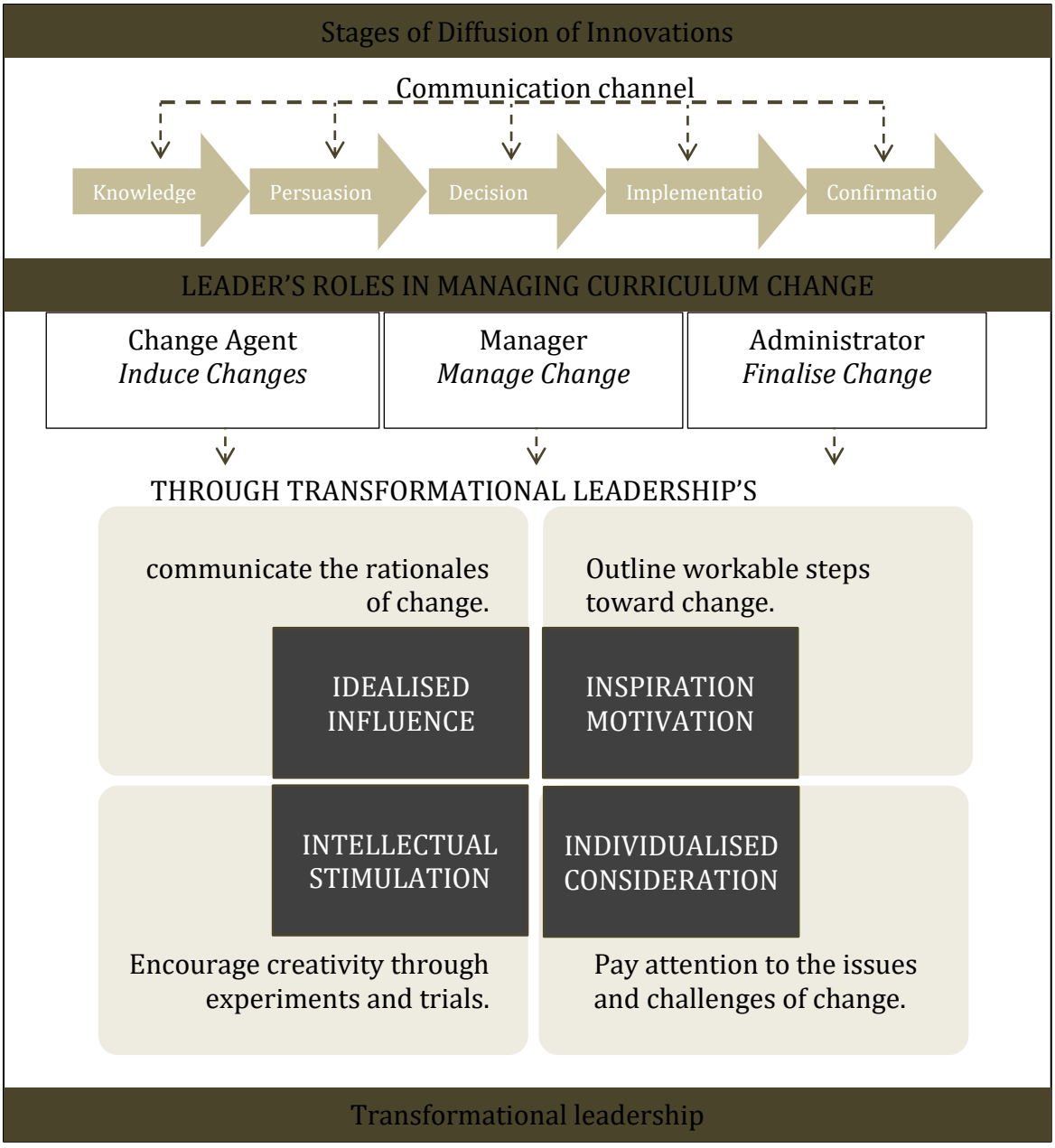
Educational leaders are expected to lead changes in the era of Education 4.0 by becoming change agents who "*catalysed change using innovative ideas and visions of future possibilities*" (Soh & Mohammad, 2021, p.238). Innovative mathematics teaching through technology integration requires leaders to lead and motivate various stakeholders towards change and move from traditional chalk-and-talk teaching practices to facilitate students learning math concepts using various technologies. Rogers' Diffusion of Innovations model and Bass's transformational leadership theory offer an opportunity to manage curriculum change effectively. See Figure 1 for the conceptual framework for the study.

Curriculum leaders play multiple roles in managing and leading curriculum change. Throughout the curriculum change process, leaders are expected to play three roles, namely: 1) *Change Agent,* who induces necessary changes that improve the curriculum; 2) *Manager*, who manages the change process by guiding followers into adopting the changes; 3) *Administrator*, who provides necessary support to bring changes into part of the routine and finalise all changes.

According to the Diffusion of Innovation model, change starts with the individuals learning about the existence of innovation and obtaining information related to it (*knowledge*). In the following step, individuals form negative or positive attitudes toward the innovation (*persuasion*). At these two stages, leaders are expected to display *idealised influence* by first communicating the rationales of change by explaining the

innovation's five characteristics: 1) *relative advantage* – how is teaching with current innovation better? 2) *compatibility* – how does teaching with the current innovation improve teaching? 3) *complexity* – how is teaching with the current innovation challenging? 4) *trialability* – how can teachers experiment and try the current technology? 5) *Observability* – how can the outcomes of using the innovation in teaching be visible to the parents and students? Leaders display *inspiration motivation* by outlining the workable steps to implement the technology in teaching and provide technical training.

Figure 1: Conceptual framework



Leaders also inspire teachers to commit to continuous improvement through professional development courses. Individuals can adopt or reject the innovation in the decision stage of Diffusion of Innovation. In the context of this study, where the curriculum change is implemented in a top-down direction, teachers could not reject the decision. However, change can be implemented with positive results if the teachers hold favourable attitudes toward technology integration in teaching. Leaders play an

essential role in guiding teachers to make favourable decisions by displaying *intellectual stimulation* where leaders encourage creativity in using the technology through experiments and trials, providing information that supports the *implementation* stage. Besides, leaders also play the role of mediator between teachers (who use technology in teaching) and policymakers (who decide what and how to use the technology) in getting feedback from teachers and channelling the information to continuous improvement of the practices. Lastly, in the *confirmation* stage, individuals seek support for the innovation-decision they made earlier. In this study, the confirmation stage refers to teachers routinely using the technology in their classrooms, making it part of their teaching practices. Leaders must display *individualised consideration,* continuously pay attention to issues and challenges in using the technology, and act swiftly to teachers' issues and concerns to finalise change.

3. Research Methods

The research design for this study was a qualitative approach to investigate leaders' perceptions of technology integration in teaching mathematics in private institutions and to compare the leadership approaches of the two leaders in managing curriculum change. In answering the research questions, the curriculum change management of the two private institutions was investigated based on Rogers' Diffusion of Innovations model and the leadership approaches of the curriculum leaders in managing curriculum change are being investigated based on transformational leadership theory.

In the present study, the researcher applied a purposive sampling method to select two participants. Both participants are franchise business owners who play the roles of principals in the institutions located in Ipoh, Perak. The researcher selected the two participants based on their years of experience in the franchised business, particularly their unique experience in facing the implementation of curriculum change. In addition, both participants play the role of curriculum leaders who manage the technology integration process, which enables them to offer valuable insight into curriculum leadership and issues and challenges in managing curriculum change.

For qualitative research, it is typical to study a few individuals or a few cases because "the overall ability of a researcher to provide an in-depth picture diminishes with the addition of each new individual or site" (Creswell & Guetterman, 2019, p.243). Two principals of the private educational institutions were selected as the participants for the present study as it allows "sufficient in-depth engagement with each individual case but also allows a detailed examination of similarity and difference, convergence and divergence" (Smith & Osborn, 2018, p. 57). The two institutions were labelled as Institution A (IA) and Institution B (IB), and the two participants were labelled as Participant 1 (P1) and Participant 2 (P2). IA and IB are in Ipoh, Perak, and both P1 and P2 are female principals. P1 has eight years of teaching experience and six years of leadership experience; P2, on the other hand, has been teaching for fourteen years and has ten years of leadership experience.

The researcher applied document analysis, including the institution's policy on technology integration, user manuals, and samples of the teaching plan of the digital learning and training materials, to gain an overview of the technology integration process in the institutions. Semi-structured interviews were conducted to collect data from principals to investigate their perceptions of technology integration, their leadership approach to implementing curriculum change, and the issues and challenges

in managing curriculum change. The researcher employed email interviews, a contemporary data collection method, to collect data for this qualitative study. Data collected through electronic methods enable the researcher to obtain responses from selected participants in "*well-written, rich and informative accounts*" (Dahlin, 2021, p. 2). The interview aimed to collect information about incidents that happened four years ago, requiring the participants to recall carefully before responding. Thus, an email interview is an asynchronous data collection method that allows participants to reflect on the questions and will "*give them a better chance of owning their narratives*" (Dahlin, 2021, p. 2).

The collected data was analysed through document analysis and thematic analysis. According to Patton (2015, as cited in Morgan, 2021), any document containing text is a potential source for qualitative analysis. The researchers analysed the institution's documents, including DC sample materials, user manuals, and training materials, to gain a comprehensive understanding of the curriculum change in both institutions.

Next, the researcher conducted a thematic analysis of the data collected through email interviews. Thematic analysis allows the researcher to identify, analyse and interpret patterns of meaning or themes within qualitative data (Clarke & Braun, 2015). There are six phases of thematic analysis, according to Clarke and Braun (2015), including 1) getting familiarised with the data; 2) generating initial codes; 3) searching for themes; 4) reviewing potential themes; 5) defining and naming themes; 6) producing the report.

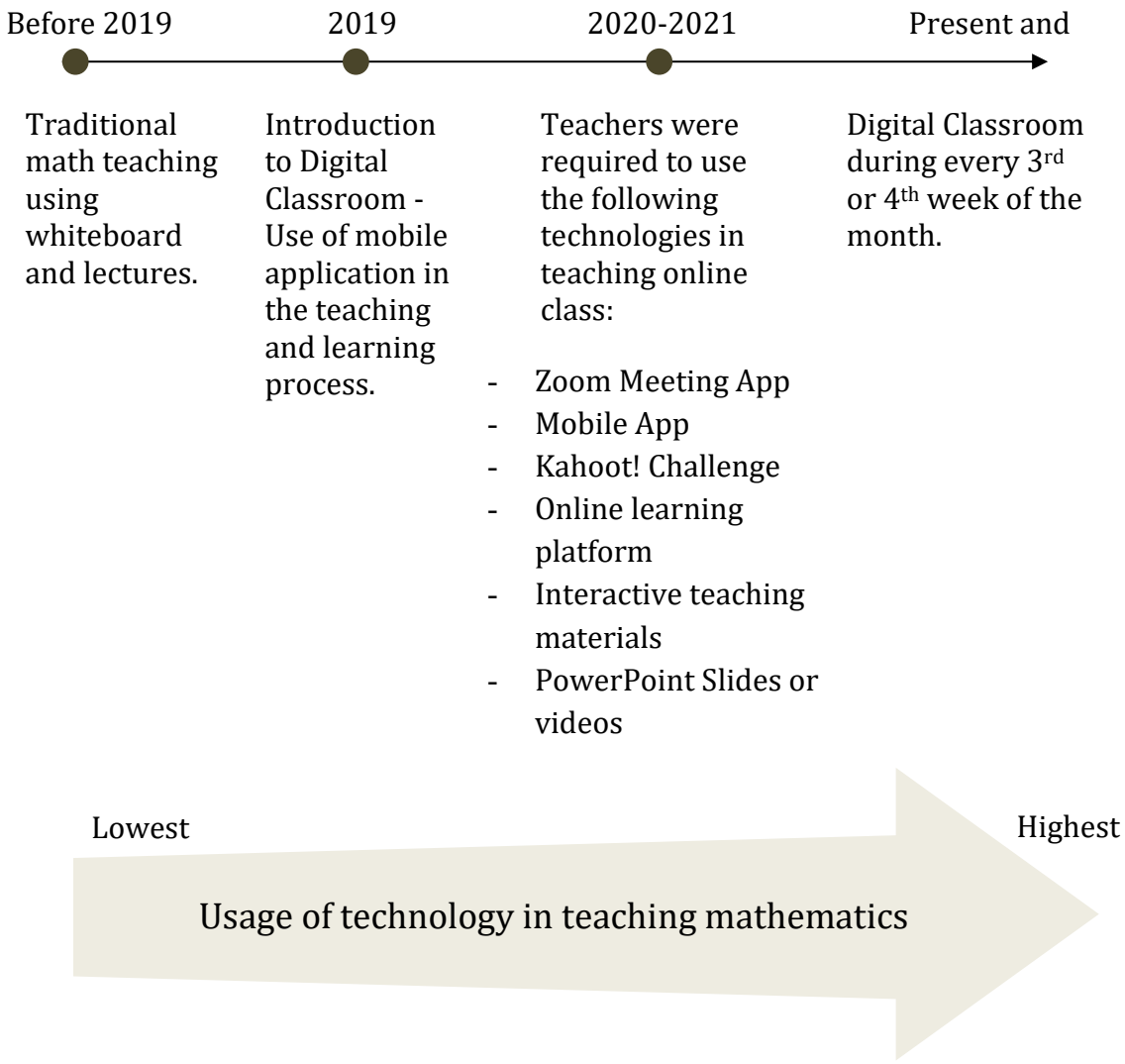
The researcher collected data from multiple sources as an approach to mitigate bias, also known as triangulation, which can enhance the reliability of the present study and saturate the data (Fusch et al., 2018). The researchers collected documents related to technology integration in institutions to learn about the curriculum change process from an objective perspective and provide data for an in-depth understanding of the curriculum change in institutions.

4. Results

4.1. Details of Curriculum Change in the Institutions

Institutions A and B integrated technology as part of the curriculum as directed by the franchise company since 2019. The franchise company invested in developing more digital teaching and learning tools, including mobile applications, videos, online learning platforms, interactive learning materials, and an online feedback system during the pandemic outbreak. These digital teaching tools are termed "Digital Classroom" (DC, hereafter). The franchise company initiated the implementation of DC to integrate technology into innovative math teaching. It is a top-down implementation where the company decides on the content and the instructional design. The company developed the policy, the user manual, and teacher training materials for implementing DC. The teachers are required to use digital tools in teaching, such as playing videos when introducing math concepts, applying interactive learning materials in the teaching process to enhance students' understanding, and using the online learning platform so students can practice on their own and get feedback instantly. See Figure 2 for the implementation process.

Figure 2: Timeline of the development of DC



4.2. Curriculum Change Processes

Institutions A and B were teaching math programs using traditional instructional practices, which mainly focused on the teacher as the source of knowledge before implementing DC. After the pandemic, the institutions were instructed to use digital tools in teaching mathematics. The curriculum change process in the institutions can be described through the Diffusion of Innovation model, focusing on technology integration as curriculum change, which includes five stages (knowledge, persuasion, decision, implementation, and confirmation).

4.2.1. Knowledge stage

According to the Diffusion of Innovation model, one's decision to adopt an innovation starts with the knowledge stage, which "commences when the individual (or other decision-making unit) is exposed to the innovation's existence and gains some understanding of how it functions (Rogers, 1983, p.164). In the present study, P1, the principal of IA, possesses superficial knowledge about the technology available in her institution that could enhance teaching practices. In contrast, P2 from IB possess in-depth knowledge that contributed to her favourable innovation decision. When asked about the type of digital tools available in the institutions that teachers could use to

enhance learning, P1 briefly described it as "LCD screen and computer for digital activities," On the other hand, P2 made a complete list of both software and hardware that make up the digital tools for effective math teaching. At the end of her list, P2 clearly outlined the need for teacher's understanding of the objectives of technology integration:

> *"Teacher must understand that the DC activities are to engage students, so they pay attention to the learning content. Students feel fun in learning and will take the initiative to learn. Students can be trained in speed calculation through the challenge and online exercises."* (P2)

The innovation-decision process is a process of information-seeking and information-processing, which will reduce an individual's uncertainty about the advantages and disadvantages of the innovation. P2 possesses in-depth knowledge about the curriculum change involving technology, which enabled her to move to the persuasion stage with a more positive attitude, compared to P1, towards the curriculum change. However, as Rogers (2003, as cited in Sahin, 2006) posits, knowing about innovation does not mean the person will adopt the innovation. However, the attitude towards the innovation will determine innovation adoption, leading to the model's persuasion stage.

4.2.2. Persuasion stage

At the model's persuasion stage, individuals seeking information about the innovations and communicating with others in the social system form favourable or unfavourable attitudes toward the innovation adoption (Rogers, 2003, as cited in Sahin, 2006). At this stage, individuals will form an opinion towards the curriculum change, that is, technology integration. When being asked about their overall experience in the implementation of DC in their institutions, participants provide different responses that reflect their attitudes towards the technology:

> *"As a senior teacher, it is a challenge for me to use technology in the classroom. Due to some reasons, I have no choice but to overcome obstacles."* (P1)

> *"By using the technology of teaching, it will ease teacher's work in marking and monitoring the student's progress"* (P2)

From their responses, it was evident that P2 has a favourable attitude towards the curriculum change compared to P1, and their attitudes will influence their teachers in forming their attitudes towards the use of technology. At this stage, individuals will continue to seek innovation-evaluation information, whose purpose is to reduce uncertainties about an innovation's expected consequences.

4.2.3. Decision stage

At the decision stage, an individual chooses to adopt or reject the innovation. Rogers (2003, as cited in Sahin, 2006) defined adoption as full use of the innovation as the best option available and rejection as not using the innovation at all. In the present study, integrating technology as curriculum change is a top-down implementation that neither of the participants could opt for rejection. However, there was a difference between the two participants in their decision to either fully adopt or only partially comply with the

curriculum change. Here are their responses when being asked about how to handle teachers' refusal to use digital tools in teaching:

> *"… they are not welcoming the implementation of DC due to mixed-levels and -age in the classroom, so I have not force them into using those technology"* (P1)

> *"… we start small, do the minimum first, try and experiment first."* (P2)

P1 has contradictory thoughts on the curriculum change. She believes that technology integration can enhance teaching. However, once she tried DC but saw the problems arising from the mixed-age class structure, she rejected the adoption, or in Rogers (2003, as cited in Sahin, 2006) terms, she experienced active rejection. On the contrary, P2 has a positive or favourable attitude towards implementing DC, then she can put the curriculum change into practice.

4.2.4. Implementation stage

At the implementation stage, the innovation is put into the routine. For the present study, it was the stage where the DC became a part of the planned curriculum. When asked about how they implemented the curriculum change, the participants gave their accounts differently:

> *"I tell them about how technology is useful, like when classes are disrupted because of weather conditions, health problems, transportation issues and etc., we can continue with teaching and learning without interruption. Students can continue to learn math using the mobile app, or online practice platform that can mark their work instantly."* (P1)

> *"I tell them about how it can help teachers in enhancing teaching and give better results. I show them how easy it was to use the technology, and yes, at first, everything seems to be a chaos… everything we plan seems to be off the track. But eventually, we managed and we put together a good system for digital learning."* (P2)

As suggested by Rogers (1983), reinvention often happens at the implementation stage, which refers to "*the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation*" (Rogers, 1983, p. 175). In fact, the implementation stage of the curriculum change happened more than once in Institutions A and B, as shown in the timeline of implementation (see Figure 2); the first implementation stage is when the franchise company introduced the use of a mobile application, then reinvention happened during the pandemic where more digital tools are being developed and introduced in the curriculum, and final implementation is enforced after the pandemic where all classes reverted to physical class with DC as part of the curriculum that teachers are required to use.

4.2.5. Confirmation stage

The confirmation stage is where the individual seeks support for her decision. Rogers (2003, as cited in Sahin, 2006) believes that the information individuals seek at this stage will support her continued adoption of the innovation, or she may reverse this

decision if there is conflicting information. In the present study, curriculum change is a top-down policy that principals must implement, but the individual's innovation decisions determine the effectiveness of the implementation. P1 shows active rejection as she discovers the conflict between class structure and DC content. Her response when being asked about the support from FC for successful implementation has shown that she has yet to acquire enough information and knowledge on using the technology effectively:

> *"I need more technical training and assistance, and their support in managing class schedules."* (P1)

In addition, she believes that her teachers required more information and help in matching DC content with mixed-age class structure; her responses when asked about the support she can provide for her teachers in the curriculum change implementation:

> *"I will need to first help them settle the issues with class schedules… we have to play different videos or conduct different activities… require much longer time for DC than the teaching plan suggests."* (P1)

On the contrary, P2 understands the implementation of curriculum change as a process and requires reinvention from time to time. She suggests that FC provides more variety in digital content and emphasises collaboration with the franchise company to improve the content. Added to that, she understands that she played an essential role in managing the change process:

> *"We will provide continuous training to teachers. If teachers cannot master the tools, provide training and videos to them. If there is new content, share and explain it to the teachers."* (P2)

In the curriculum change process, both curriculum leaders have gone through the five stages of Diffusion of Innovation, but to different degrees and, hence, different outcomes in implementation. P1, who obtained less information about how to use technology in teaching mathematics, developed a less favourable attitude, which influenced her and her teachers' decision to adopt innovation. This less favourable attitude contributed to the partial implementation of DC; as described by P1, she has not forced them into using digital tools as instructed. She continued to seek information about the benefits of using technology. She was aware of her need for technical training and support from the franchise company, which might help her in the implementation. P2, on the contrary, possesses adequate knowledge about the technology, how to use it, and the rationale of technology integration in her institution, leading to a favourable attitude and adoption decision. Her implementation of curriculum changes also, not surprisingly, faced challenges. However, with sufficient technical knowledge and a positive belief in teaching with technology, she managed to lead the change effectively. She could finalise the change and make technology an integral part of her institution by using incentives and recognising teachers who successfully use technology in teaching mathematics.

4.3. Curriculum Leaders' Roles in Managing Curriculum Change

Curriculum leaders are expected to play three roles in managing curriculum change, namely, 1) Change Agent, who induces necessary changes that improve the institution; 2) Manager, who manages the change process by guiding followers into adopting the

changes; 3) Administrator, who provides necessary support to bring changes into part of the routine and finalise all changes. The transformational leadership approach can help curriculum leaders manage curriculum change more effectively by influencing and inspiring followers to embrace change.

4.3.1. Curriculum Leaders as Managers

Curriculum leaders must communicate the five innovation attributes: *relative advantage, compatibility*, *complexity, trialability,* and *observability*. The participants' responses will be discussed in the following part.

Here are the responses of both participants in their attempts to articulate the relative advantage of DC in teaching math:

> *"I strongly believe that DC has both pros and cons. I will encourage them to use technology accordingly, after all, we are now in the digital age. Most developments are related to technology, and students will engage in their learning."* (P1)

> *"I talk to them about the importance of keeping up with the game. Our competitors are using technology, schools are having smart whiteboard, kids love learning using devices, and there is no reason for us to stay back with chalk-and-talk"* (P2)

Although both participants reported communicating the relative advantages of using technology in math class, they are doing so at a different level. P1 gives a general description of the benefit of using technology as we are now in the digital age, which teachers might be unable to resonate with. On the contrary, P2 gives concrete examples, including competitors, schools, and even learners who used technology, which teachers could easily visualise and resonate with.

The second attribute that influences an individual's innovation decision is compatibility. P2 has succinctly described the compatibility of DC in her institution, which increased their competitiveness by doing the same thing schools and competitors were doing – integrating technology into their teaching practices. P1, on the contrary, believes that technology could help in teaching but is uncertain about how it could add value to her institution. Both P1 and P2 responded to the question about how DC can work with existing instructional practices in improving students' learning as follows:

> *"I am not good at using technology, so I can't really see its value. But like I said before, technology is something we can't avoid, and it must have its pros and cons." (P1)*

> *"We talked about it. I mentioned to them that technology can save us time from marking student's work, presenting math concepts in a more engaging way, and provide interactive games for students."* (P2)

The third attribute that will influence one's adoption of innovation is complexity. Both participants of this study perceived the technology the franchise company proposed as difficult and complex. P1 pointed out that the implementation process "is daunting", and

the digital contents are against the class structure. When asked why she thinks digital activities are time-consuming:

> *"Our class is in mixed-age structure, so students were learning at different progress, and sometimes, there will be different groups of students in one class, and they have to take-turn in Kahoot! Challenge, so we ended up doing it for too long without actually getting something out of it."* (P1)

P2 understands the complex nature of curriculum change involving technology integration by calling the initial process "chaos!" and she describes the complexity as a result of teachers' lack of technological knowledge, such as losing passwords, being unable to access the software's backend, and used the wrong digital content in teaching. However, she managed to communicate the idea that the complexity of technology is temporary and solve the issue:

> *"We managed and we put together a good system for digital learning. Now teachers are better technology users, because I told them it's okay to fail at first, let's experiment with it, and tell the trainer what we still need, what we still lack, and the trainer will provide support."* (P2)

According to the Diffusion of Innovation model, when the innovation offers an individual more opportunity to try the digital tools, it will increase the possibility of adoption. In the present study, P2 had consistently told her teachers that they could and should experiment with the digital tools available in DC. She responded multiple times, "Let's experiment with it", "Trial-and-error tactic is helpful", and "Try and experiment first". P1, on the contrary, does not invite teachers to experiment with digital tools and overly emphasises issues and problems with technology integration, including Internet connectivity, the digital divide, and teachers' lack of technical knowledge in operating digital tools.

Observability is the fifth attribute of innovations. P2 has better articulated the observability of DC implementation with more details, which will likely motivate her teachers to develop positive attitudes towards DC implementation.

> *"I talk to them, a lot. Like when meeting them in the pantry, or when we are having recess, even during the weekly briefing. I talk to them about the importance of keeping up with the game. Our competitors are using technology, schools are having smart whiteboard, kids love learning using devices, and there is no reason for us to stay back with chalk-and-talk. And I invite them to my class when I am having DC session and I show them how happy my students were, how engaging they were solving problems on devices where they can compete with each other, compared to when they have to work alone on their books. So they see it, they see the value of DC by themselves."* (P2)

In contrast to P2, P1 briefly described the benefits of using technology in teaching math, and she held contradictory thoughts about the curriculum change. On one side, she sees the inevitable implementation of technology in teaching; on the other, she lacks the motivation to learn to use the technology by referring to her seniority as an obstacle, "*As a senior teacher, it is a challenge for me to use technology in the classroom*".

P2 played the role of Change Agent effectively through articulating clearly the five characteristics of innovation, namely 1) relative advantage of DC; 2) compatibility of DC with institutional practices; 3) complexity of implementation, which can be reduced through training and learning; 4) trialability which encourage teachers' involvement in reinvention of the curriculum; 5) observability where leader make the benefits of DC implementation visible to all teachers. In addition, P2 mentioned that she gives incentives to teachers who successfully adopt technology in teaching classes, which Drape et al. (2013) believe would increase the degree of relative advantage.

4.3.2. Curriculum Leaders as Managers

Curriculum leaders are expected to play the role of manager in managing curriculum change, which includes making plans and decisions related to the curriculum change. P2 showed her ability to engage in future planning, where she made a purchasing plan for digital devices to implement DC in her institution. Both participants were aware of the issues and challenges in the curriculum change implementation, which will affect their decision in adoption. Their responses when being asked about the issues and challenges in implementing DC:

> *"I think before implementation, we need to bring together all stakeholders (including educators, management, parents and students) to plan the implementation, seek support and guidance in the process… Some parents faced problems with devices, they can't afford an extra device for children… students are young and immature, we are sceptical about using technology on them…"* (P1)

> *"… we invested in some devices like tablets for students to use in class… it is kind of hefty for our institution to invest in purchasing many devices at once… we have to upgrade our Internet package… teachers' attitudes are another big issues, senior teachers are very hard to change… they simply use the technology for the sake of using it, instead of using it for a purpose – to improve student learning!"* (P2)

P1 briefly describe the problems and issues that limited her ability to successfully implement the curriculum change instead of providing workable solutions for those problems. P2 showed her managerial ability by creating an investment plan for the devices and Internet package and coming up with alternatives to address the issues with devices:

> *"… we made the purchase in different phrases – computer, LCD screen, a few tablets, and after the pandemic, we encourage students to bring their own digital device for DC."*

4.3.3. Curriculum Leader as Administrator

Once the curriculum change has been implemented, curriculum leaders must play the administrator role by providing the necessary support and resources to finalise the change and make it part of the routine. Both P1 and P2 are aware of the support and resources their teachers need to implement the curriculum change effectively, but P2 showed that she played the administrator role effectively by managing the resources, including various hardware and Internet connections for DC. Even when senior teachers

and parents refuse to participate in DC, she comes up with solutions to issues and problems by suggesting the content to use in the classroom according to their needs and calling on teacher-parent meetings to educate parents on the benefits of technology integration.

Without the support from curriculum leaders, curriculum changes will not last. P1, who has not taken any action to solve teachers' issues in using technology, continue to see the implementation as incomplete. She commented,

> *"My teachers are not keen to use DC in teaching. I see that they have a negative attitude towards the implementation, but I cannot blame them as the class schedule is one big issue."* (P1)

4.4. Transformational Leadership in Leading Curriculum Change

Curriculum leadership is complex and challenging as leaders are responsible for keeping schools running and improving educational outcomes (DeMatthews, 2014; O'Shea, 2021). Curriculum leaders are expected to display four characteristics of transformational leaders throughout the implementation of DC according to the innovation-decision process. See Table 1 for the characteristics of transformational leaders according to stages in the innovation-decision process.

Table 1: Four transformational leadership characteristics displayed along the innovation-decision process

Innovation-decision stages	**Transformational leadership characteristics**	**Description**
Knowledge Persuasion	*Idealised Influence, Inspiration Motivation*	Curriculum leaders effectively articulate the five attributes of innovation to convey the rationale of curriculum change, outline workable steps to implement change and provide technical training. Leaders inspire teachers to commit to continuous improvement through professional development programs.
Decision Implementation	*Intellectual Stimulation*	Curriculum leaders encourage creativity in using technology through experiments and trials. Leaders play the role of mediator between teachers (users of DC) and policymakers (designers of DC) by collecting, interpreting, and providing data to policymakers for continuous improvement from experiments teachers conducted.
Confirmation	*Individualised Consideration*	Curriculum leaders continuously pay attention to teachers' needs and concerns in using technology in teaching math and respond swiftly to issues and problems to finalise change.

In the knowledge and persuasion stage of the innovation-decision process, teachers actively seek information to assist their adoption decision. Curriculum leaders must communicate the rationale of change with teachers openly and precisely. In this study, P1 mentioned how teachers could utilise technology to teach during the disruption caused by "*weather conditions, health problems, transportation issues*". P2 reiterates the benefits of using technology in teaching whenever she meets teachers in the institutions, and she invites teachers to her class so that they "*see the value of DC by themselves*".

Transformational leaders display idealised influence and inspirational motivation when they convey their compelling visions, articulate workable steps to achieve those visions, become the model of emulation, and show determination and confidence. In the present study, both participants have shown these two transformational leaders' characteristics, but to different extents. P1 briefly describes the curriculum change and its impact on teachers' work. Contrary to P1, P2 has described the rationale for change with more detail, emphasising the technology used to improve students' learning while keeping teachers' workloads minimal and inspiring teachers to commit to self-improvement.

> *"… we managed and we put together a good system for digital learning. Now teachers are better technology users, because I told them it's okay to fail at first, let's experiment with it, and tell the trainer what we still need, what we still lack, and the trainer will provide support. I tell them don't worry about using technology, let's focus on how we can use technology to help students learning. Now they come up to me to show how they have used technology in training students, they are now better at it."* (P2)

At the decision and implementation stage in the innovation-decision process, teachers will decide either to adopt or reject the implementation of DC, and it is imperative for curriculum leaders to display the transformational leadership quality of intellectual stimulation, which requires leaders to be open-minded to innovative and creative ideas. In the present study, P1 acquiesced to teachers' decision to reject the implementation of DC by providing feedback like "it's time-consuming" because they have "mixed-age class structure", implying the absence of intellectual stimulation in her leadership. P2's leadership approach is the opposite of P1, where she has mentioned multiple times "experiment first", "try first", and "trial-and-error", indicating that she is displaying intellectual stimulation that encourages creativity.

The final stage of the innovation-decision process, the confirmation stage, involves curriculum leaders finalising the change. Here, curriculum leaders should display the quality of individualised consideration where they pay attention to teachers' developmental needs, issues, and challenges in implementing the planned curriculum change. Both participants displayed this leadership quality of individualised consideration but to different degrees. P1 noticed the issues and challenges teachers faced in implementing the curriculum change but did not mention workable solutions; P2 described issues and challenges in detail and provided possible solutions that meet the needs of individual teachers.

> *"There are teachers who do not like to use digital tools as they think they can guide the students well without the digital tools. I don't punish them, but I will try to talk them into using the minimum amount of technology in the class. For example, use the mobile application (which is easiest to use, in case the teacher is not tech-savvy) or use the online practice*

> *platform (which is convenient to use because the feedback is instant, in case teacher is busy).”* (P2)

In the present study, P2 adopted a transformational leadership approach in motivating followers to raise their consciousness about the institutional goals and inspire them to move beyond self-interest for the greater good of the institution (Gumus et al., 2016). On the contrary, P1 displayed a weak sign of transformational leadership qualities. Her leadership approach was inclined toward managerial leadership, which focused on managing existing practices in the institutions rather than envisioning change and improvement (Gumus et al., 2016).

5. Conclusion

Curriculum leadership is no easy task, even for veteran principals. Principals must play multiple roles to keep the institutions running, manage teachers and students, and implement and manage curriculum change. Technology integration in education is an idea far from new, but technology in teaching mathematics still faces various challenges (see Abdullah et al., 2016; Daher et al., 2018; Das, 2019; Li, 2023). The findings of this study showed that Rogers’ Diffusion of Innovation model is an effective model for curriculum change involving the adoption of technology. The curriculum change process in the institutions can be explained through the Diffusion of Innovation model, where leaders and teachers go through stages of learning about the digital tools, to forming positive or negative beliefs about the tools, which help make adoption or rejection decisions, then, implementing and seeking support to confirm the change. As the findings suggest, management should continuously feed teachers about the technology to support their adoption decision.

The findings of this study suggested that leaders with transformational leadership qualities can effectively communicate the attributes of the technology that affect teachers’ attitudes towards technology adoption. In addition, transformational leaders who pay attention to teachers’ needs in the curriculum change process are more effective in curriculum change management. The two leaders in this study are reported to have different leadership approaches in embracing and managing curriculum change in their institutions, affecting the curriculum change processes differently. The findings imply that future leadership programs should focus on developing leaders with transformational leadership qualities, which include *Idealised Influence, Inspirational Motivation, Intellectual Stimulation,* and *Individualised Consideration.* Educational institutions should focus on developing leaders’ communication abilities to deliver compelling organisational visions and their observational ability to identify teachers’ developmental needs to ensure effective curriculum change management.

Technology integration in teaching math is necessary for effective teaching in the 21st century. However, such changes in curriculum required leaders to act differently to rethink and reinvent the system to better suit the dynamic of the education system in the 21st century. As McKee and Gauch (2020) put it, education in the 21st century requires “*brave, thoughtful, and dedicated leadership*” (McKee & Gauch, 2020, p.286).

The present study's findings were concluded based on the two curriculum leaders in private institutions that offered math programs in Malaysia. The research design employed in this study was a qualitative approach with a small sample size. Owing to these, the findings could not be generalised to represent the wider population. However,

a qualitative research approach is employed to capture curriculum leaders' perceptions of curriculum change involving technology integration. It enables the researcher to develop a meaningful and deeper understanding of the curriculum change management and leadership approaches applied in managing the process. Another limitation of this study is the accuracy of leaders in recalling the curriculum change that happened four years ago, which might result in inaccurate responses and affect data validity (Brewer, 2004**,** as cited in Leong, 2022).

Ethics Approval and Consent to Participate

Before the interview protocols were sent out to the selected participants, informed consent was secured for every participant, and the researcher followed the confidentiality agreement as instructed by the franchise company. The participants were assured that their participation was entirely voluntary and that they could withdraw from the study at any time without any negative consequence. Participants' identities were kept confidential, and the franchise company's logo and name were concealed.

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Conflict of Interest

The authors reported no conflicts of interest for this work.

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