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Research Article

The Importance of Digital Literacy in Quadratic Equations, Strategies Used, and Issues Faced by Educators

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ABSTRACT

The purpose of this study is to identify the teaching styles and problems that are faced by teachers in cultivating digital literacy skills for the topic of quadratic equations. This study helps to overcome and refine all shortcomings that occur in the process of instilling digital literacy skills into the topic of quadratic equations. This study employed a qualitative approach by adopting the structured interview method that involved four participants from three districts in Malaysia. The interview data were analyzed using the ATLAS.ti 8 software by dividing the transcripts into small codes based on thematic analysis. The findings show that the importance of digital literacy skills in quadratic equation comprises the aspect of motivation, space saving, conducive environment, fostering thinking skills, and diversity of resources. The results have also indicated that the teachers' teaching approach is based on existing hardware and software such as the Microsoft software, Google software, teaching aids, the Internet resources, and mobile device applications. Among the constraints that are faced by the teachers include the use of technology in calculations, communicating information, issues in exploring the diversity of information, issues in mathematical modelling, and technical limitations. Accordingly, all emerging themes and codes are summarized using schematic diagrams. A major implication of this research is that it serves as a catalyst in cultivating digital literacy among generation Z such as using the TI-Nspire software to solve mathematical problems.

Keywords: quadratic equation, qualitative approach, teaching styles, problems, digital literacy skills

INTRODUCTION

Algebra is one of the main components of knowledge in the mathematics subject that is taught around the world. In fact, it has been tested in all 79 participating countries of PISA 2018, including Malaysia (OECD, 2019). Algebra is also a required course for many students majoring in science, education, technology, and mathematics (STEM) and its abstract nature can cause significant difficulties for students who struggle to grasp the more theoretical aspects of the course (Stewart et al., 2019). Thus, it is not surprising that algebra is regarded as the main key to enter the higher level of education such as universities (Utami & Jupri, 2021). In Malaysia, algebra is integrated into the national syllabus according to specific chapters. In this regard, algebra chapters for lower secondary mathematics are related with those that are taught in upper secondary where a number of algebraic formula and problem solving that is learned in the former will be applied in the problem solving during the latter. Therefore, it is important for the students to be equipped with a strong

fundamental in algebra so that the time and effort that are allotted by the teachers to teach new knowledge are not wasted on repeating the lower secondary lessons.

The current public examinations scenario has seen the inclusion of more algebraic concepts being instilled into the Mathematical questions with a particular emphasis on the inclusion of the quadratic equation topic into the national examinations. The topic also receives high weightage in the marking scale with an allocation of four to 12 marks in two examination papers. Such high weightage is prompted by the fact that quadratic equation is regarded as an important topic to be mastered as it helps to establish a connection between various mathematical knowledge such as trigonometry, limit, integral, and so forth (Aziz et al., 2018). Despite its importance, solving quadratic equation remains as the most challenging algebraic topics to be mastered as compared to other contents in the mathematic syllabus (Hu et al., 2021). This is due to its suitability to be used as a concept that best illustrates ideas through models that are realistic or similar to real life situations (Didis & Erbas, 2015).

Since time immemorial, mathematicians have been using various strategies to solve quadratic equation problems. This has been further expanded with continuous research in the field of algebra, which begins from arithmetic equation and numerical strategies to algebra and symbols as well as the use of visual or geometrical techniques (Katz & Barton, 2007). Although quadratic equation is seen as a relatively easy topic involving basic skills, human daily lives revolve around adapting from the said concept such as its application in sports and architecture. For instance, the quadratic equation concept is prominent in sports such as shot put, discus throw, and the javelin throw. Furthermore, the use of parabolic curve in constructions is also closely related to quadratic equation (Yeow et al., 2019). Thus, the students' failure to master fundamental basic skills will fossilize incorrect concepts in their mind that will affect future learning. This is parallel with Watt (2005) who posits that the students' difficulty to further their study into the science field at the university is closely related to their failure in mastering basic quadratic equation skills, which is the key prerequisite to access higher mathematical knowledge.

Generally, problem solving in a mathematical context refers to the process by which students, when faced with a problem, will try to understand the problem, determine appropriate strategies, implement a solution plan, and finally, validate by reviewing the solution (Majeed et al., 2021). This systematic problem solving process can be further strengthened with the students' digital literacy skills using a multimedia software. Digital literacy skills refer to the students' awareness, attitude, and their ability to use digital tools and facilities accurately to identify, access, manage, integrate, evaluate, analyze, and synthesize digital resources for the purpose of constructing new knowledge (Zan et al., 2021). Hence, mathematical knowledge is important in order to build a relationship between the problems and real life situations. For this purpose, multimedia materials can help students to understand abstract mathematical problems by seemingly participating in realistic problems using graphic, video, audio, animation, and graph materials. This statement is supported by a study that has been conducted by Pradana et al. (2020), which reported that the use of digital media makes mathematical objects more dynamic and allows the students to explore their own learning, in line with the 21st century pedagogy.

In addition, one of the important aspects of digital literacy is problem solving (Rizal et al., 2019). Peng et al. (2020) have also stated that the mastery of information communication technology literacy by the current generation is the result of the interaction between two main elements, namely the general skills in problem solving and also the technical skills that are related to information technology.

Problem Statement

Quadratic equation

Although the topic of quadratic equation is considered important in the school curriculum, many students are still producing errors in finding the right final solution (Utami & Jupri, 2021). This has sparked a major concern among researchers in recent times. Findings by Baring and Alegre (2019) show that many students still think that quadratic equation is a challenging and difficult topic. This issue is supported by the findings of Thomas and Mahmud (2021) who reported that the main reason why Malaysian students often make mistakes in solving quadratic equations is because they fail to clearly understand the question and often misunderstood the requirements of the question. This is further supported by Teoh et al. (2018) who have

reported that the level of achievement for the quadratic equation topic among the students in the country is extremely low. In fact, this finding is also consistent with the results that are presented in the Malaysian Examinations Board report (Malaysia Examination Board, 2022), where Malaysian students are seen as careless and are unable to organize their strategies when solving quadratic equation problems. The findings of the study also prove that students are weak in figuring out the correct answer, subsequently indicating their cognitive weakness and inability to conduct structured problem solving as the teaching and learning of algebra is something that is difficult for them (Lima & Tall, 2006).

In addition, the use of the 'unknown' in quadratic equation also confuses the students. According to Kim How et al. (2022), students face significant difficulty in understanding mathematical language such as symbols, notations, and mathematical terms in quadratic expressions. This is evident by the low performance of the local students in the topic of algebra as compared to other Asia Pacific countries (OECD, 2013). The students also practice rule-based solutions such as memorizing the steps and formula in solving quadratic equation problems, subsequently causing them to miss the opportunity to grasp that the 'unknown' is a key feature in quadratic equation (Didis & Erbas, 2015). Moreover, past studies have also reported that many students are unaware that quadratic equation have more than one root (Vaiyavutjamai et al., 2005), which in turn contributes to misconceptions in the concept of quadratic equation. This suggests that the students have limited understanding about the main gist of the quadratic equation question along with the difficulty in identifying the true meaning of the roots in quadratic equation (Guner & Uygun, 2016).

Furthermore, Kabar (2018) has also reported that students are unable to provide an accurate definition of quadratic equation and that the given answers are not parallel to the set standards. This is further supported by Morales Carballo et al. (2022) who have reported that majority of the students had a misconception about the definition of quadratic equation and did not know the meaning of solving a quadratic equation. In the context of teachers, a study by Sari and Jailani (2019) have discovered that mathematics teachers are too fast in their delivery of quadratic equation teaching materials while their boring teaching delivery diminishes the students' interest in this topic. Vaiyavutjamai and Clements (2006) advocate this statement by stating that the teaching of quadratic equation is highly teacher-centered where the teachers only focus on the skill of manipulating the structure of quadratic mathematical symbols without translating the meaning or significance of the symbols.

These arguments thus, signify the prominence of the studies on the teaching of quadratic equation, where Teh (2015) further advocates that despite the vast number of studies that are related to algebra education, studies on the teaching and learning of quadratic equation are very limited. Teachers are also confused in choosing the most appropriate approach to teach quadratic equations in the classroom (Sosa-Moguel & Aparicio-Landa, 2021). As a continuum to the above discussion, further investigation on the teaching approach as well as the constraints in implementing the teaching process of quadratic equation is necessary. This will enable the teachers to identify problems at an early stage and to take the best steps to correct the misunderstandings that are faced by the students on the topic of quadratic equation.

Digital literacy skills in mathematics

Digital age literacy skills are not solely limited to technical skills in using advanced technology such as a modern software or equipment. Rather, digital literacy involves the mastery of ideas and not just the tapping of fingers on a keyboard (van Laar et al., 2017). In fact, Ng (2012) has divided the formation of the digital era literacy into three interrelated dimensions, namely, technical, cognitive, and emotional-social skills. Digital literacy is a pattern of thinking that is employed by the users to perform tasks intuitively, by following the correct and effective sequence when exposed to wide information gaps in the digital environment (Martin, 2008). The use of this new digital concept is appropriate to measure the students' learning where the utilization of multimedia in the mathematics subject shall enable students to build digital literacy skills and subsequently to cultivate their interest to explore the functions of technological applications. These skills are important especially in helping the students' career development and in preparing them towards future technological advances. Moreover, multimedia in mathematics also enriches and transforms the existing mathematics learning methods through the sharing of digital literacy within and outside the classroom.

In the 21st century, students should no longer be assessed merely on their ability to answer test questions but also on their digital skills mastery for them to communicate and provide ideas effectively when using

digital resources during the teaching and learning process. The Malaysian mathematics curriculum also acknowledges the effective use of digital technology as one of the mathematical skills that needs to be mastered by the students. This is due to the fact that students who learn through textbook resources within an exam-oriented environment are often short in digital literacy knowledge, subsequently resulting in incompetent human resources with a lack of competitiveness and skills to face challenges in the future (Iberahim et al., 2017). The criticality of this issue has been raised by Salleh et al. (2015), which highlighted the extremely low level of ICT literacy skills among the indigenous students in the district of Mantin, Negeri Sembilan. In addition, another study by Mohamed et al. (2012) have examined the level of information and communication technology literacy among 585 students from a secondary school in the state of Johor, and have reported that the majority of students are in the category of very weak, weak, or moderate. Although information accessing skills are a part of the components of digital literacy skills (Setyaningsih et al., 2019), the findings by Shariman et al. (2012) indicate that the digital literacy competency of Malaysian students, especially their information seeking skills, is at a low level. The study has also found that the local students often face difficulty in finding relevant information, are capable of comprehending digital contents on the surface level only, and experience difficulty in scanning authentic information that meets their needs. Such finding is in line with other studies that have been conducted abroad such as Robabi and Arbabisarjou (2015) who have found that the computer literacy skills of Iranian students are at an unsatisfactory level. This serves as a clear indication that the students' mastery in digital literacy skills is still at an unsatisfactory level, and this issue needs to be addressed.

Hence, the above discussion suggests that there is a significant relationship between digital literacy skills and mathematics learning especially in the topic of quadratic equation. Abramovich (2016) argues that the presence of digital software indirectly improves the teaching and learning quality of the quadratic equation topic. This is advocated by Barraza Castillo et al. (2015) who have reported that students could see and learn the shape of quadratic equation in 3D virtual world images using the augmented reality application. Such findings indicate that teaching strategies such as applying computerized dynamic tools in fostering visualization of mathematical abstract concepts are indeed an important element of digital literacy (Klemer & Rapoport, 2020). Therefore, the researcher shall take this opportunity to unravel the teaching approach as well as the problems that are faced by the teachers when integrating digital literacy skills in the teaching and learning of quadratic equations.

Research Objectives

1. To identify the importance of implementing the teaching and learning of digital literacy skills in the topic of quadratic equations.
2. To identify the teaching styles and problems faced by teachers while implementing the teaching and learning of digital literacy skills in the topic of quadratic equations.

Research Questions

1. In your opinion as a teacher, is it important to integrate digital literacy skills among the students during the teaching and learning process of quadratic equation topic? Why?
2. Do you implement a particular teaching approach to promote digital literacy skills in the quadratic equation topic?
3. What are the problems that you face while implementing the teaching and learning of digital literacy skills in the quadratic equation topic?

METHODOLOGY

The current study is a qualitative investigation that has been conducted through a structured interview method. The advantage of using an interview is that the interviewer can clearly describe the purpose of the study and the type of information that is required (Amran et al., 2021). During the structured interview, the researcher will act as a moderator who prepares the specified questions for all the participants. One of the advantages of using the structured interview instrument is that all the participants will receive the same set of questions and the responses that are received from the participants can be compared, compiled, and

Table 1. Participants' profile and experience

Participants	District	Selection criteria
Ms. Karlina (G1)	Lahad Datu	A graduate teacher in the mathematics/biology option. 11 years of experience in teaching mathematics (since 2009). Held the position of Head of Mathematics Department for 10 years.
Ms. Arania (G2)	Lahad Datu	A graduate teacher in the mathematics/science option. 15 years of experience in teaching mathematics (since 2005). Former Senior Teacher of Science and Mathematics and currently the District Head Coach of Mathematics Curriculum.
Mr. Chin (G3)	Kunak	A graduate teacher in the mathematics/chemistry option. 10 years of experience in teaching mathematics (since 2010). Held the position of Head of Mathematics Department for 3 years.
Ms. Ivy (G4)	Tawau	A graduate teacher in the mathematics/physics option. 10 years of experienced in teaching mathematics (since 2010). Held the position of Head of Mathematics Department for 7 years.

analyzed more meaningfully (Rashidi et al., 2014). It also reduces potential errors that can distort the findings of the study as well as saving the researcher's time (Bryman, 2012). The structured Interview protocol that is used in this study has been adapted and modified from Zulnaidi (2013). The protocol aims to obtain information orally from the mathematics teachers about the teaching approaches that are used as well as the problems that are faced by them while integrating digital literacy skills into the teaching and learning of quadratic equations. There were also interview questions that are related to the teachers' existing knowledge on the importance of integrating digital literacy skills in the teaching and learning process of the quadratic equations topic.

Research Sample

The participants for this study were four teachers from three districts in Malaysia who were selected based on the recommendation from the school. A snowball sampling technique was used to select the participants for the interview as the researcher did not know which participants could provide an in-depth as well as rich information. Moreover, the use of snowball sampling to recruit prospective participants for the face-to-face interviews also gave the participants a high level of trust due to their acquaintance with the person who had recommended them to the researcher (Kirchherr & Charles, 2018). The names of the four teachers who were selected as the participants of this study were proposed by the Principal and the Senior Assistant of Administration. They are Ms. Karlina (G1), Ms. Arania (G2), Mr. Chin (G3), and Ms. Ivy (G4); **Table 1** shows the selection criteria of the interview participants for the needs analysis phase. At this stage, the addition of participants was no longer required except for specific topics or issues due to data saturation. Correspondingly, Creswell (2012) has stated that the ideal number of qualitative participants is between three to ten people depending on the depth of the study, which justifies the selection of four teachers as the participants of the study. This selection is also in line with Melnick and Meister (2008), who have reported that in-service teachers with four to 37 years of working experience are categorized as experienced teachers.

Pilot Study

The validity and reliability of the study has involved several measures that have been proposed by Bogdan and Biklen (2007), namely, the validation of the interview protocol by field experts, pilot study, data triangulation, and the participants' validation against the interview data. Although a pilot study is commonly used as a method to assess the validity and reliability of a research instrument in quantitative studies, its importance has been extended to qualitative research design (Majid et al., 2017). This can also help the researcher to identify any shortcomings or limitations in the study so that initial modifications can be made before the main study is conducted. In this study, a pilot study has been conducted to test the structured interview protocol for mathematics teachers at one of the national secondary schools in the Tawau district. A teacher who seems to represent the research subject has been selected as the participant; the teacher is an experienced teacher who holds the position of the Head of Science and Mathematics. Accordingly, a one- time interview session was conducted, where the notes that had been made by the researcher and the participant were used to make appropriate adjustments and improvements. Findings from the pilot study were also used as a reference to identify issues and aspects that should be considered during the actual interview. Before the pilot study was conducted, the completed interview protocol was reviewed by the mathematics education expert and language expert in order to check the coherence between the research objectives and language suitability.

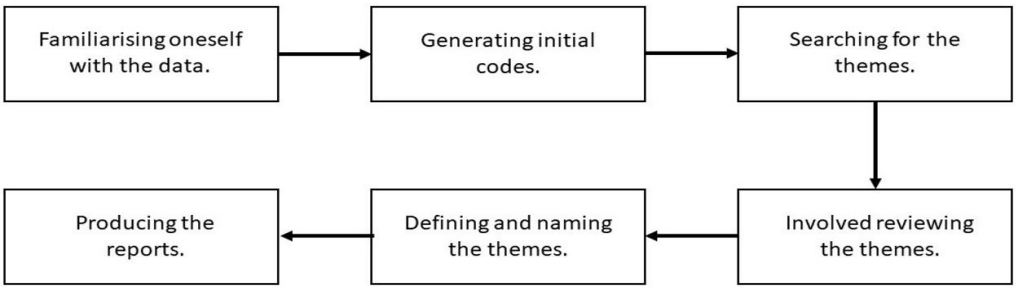

Figure 1. Data analysis procedures

Data Analysis and Triangulation

In this study an analysis was carried out on the transcripts of the interview sessions that were conducted with the mathematics teachers regarding the teaching and learning of mathematics, including aspects such as the importance and teaching approaches that were implemented by the teachers for the topic of quadratic equation, and the problems that were faced by the teachers in applying digital literacy skills for the said topic. The collected data were analyzed using the ATLAS.ti 8 software where it was divided into small codes and coded based on several themes that were appropriate with the research questions. The six procedures of thematic analysis in this study were based on Braun and Clarke (2006), as shown in **Figure 1**.

Triangulation

The triangulation method that was employed in this study was the within-method triangulation as suggested by Talib (2019). The researcher had used the same questions in the interview protocol but had implemented it at two different times in order to improve the validity of the answers (data) that were given by the participants. The main purpose of triangulation is to overcome potential weaknesses and biases from the analysis of the qualitative data. In addition, Bogdan and Biklen (2007) had also recommended the validation of the qualitative data that were collected through the interview by having the written transcript reviewed and signed by the participants to increase its validity and reliability. The participants were allowed to correct any inaccurate information, and subsequently to sign the transcript after they were satisfied with it. The correction of information, recognition, and validation by the participants on the interview data thus improved the validity and reliability of the data.

RESULTS AND DISCUSSION

Three themes had emerged following the analysis of the interview transcript of the four participants, namely:

1. importance of digital literacy skills,
2. digital literacy skills teaching approach, and
3. issues in teaching and learning of digital literacy skills for the quadratic equation topic.

Theme 1: Importance of Digital Literacy Skills for the Quadratic Equation Topic

There are six codes that have appeared under this theme, namely:

1. Motivation,
2. Cost, space, and time saving,
3. Learning outside the classroom,
4. Fostering thinking skills,
5. Conducive environment, and
6. Accessibility and diversity of teaching and learning resources.

The emerging themes and codes are summarized in the schematic diagram in **Figure 2**.

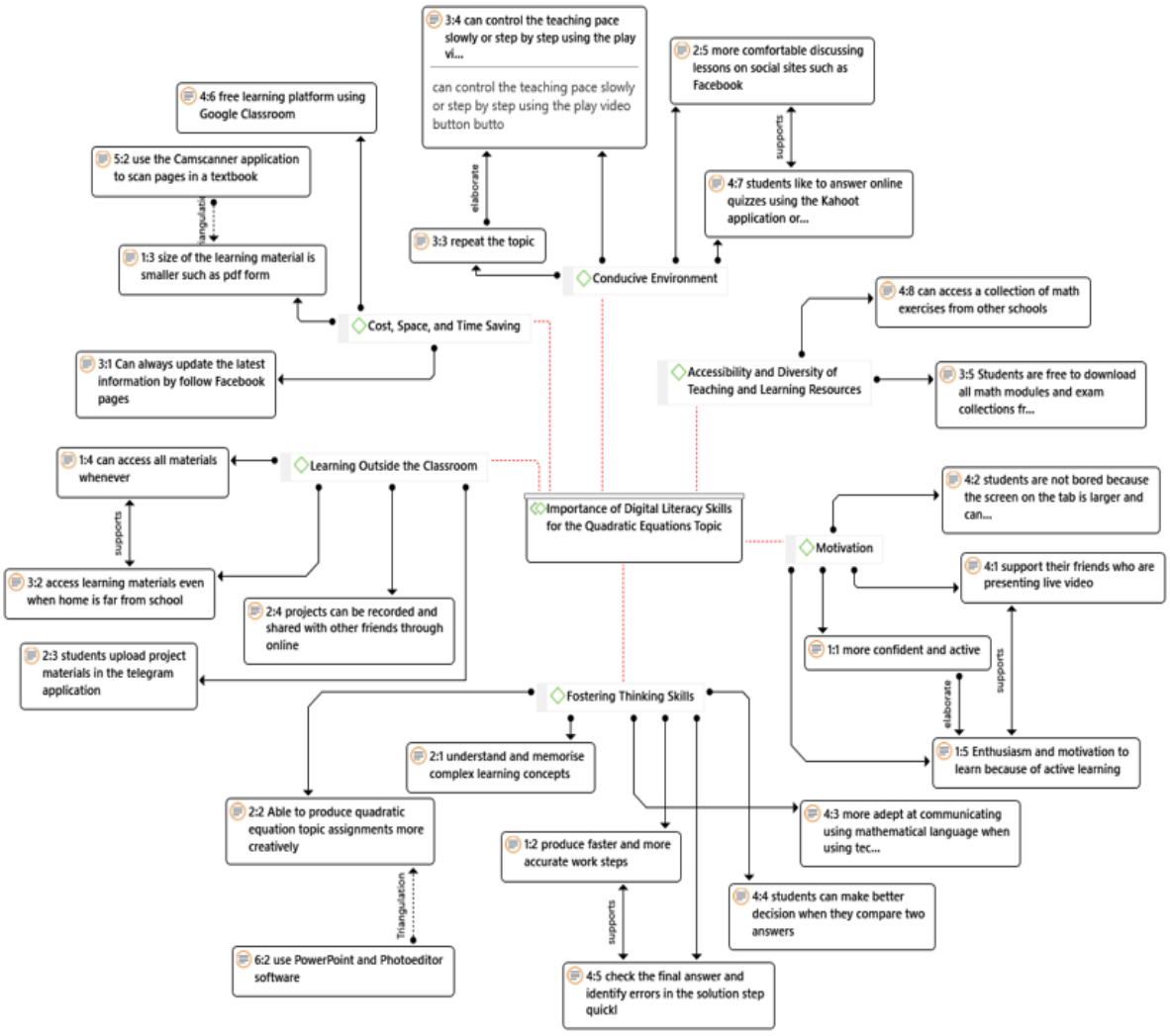

Figure 2. Importance of digital literacy skills

Two teachers, teacher 1 (G1) and teacher 2 (G2), have agreed that students who apply digital literacy skills in learning quadratic equation have a more confident attitude towards themselves and are motivated to solve more complex problems. As illustrated by Hallová at al. (2017), the only advantage of using ICT in the teaching and learning of mathematics is to increase the level of the students' interest and motivation.

For instance, G1 has stated:

> "students are more confident and active if using technology like calculator when learning compared to their friends without calculator" (Int-G1-15/7/2020, p. 116-118).

A total of three teachers have agreed that instilling digital literacy into the topic can cultivate thinking skills among the students such as using mathematical language correctly and ensuring that a quadratic equation idea can be explained creatively.

Through digital literacy, the students can use the technology to test the expected results, that is to check the balance of the manually generated answers which are supported by the skill of exploring alternative answers from a calculator or GeoGebra software. To quote teacher 4 (G4):

> "For example, the quadratic graphs done by students on the graph paper can be compared with the graph display on the graphic calculator. Students can make better decision when they compare two answers" (Int-G4-22/7/2020, p. 111-114).

G2 has also added that the quadratic equation problems can be converted into a more concrete concept to support the students' thinking skills without changing the original meaning of the questions:

> "...help students to understand and memorize complex learning concepts ... For example, quadratic equation that relate the speed of a motorboat with time. Video element transforms the static image of the motorboat into a moving boat...presents the content much clearer. They cannot get into a real motorboat ..." (Int-G2-15/7/2020, p. 102-105).

Apart from cultivating thinking skills, digital literacy skills also provide an opportunity for the students, especially those living in rural areas, to access materials on the topic of quadratic equation from a distance. To quote G1:

> "...students can access all materials whenever and wherever they are including when they go back to their hometown" (Int-G1-15/7/2020, p. 123-124).

This statement is supported by three other teachers who have stated that students can utilize digital literacy skills to upload quadratic equation learning videos that have been recorded using a software such as Telegram, to be accessed outside the classroom. G2 has stated:

> "projects can be recorded and shared with other friends through online using Facebook videos" (Int-G2-15/7/2020, p. 113-114).

Regarding the aspect of a conducive environment, it is important for the students to understand, plan, and interpret the steps of solving quadratic equation problems for more advanced learning. Thus, digital literacy skills such as learning through videos can allow students to control the rate and flow of teaching and learning according to their needs and levels. Teacher 3 (G3) supports this statement by stating:

> "...students can control the teaching pace slowly or step by step using the play video button compared to learning in class. Students also can repeat the topic" (Int-G3-15/7/2020, p. 113-115).

Such a finding is aligned with Santagata et al. (2021) who posits that the use of digital videos will slow down the process of teaching and learning mathematics and further details of all teaching information can be viewed clearly by the students as compared to the conventional methods of teaching mathematics. Therefore, effective teaching and learning of quadratic equation needs to maximize the cultivating of the students' digital literacy skills in order to form proficiency and to compensate for any shortcomings that are found in traditional methods of teaching the quadratic equation topic.

Theme 2: Digital Literacy Skills Teaching Approach for Quadratic Equation

The digital literacy skills teaching approach for quadratic equation consists of five main codes, namely:

1. Microsoft software,
2. Google software,
3. Mathematics teaching aids,
4. Internet resources, and
5. Mobile device applications.

The emerging themes and codes are summarized using the schematic diagram in **Figure 3**.

All the four teachers have admitted to have used appropriate technological hardware and digital resources as their strategies to teach digital literacy skills for quadratic equation in addition to relying on the existing mathematical technology such as the calculator. Under the Microsoft software code, the four teachers have also agreed that the use of Microsoft software such as Microsoft Team, Microsoft Excel, Microsoft PowerPoint, and Microsoft Word help in the calculations, to solve quadratic equation problems effectively. As said by G2:

> "...use Microsoft Word to do higher order thinking questions by forming quadratic equation for the area of a paddy field...they will use graphics to resemble the problem using Photo Editor apps... then use Microsoft PowerPoint slide to present" (Int-G2-15/7/2020, p. 124-127).

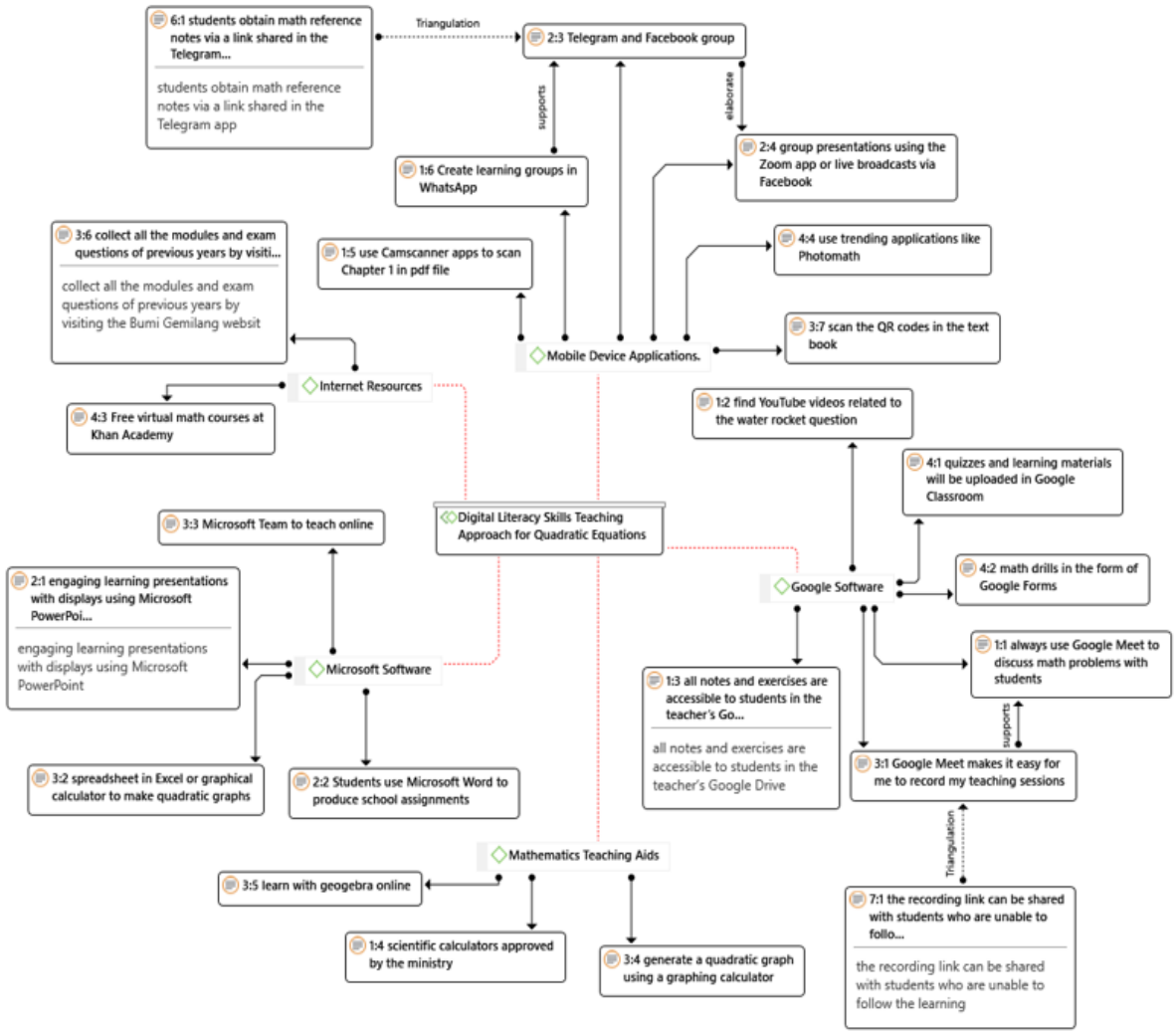

Figure 3. Digital literacy skills teaching approach

The finding is in line with Yanuarto et al. (2021), which have reported that senior teachers often integrate Microsoft software such as Microsoft PowerPoint in the process of teaching mathematics. This is supported by G3:

> "...commonly used software is like spreadsheet in Excel or graphical calculator to make quadratic graphs, and do not forget. Microsoft Team to teach online" (Int-G3-15/7/2020, p. 124-126).

Besides Microsoft software, all the four teachers have also named Google software as an alternative to digital resource support in modelling quadratic equation and subsequently in forming in-depth concepts. G1 has mentioned the use of Google software such as YouTube:

> "...quadratic equation question that represents the movement of water rocket. I will encourage students to find YouTube videos related to the water rocket question" (Int-G1-15/7/2020, p. 143-145).

G2 has supported the statement by stating:

> "...students also record their presentation with other friends using hand phones and upload it on YouTube for me to mark" (Int-G2-15/7/2020, p. 130-132).

Such statement is in line with the findings of Sari et al. (2020) who reported that the use of YouTube can overcome the difficulty of learning mathematics. This is because students can solve math problems in a

relaxed atmosphere without stress as well as the accessibility of materials regardless of time and place. In addition to YouTube, there are numerous excerpts from the interviews that have mentioned Google Meet, Google Form, and Google Classroom. For example, teacher 4 (G4) has used Google Form to conduct non-routine mathematics quiz for each topic including the quadratic equation so that the students can answer it online through Google Classroom. Meanwhile, teacher 3 (G3) has recorded a Google Meet session for students who could not attend the quadratic equation teaching and learning session.

Aside from these software, the teachers have also utilized mobile device applications and mathematics teaching aids to support the students' digital competency in performing calculations so as to determine the root of a quadratic equation. To quote G4:

> "...to find the root value. Students can use trending applications like Photo Math apps to solve quadratic equation" (Int-G4-22/7/2020, p. 129-131).

and G3:

> "...students scan the QR codes in the textbook that expose them to the use of dynamic geometry in quadratic equation" (Int-G3-15/7/2020, p. 135-136).

Furthermore, both teachers and students use mobile device applications such as the Cam Scanner apps to scan quadratic equation notes from books and save it as .pdf files; its small size makes it space effective and eases the students to bring it anywhere as opposed to physical notes. According to G1:

> "...I pity students because they have to bring the heavy Pelangi mathematics reference book just to learn about Chapter 1-Quadratic equation only. Some students use Cam Scanner apps to scan Chapter 1 in .pdf file that is small in size and can be easily stored by uploading on Google Drive" (Int-G1-15/7/2020, p. 130-133).

This statement is further advocated by the findings in Gay et al. (2020), who have reported that teachers and students prefer the mathematics textbooks in digital format.

In conclusion, students should not only be assessed on their ability to answer mathematics test questions using paper and pencil but should also be assessed on their digital literacy mastery, to understand technological hardware and digital resource support, how the technology works, its purpose, and how it can be utilized effectively to solve problems that are related to the topic of quadratic equation.

Theme 3: Issues in the Teaching and Learning of Digital Literacy Skills for the Quadratic Equation Topic

There are many issues that are faced by the teachers and the students in the teaching of digital literacy skills for the topic of quadratic equation. Different perspectives have been expressed by the four teachers regarding the challenges that are faced by the students. A total of six main codes have emerged under this theme, namely:

1. Technology assists calculation,
2. Technology helps to communicate information,
3. Technology explores the diversity of information,
4. Technology models mathematics,
5. Technical limitations, and
6. Students' attitude.

These themes and codes are summarized using the schematic diagram in **Figure 4**.

Based on the analysis, the first problem is in terms of digital literacy assists calculation in quadratic equation. Guided by technological tools, students often have the perception that the answers that are given by the calculator are always correct. According to LaCour et al. (2019), it is known that individuals who are proficient in mathematics are dependent on tools (i.e., calculators) when solving problems that they master.

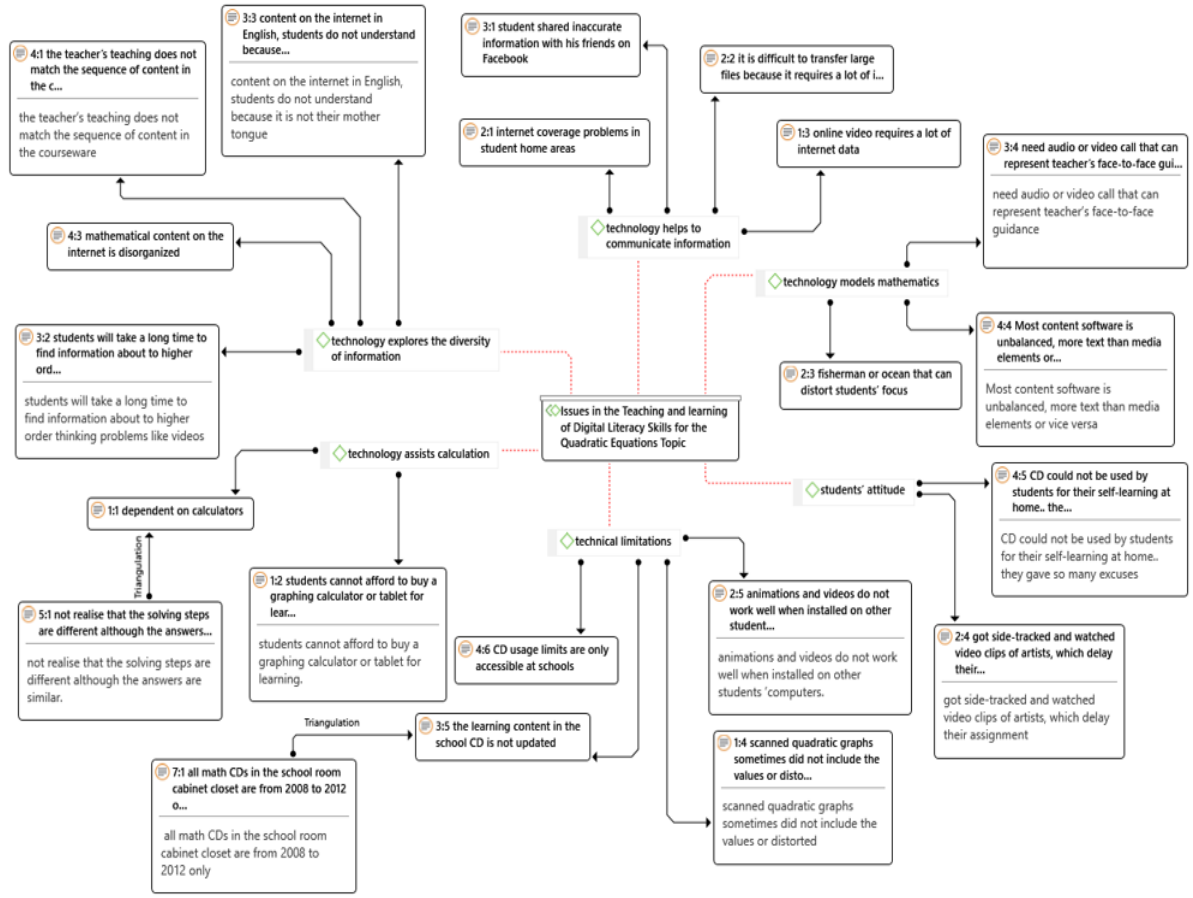

Figure 4. Issues in the teaching and learning of digital literacy skills

However, over-reliance on calculators can jeopardize the students' understanding of the concepts as well as lowering their confidence in their own answers (Pierce & Ball, 2009). As G1 has said:

> "...assistance such as calculators to find the roots that satisfy quadratic equation. Students will be dependent on calculators" (Int-G1-15/7/2020, p. 160-161).

The statement is further supported by an example of the calculation that has been taken from the triangulation of the interview with G1:

> "...if we use calculator to find the root for $x^2–3x–10=0$ and $-x^2+3x+10=0$, the calculator will give the same answers. but students do not realize that the solving steps are different although the answers are similar" (IntT-G4-23/11/2020, p. 72-73).

The technology that is used to communicate information is also an obstacle for the students to master digital literacy skills for this topic. According to teacher 2 (G2), apart from the high cost of the internet data purchase, students also find it difficult to share information as the internet coverage varies according to their location. Furthermore, without proper guidance from the teacher, there is a risk that the students might share inaccurate information rather than what is required in the teaching and learning of the quadratic equation topic. This will have an impact on the students' misconceptions in the calculations to solve quadratic equation problems. G3 has explained that:

> "...there was once, a student shared inaccurate information with his friends on Facebook such as wrong quadratic formula... it's not entirely wrong, but he forgot to put negative in front of b... but all class follow and all get the wrong answer" (Int-G3-15/7/2020, p. 157-159).

Typically, low digital literacy skills will make it difficult for the students to identify, find, and download materials such as graphics, modules, or learning videos that explain about a quadratic equation topic. This is

because they do not have the proper techniques or have inaccurate website resources. For example, this illustrated answer by G3:

> "…students will take a long time to find information about to higher order thinking problems like videos related to quadratic equation, there is no guidance to guide them or some websites have too many adverts or spam" (Int-G3-15/7/2020, p. 145-148).

G3 has added that even if the students manage to find materials from the correct website, they will still have difficulty to understand the mathematical content because the information is in English.

The study has also found a number of interview excerpts that are shared by the teachers regarding the technical limitations code. Among the technical limitations is the software's incompatibility with certain hardware. This is acknowledged by G2 who has stated that the provided animations and videos on the topic of quadratic equation sometimes do not work well when they are installed on other students' computers. In addition, low digital literacy skills also pose a significant impact on the students' ability to use hardware better and more comprehensively. As G1 has said:

> "…students will scan graphs that show the root of quadratic equation in the workbook, but the scanned quadratic graphs sometimes did not include the values or distorted. Students in my class are less skilled" (Int-G1-15/7/2020, p. 179-181).

Moreover, G1 and G4 assume that the use of CD resources is less effective in learning the quadratic equation topic because the contents are only accessible in schools and are limited to low-level concepts only.

The use of technology to model mathematics and subsequently to form in-depth concepts is another obstacle for the students to master digital literacy skills for this topic. Software that integrates multimedia displays (texts, audios, videos, animations, or graphics) that are incompatible with the teaching strategies will serve as a distraction for the students in interpreting the message to be conveyed on the concept of quadratic equation. G2 has explained:

> "…the question asked about boat only… but the video was full of graphics that were not related with the math problem like the fisherman or ocean that can distort students' focus" (Int-G2-15/7/2020, p. 143-145).

G3 has also agreed that for students to be able to model mathematical concepts better, they require audio support or video calls that can represent face-to-face guidance. Citing a comment by G3:

> "…students complain they can download information that they need but still they can't do the questions because there is no explanation from the teacher…they need audio or video call that can represent teacher's face-to-face guidance" (Int-G3-15/7/2020, p. 152-154).

Such finding is in line with Akugizibwe and Ahn (2020), who have found that even though the presence of technology eases the learning of complex algebra, the students still require the presence of a teacher. This is because the sophisticate technological equipment is incomparable with the teachers' guidance in the teaching and learning of mathematics. Furthermore, this study has found that the students' attitude is also among the constraint that are faced by the teachers in implementing the teaching and learning of digital literacy skills for the topic of quadratic equation. This is because the students' attitude of using technology irresponsibly does affect the way they learn, and subsequently impact their understanding of the topic. This is narrated by G4, as follows:

> "…I used to lend to them…but the CD could not be used by students for their self-learning at home… they gave so many excuses" (Int-G4-22/7/2020, p. 156-157).

She further added:

> "…students are not interested to use the software given" (Int-G4-22/7/2020, p. 150-151).

Meanwhile, G2 stated:

> "...students should make YouTube as one of their references for the assignment, but they got side-tracked and watched video clips of artists delaying their assignment" (Int-G2-15/7/2020, p. 137-140).

From the teachers' perspective, the findings that are reported in this study have illustrated various constraints such as the technical limitations of the hardware, challenges that are imposed by the costs and functions of the software, and the students' attitude that is faced by the teachers in implementing the teaching and learning of digital literacy skills for the topic of quadratic equation. Such a result is important because a systematic literature review (Mat & Maat, 2020) indicates that most of the previous studies only focus on the impact or effectiveness of implementing Mathematics-related technologies in schools. This may be due to the lack of materials and studies that focuses on the barriers and constraints that are encountered. Given these limitations, there seems to be a need to develop alternative teaching frameworks or modules in order to facilitate the teaching and learning of digital literacy skills for the topic of quadratic equations.

At the same time, the interviews have also revealed that students are highly interested in learning mathematics using a multimedia software that incorporates everyday situations along with the use of videos and animations that are related to the topic of quadratic equation. Through digital literacy skills, the students' skills to solve quadratic equation problems are not solely limited to using calculators but rather they will have the opportunity to hone alternative skills such as using a spreadsheet in Microsoft Excel, Microsoft Math Solver software, or Geometric Dynamic in order to determine the roots in quadratic equation. The findings also show that the students' level of analyzing their answers can be strengthened when they are able to evaluate and balance the manually generated answers that are supported by the skills of exploring alternative answers. For example, a quadratic graph that is produced by students on a graph paper can be compared to a graph display in GeoGebra Dynamic; this enables them to anticipate and make better decisions when comparing two answers through discussion and justification.

Moreover, the students' interest in the topic of quadratic equation is often diminished by their inability to understand important skills in mathematics, i.e., digital literacy skills, which some of them have considered to be difficult. In this regard, students with a limited understanding in basic mathematical skills such as solving problems using calculators, finding exact formulas on the internet, and generating graphs through spreadsheets, are often less proficient in mathematics as these skills are significantly used in both daily life as well as for work. Corresponding to the importance of digital literacy skills in mathematics, a study by Akugizibwe and Ahn (2020) has also recommended the establishment of a mathematics e-lab that can be accessed by the students for at least three days in a week in order to learn mathematics-related technologies such as GeoGebra Dynamic. This is because students who learn solely through textbook resources in an exam-oriented environment without any digital literacy knowledge will have a lack of competitiveness and will face significant difficulty to face future challenges.

CONCLUSIONS

Upon analyzing and discussing the findings of the study based on the three themes that have emerged through the structured interviews, the researcher has found that teachers have limited understanding on the implementation of digital literacy skills for the topic of quadratic equation. The results also prove that the teaching style of digital literacy skills is still based on the existing hardware and software such as calculators, Microsoft Excel, and Google Classroom. Notably, there are various up-to-date mobile device applications that have been made specifically for the topic of quadratic equations that teachers can explore and introduce to students. such as the GeoGebra Graphing Calculator, ClevCalc Apps, and Desmos application. This is in line with the study conducted by Alkhateeb and Al-Duwairi (2019) showed that the use of mobile device applications facilitates students on learning mathematics. Mobile devices were used to promote the collaborative learning environments, which indicated the mobile devices' abilities to narrow the gap between the school math and the world as compared with the schoolbooks. From the teachers' perspective, it seems that these skills are highly important for the students to master because those who apply digital literacy skills in learning quadratic equations being highly motivated to solve more complex problems. However, there are a number of problems that are faced by the teachers in implementing the teaching and learning of digital literacy skills for the quadratic equation topic such as technical limitations of the hardware, challenges that

are imposed by the costs and skills in using the software, as well as the students' irresponsible attitude in using the software.

Accordingly, there are several steps that can be taken in order to improve the teachers' teaching style in implementing digital literacy skills for the topic of quadratic equations. This includes creating initial exposure such as conducting workshops or the provision of guidance on the use of ICT from the Education Technology Division of the Ministry of Education. This is necessary as there are limited available professional courses for Mathematics trainee teachers compared to professional courses for university lecturers (Tran et al., 2020). In addition, the Curriculum Development Division needs to make appropriate textbook improvements such as to include QR codes that teachers can scan to obtain additional information or links to download online mathematics software such as GeoGebra Classic. Apart from textbooks, both teachers and students can conduct weekly training sessions on the use of technology such as the computer algebra system (CAS) graphical calculator with the additional support of relevant modules that serve as a guide and reference. Further studies are also proposed that focus on the impact of applying digital literacy skills to the topic of quadratic equations that aims at students with special needs.

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