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Difficulties in instructing mathematical modeling: Case study in Malaysia

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ABSTRACT

Mathematical modeling is crucial in the field of education, particularly in mathematics, as it enhances students' mathematical skills and prepares them for solving real-world problems. The study focuses on the challenges of teaching mathematical modeling, specifically in the Malaysian education system. We utilized a case study approach, involving five participants selected purposefully, comprising three females and two males. Data collection primarily involved interviews, with the collected data undergoing thematic analysis for a thorough examination. The process of conducting thematic analysis involves several systematic steps, including familiarization with the data, generation of initial codes, searching for themes, reviewing and refining these themes, defining and naming them, and ultimately producing a thematic map or report. We found Malaysian educators encounter difficulties in teaching mathematical modeling due to deficiencies in content and pedagogical knowledge, assessment methods, low student interest, and time constraints. This suggests a need for comprehensive reforms in curriculum design, professional development, assessment practices, and instructional strategies to enhance the effectiveness of mathematical modeling instruction.

Keywords: case study, mathematical modeling, mathematics teacher, modeling challenges

INTRODUCTION

Mathematical modeling holds significant importance in the realm of education, especially within the field of mathematics. It is pivotal in advancing students' mathematical proficiency and equipping them for real-world problem-solving (Zeytun et al., 2016). Instruction in mathematical modeling aids students in comprehending the process of crafting mathematical models to represent and address real-world challenges. This approach bolsters their problem-solving capabilities, critical thinking aptitude, and mathematical reasoning (Stohlmann & Albarracín, 2016). One of the primary advantages of teaching mathematical modeling is the refinement of students' communication, interpretation, and teamwork skills (Zhang, 2022). Through mathematical modeling, students learn to effectively convey mathematical concepts, decipher mathematical principles, and collaborate harmoniously with their peers, thus enhancing their mathematical competence and preparing them for future professional and academic pursuits (Zhang, 2022).

Furthermore, teaching mathematical modeling plays a pivotal role in fostering students' self-efficacy in their mathematical capabilities. Beyond the advantages for students and educators, mathematical modeling also incorporates science, technology, engineering, and mathematics (STEM) education. It offers a platform for students to employ mathematical ideas and proficiencies in addressing real-world predicaments across various STEM domains (Qudratuddarsi et al., 2022). By integrating mathematical modeling into STEM education, students garner a deeper appreciation of the interconnectedness of these disciplines and cultivate the skills requisite for future careers in STEM fields. Consequently, mathematical modeling instruction is indispensable for nurturing students' mathematical acumen, problem-solving competencies, and readiness for real-world challenges. It elevates their communication, interpretation, and collaboration prowess while instilling confidence in their mathematical abilities. Furthermore, mathematical modeling contributes significantly to the assimilation of STEM education, offering students a comprehensive grasp of the interwoven nature of STEM disciplines. Thus, it is imperative to accord priority to the incorporation of mathematical modeling in educational curricula.

Contemporary research concerning the structure of instructing mathematical modeling incorporates diverse viewpoints from across the globe, including the integration of mathematical modeling into physics education (Uhden et al., 2011), the panorama

of research in specific contexts (Araújo, 2010), the integration of mathematical modeling into STEM disciplines (Doğan et al., 2019), and the specialized knowledge required for effective mathematical modeling instruction (Carrillo et al., 2018). These studies contribute to developing effective strategies and frameworks for teaching mathematical modeling in various educational settings. Carrillo et al. (2018) propose the mathematics teacher's specialized knowledge model in the realm of mathematics education. This framework recognizes the specialized nature of a teacher's mathematical knowledge and extends across various sub-domains. Considering the content and pedagogical content knowledge, this model provides a comprehensive framework for understanding and developing teachers' expertise in mathematical modeling instruction.

While the current body of research provides valuable insights into various aspects of teaching mathematical modeling, a conspicuous research void exists regarding the practical application of these diverse viewpoints within real educational contexts. The studies mentioned furnish theoretical foundations and frameworks but often lack empirical substantiation or illustrative case studies that reveal the implementation of these methodologies in actual classroom settings. Furthermore, Pourdavood and Song (2021) have emphasized the substantial impact of social and cultural factors on the practices of mathematics educators. Factors such as understanding students' cultural backgrounds (Hendriyanto et al., 2024), ensuring equitable access to mathematics education, and considering learners' social and emotional development constitute pivotal facets that can mold instructional approaches in mathematical modeling. Consequently, there exists an imperative need for research that addresses this gap by exploring models or frameworks for teaching mathematical modeling within the unique context of Malaysia. The introduction of mathematical modeling into the Malaysian secondary mathematics curriculum in 2021 (Segaran & Eu, 2022) underscores the timeliness and significance of this research opportunity. Since mathematical modeling is a relatively nascent topic in the secondary school curriculum of Malaysia, this provides substantial research opening to investigate difficulties in instructing mathematical modeling in Malaysia. As such, the primary aim of the current case study is to difficulties in instructing mathematical modeling in Malaysia.

Research Question

RQ. What are difficulties in instructing mathematical modeling in Malaysia?

LITERATURE REVIEW

Mathematical modeling is a process that employs mathematical methods to comprehensively analyze and gain insights into real-life or practical scenarios (Stillman et al., 2013a). It involves the creation of mathematical models that accurately represent and elucidate the intricate relationships, patterns, and behaviors exhibited by the phenomena under investigation. These models serve as valuable tools for making predictions, problem-solving, and delving into the fundamental mechanisms of the system being studied (Afzal et al., 2021). In the realm of mathematics education, mathematical modeling plays a crucial role in instructing students in abstract mathematical concepts through a practical and context-based approach (Milinković & Ćurčić, 2019). This multifaceted process encompasses several vital steps. First, it entails identifying and defining a problem or scenario, alongside identifying the relevant variables and parameters (Stillman, 2019). Subsequently, a mathematical model is crafted, necessitating the formulation of assumptions and simplifications that accurately represent the essential characteristics of the system. Following this, the model undergoes analysis employing various mathematical techniques, including solving equations, conducting simulations, or utilizing computational algorithms. The insights derived from this analysis are then interpreted and harnessed for making predictions or drawing conclusive inferences regarding the system under scrutiny (Afzal et al., 2021). Ultimately, mathematical modeling is a powerful educational tool that enables students to appreciate the relevance and applicability of mathematics within real-world contexts (Asempapa & Love, 2021).

Proficiency in mathematical modeling requires a range of competencies that educators must possess in order to effectively teach this subject. One fundamental requirement is a deep understanding of the mathematical modeling process (Zhang et al., 2023). Educators should excel in the sub-competencies associated with mathematical modeling, including simplification, mathematization, mathematical reasoning, interpretation, and validation. This expertise enables them to guide and support students as they navigate the modeling process. Quality instruction is another critical component (Blum, 2015; Jabar et al., 2022). Educators should employ effective teaching methods to provide impactful learning opportunities. Research indicates that integrating high-quality teaching practices is essential for secondary school students to acquire mathematical modeling skills successfully. Furthermore, educators should be well-versed in the complexities and challenges inherent to mathematical modeling in mathematics education (Asempapa & Sturgill, 2019). Understanding these challenges empowers educators to proactively address potential obstacles that students might encounter during modeling. By acknowledging and tackling these issues, educators can provide the necessary support and mentorship to help students overcome challenges and improve their modeling skills.

Blum (2011) presents a model outlining the necessary skills for teaching mathematical modeling, which comprises four key dimensions. The first dimension, the theoretical dimension, pertains to having a solid grasp of concepts related to modeling cycles, modeling objectives/perspectives, and the various types of modeling tasks. This dimension serves as the foundational knowledge essential for practical skills in teaching mathematical modeling. The second dimension, the task dimension, involves the ability to solve, analyze, and create modeling tasks, which are crucial components of effective teaching. The instruction dimension encompasses understanding how to effectively guide and support students in their modeling processes and the capacity to design and implement modeling activities. Finally, the fourth dimension, the diagnostics dimension, encompasses the skills required to identify and differentiate the stages in students' modeling processes and to recognize and address the challenges that students may face during these activities.

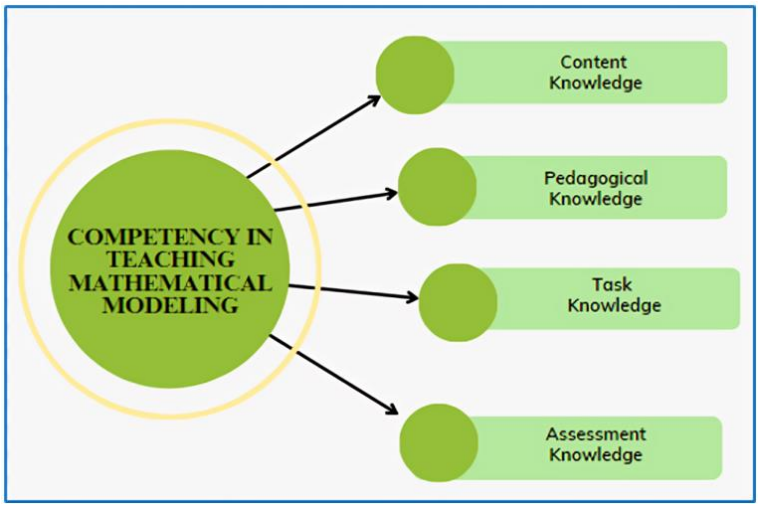

Figure 1. Conceptual framework (Blum, 2011)

A comprehensive framework discusses competencies essential for teaching modeling across various aspects, particularly applicable in the context of mathematical modeling. These competencies encompass content knowledge, pedagogical content knowledge, curricular knowledge, and pedagogical knowledge. Content knowledge entails the ability to structure learning materials in accordance with students' preferences, emphasizing the selection of materials that align with the subject matter's relevance. Pedagogical content knowledge equips educators with practical techniques for conveying educational content effectively, such as using comparisons, examples, and explanations. This knowledge forms a crucial foundation for recognizing and addressing specific challenges related to various subjects, as well as understanding the importance of anticipation, prior knowledge, and misconceptions in the learning process. Curricular knowledge encompasses a thorough understanding of the educational curriculum, including how topics are organized and classified across different grade levels. It further breaks down into two categories: vertical knowledge, which pertains to content that has been or will be studied, and lateral knowledge, which covers contemporary subjects and content from other disciplines. Lastly, the pedagogical knowledge dimension places less emphasis on a teacher's expertise in a specific subject and instead focuses on effective classroom management and the ability to handle behavioral issues. This framework offers a well-rounded approach to equip educators with the skills necessary for effective teaching, particularly in the domain of mathematical modeling.

To summarize, effective instruction in mathematical modeling necessitates educators to possess a wide range of skills, encompassing a deep comprehension of the modeling process and its sub-skills like simplification, mathematization, reasoning, interpretation, and validation. Educators should utilize effective teaching strategies and incorporate high-quality instructional methods to facilitate students' mastery of mathematical modeling. In addition, they should be well-informed about the specific challenges associated with mathematical modeling in the context of mathematics education to proactively support their students. Blum's (2011) model delineates essential teaching skills, covering theoretical, task, instruction, and diagnostics dimensions. Another framework introduces the necessary competencies for teaching modeling in various aspects, with a particular focus on mathematical modeling, including content knowledge, pedagogical content knowledge, curricular knowledge, and pedagogical knowledge. This comprehensive approach is represented in **Figure 1**, as the conceptual framework in our study.

METHODOLOGY

Research Design

The current research employs a case study design (Nasir et al., 2022; Yin, 2014) characterized by its meticulous analysis of a single subject or a small cluster of interconnected subjects. According to Yin (2014), case study is suggested when research questions prioritize understanding 'how' and 'why', there is no control over behavioral events, and the research centers on current events. Case study research is a multi-faceted approach that allows for in-depth exploration and understanding of specific cases or phenomena (Mohd Saad et al., 2023; Ridder, 2017). This approach involves an exhaustive and rigorous investigation into a specific scenario, event, individual, organization, or phenomenon. Its primary goal is to deeply understand the subject and extract valuable insights, explanations, or knowledge that may have broader relevance, all grounded in the particular case under examination. We opt for a case study because of the recent addition of mathematical modeling to the Malaysian secondary mathematics curriculum, highlighting the importance of investigating effective teaching models or frameworks customized to this new educational requirement. Additionally, the distinctive cultural and contextual aspects of education in Malaysia make it imperative to delve into how these factors impact mathematical modeling instruction. This study addresses a noteworthy research gap specific to the Malaysian educational setting, providing valuable insights for the academic community and educational practitioners. Ultimately, the results of this case study can directly influence educational practices in Malaysia, enhancing the quality of mathematical modeling instruction and contributing to the country's educational objectives.

Participants

Our research revolved around individuals who have expertise in teaching mathematical modeling, including educators in university settings and form 5 teachers in secondary schools who have experience in this area. The participants were selected using purposive sampling, resulting in a group of three males and one female. We included four participants in this study: two mathematics teachers from secondary schools and one mathematics education lecturer. These four individuals contributed a wide range of experiences to our research, all having previously taught mathematical modeling in various educational contexts. Our participant pool was drawn from university and secondary school environments, encompassing a mix of public and private schools with diverse cultural backgrounds. It is worth noting that the teachers who participated in this study held qualifications in mathematics education, while the lecturers possessed qualifications in mathematics education and mathematical modeling. This diverse mix of participants allows for a comprehensive investigation of the teaching of mathematical modeling across various educational settings and diverse backgrounds. Finally, we provided an informed consent letter to all participants in the study. This letter was given to ensure that participants fully understood the nature of the study, their involvement in it, and the ethical considerations in place. It served as a means to obtain their explicit consent to participate in the research and affirm their willingness to engage in the study activities, which was crucial for maintaining the ethical standards and transparency of the research process.

Data Collection Tools

After addressing ethical and methodological considerations, interviews were carried out following a pre-established schedule that aligned with the study's objectives. Data collection was primarily accomplished through interviews. The research team collaboratively developed the interview questions, engaging in discussions with three team members before commencing data collection. The interview protocol was thoughtfully designed to align with the research aims and inquiries of the case study. This protocol consisted of open-ended questions intended to elicit detailed responses and encourage participants to share their teaching experiences and perspectives on mathematical modeling. In particular, it encompassed a set of 10 open-ended questions aimed at exploring models or frameworks for teaching mathematical modeling in Malaysian educational settings. During the interviews, the research team adhered to the interview protocol while remaining adaptable to explore emerging themes and follow up on participants' responses, in line with the guidance provided by Crowe et al. (2011), which advocates for a combination of open-ended and probing questions to delve deeper into participants' experiences and viewpoints. To ensure data accuracy and maintain its integrity, all interviews were recorded with the consent of the participants. Additionally, video recordings of classroom sessions were collected for further analysis. Each interview took place at the selected schools and lasted between 30 to 60 minutes, and subsequently, the interviews were transcribed. Malay was the primary language employed during the interviews, and it is thought that ensuring the interviewees could communicate in their native language guarantees the quality of the results. To gain a comprehensive understanding of the data, both researchers read and reviewed the interview transcripts multiple times.

Data Analysis

In the current case study, we employ the thematic analysis approach for data analysis. Thematic analysis is a qualitative research method aimed at identifying patterns and themes within the data to deepen our insights and comprehension of the phenomenon under examination (Braun & Clarke, 2006). This approach is known for its flexibility and accessibility, making it suitable for the identification, analysis, and reporting of qualitative research data (Aini et al., 2019). Through thematic analysis, we can uncover and analyze emerging themes within the data, providing a rich and intricate understanding of the case under investigation (Phelan, 2011). This method enables a comprehensive exploration of the data, capturing the intricacies and nuances of the case study. The process of conducting thematic analysis involves several systematic steps, including familiarization with the data, generation of initial codes, searching for themes, reviewing and refining these themes, defining and naming them, and ultimately producing a thematic map or report (Lungu, 2022). Central to this process is the coding step, where the researcher assigns labels or codes to data segments relevant to the research question or objectives (Lungu, 2022).

FINDINGS

Challenges of Teaching Mathematical Modeling

The analysis from the findings found five themes of the secondary mathematics teachers' challenges in teaching mathematical modeling: content knowledge, pedagogical knowledge, assessment methods for mathematical modeling, insufficient student interest, and time constraints. The five respondents gave their views regarding the challenges faced during teaching mathematical modeling.

Content Knowledge

Table 1 highlights the themes, sub-themes, and frequency of secondary teachers' challenges in teaching mathematical modeling. R1, R4, and R5 mentioned content knowledge should be enhanced while teaching mathematical modeling. R1 highlights the discovery he found out from colleagues and supports the importance of doing research regarding mathematical modeling. R4 lacked confidence to address the knowledge of mathematical modeling to students since his/her professionalism is not in the mathematics education area while R5 kept on mentioning new teachers facing difficulties in strengthening their content knowledge to address the information correctly to students.

Table 1. The frequency of themes for secondary teachers' challenges of teaching mathematical modeling

Themes	Sub-themes	Study respondents					Frequency
		R1	R2	R3	R4	R5	
Secondary teachers' challenges of teaching mathematical modeling	Content knowledge	/	X	X	/	/	3
	Pedagogical knowledge	/	/	/	/	/	5
	Assessment methods for mathematical modeling	/	X	X	/	/	3
	Insufficient student interest	/	/	/	X	/	4
	Time constraint	/	/	/	/	/	5

> "I discovered examples in textbooks are also very limited to unearth, for example, what is recommended by the Ministry of Education, such as high-level thinking skills among students" (R1).

> "Mathematical modeling is actually difficult for me to teach and explain to students" (R4).

> "When I lack the knowledge to carry out the 6 processes, it's as if I lack the creativity to solve the situation" (R4).

> "For me it's more about understanding the process, how we want to solve each process, for me I don't feel confident" (R4).

> "If the teacher is a new teacher, it is quite difficult for him to teach mathematical modeling" (R5).

> "The skills in defining and assuming are less found out in teachers themselves which makes modeling harder" (R5).

Pedagogical Knowledge

In terms of pedagogical knowledge, all of the respondents agreed that teachers faced obstacles in the way they delivered mathematical modeling knowledge to their students. R1 had difficulties in technology knowledge while R2 did not know what should be delivered to students though he utilized YouTube as an application in modeling teaching.

> "An example of a school where his exposure is less in terms of technology, he still has a hard time succeeding in mathematical modeling" (R1).

> "But in terms of pedagogy, for me to convey to my students, that is a constraint for me compared to other titles, from chapter 1 to chapter 7 there is no problem. We have various pedagogies that we can diversify, teaching aids that we use. But in entering this mathematical modeling chapter, it seems to be a blur because I am not fully educated in mathematics, and we never learn" (R2).

> "I want to convey to our students that most of them are not mature yet because most of them are still 17 years old which is a problem for me because even the foundation of mathematics is not very strong. So we are not sure what we should say" (R2).

For R3, fun learning or hands-on activity is frequently being done but the inaccuracy of mathematics application makes the lesson harder whereas R4 had the same problems in how to apply technology in their pedagogy.

> "Now we have AI, and I've tried many apps, so we put in a problem, he came out with a solution, but I can't believe it because I've tried one app but forgot its name. Enter the problem in the app and get a solution, but the solution is a little different from what we do" (R3).

> "For that situation, there is something that we think can be shown through the application of technology. But the problem with constraints is that we don't know. It's like I don't know programming like that or in this title we also need expertise like statistical analysis right, data analytics" (R4).

In R5's opinion, the teacher must have strong pedagogical knowledge for mathematical modeling to be successful since modeling is an open-ended question.

> "What I see here, the teacher must have a strong pedagogy of content knowledge because this mathematical modeling, even though we see in the syllabus only linear, quadratic and exponent, in fact he has concepts involving algebra, geometry, acceleration speed limit, he still involves various concepts the basics that a teacher should know so that he can solve them in mathematical modeling" (R5).

Assessment Methods for Mathematical Modeling

Only two respondents faced challenges when came to assessing students for mathematical modeling. R1 uses classroom-based assessments but it seems harder for students to get level 6. R4 as an SPM examiner and R5 has the same point of view that difficulties are found during evaluating students' answers since modeling is open questions.

> "When we assess students, we have a classroom assessment, we will use TP1 until TP6. In modeling title, if we want to give him TP 6, so far we have tried several times but without success" (R1).

> "When I asked the chief examiner, because I'm also an SPM examiner right, because the question was an open response, then he made it difficult for the examiner actually, how do we want to evaluate the student's answers. It is possible for students to give various answers that we want to determine whether we can accept it or not. He is so difficult for us to evaluate" (R4).

> "In my opinion, it is difficult to ask because the answers are varied, how to check because this is an open question" (R5).

Insufficient Student Interest

R1 clearly define that students do not have interest if mathematical modeling needs a long process to go.

> "Because for me in this topic, usually the shortest question is half a page, if there is a lot of writing, students in this era of TikTok, where students prefer videos, they are less interested in reading long questions. He will be a burden for them to process questions" (R1).

R2, R3, and R5 have same opinion where students with low basic knowledge were not able to master's in mathematical modeling which involve diverse topic which then makes the students lose interest in modeling.

> "My colleague got introduce modeling to students, but students can't because they don't master the basics" (R2).

> "As for the current secondary school student level, it is also quite difficult because the students do not have the basics of introduction for modeling, so they find it very difficult when we want to teach" (R3).

> "If the student cannot justify, his imagination is low, it is very difficult for the student to explain because he really does not understand. As I said earlier, we do hands on activities, even if we do hands-on activities, but the boys have to know what is happening. That's one of the problems I face when I teach" (R3).

> "Based on my experience, I went to observe the practicum, I saw students doing PDP with the practicum teacher, they were very weak with the concept of basic concepts. How do these students who have weak basic concepts to implement a very difficult topic, which requires a lot of skills, strong knowledge content, that is a challenge to which this topic of mate modeling was taught in the 5th grade and that topic is the last topic?" (R5).

Time Constraints

All of the respondents faced time constraints while engaging in mathematical modeling. R1 suggested discussion could be carried out instead of project-based learning suggested by R5. However, R2, R3, and R4 face time constraints, especially during discussions with students on modeling topics. R3 was also short of time during making a model to explain modeling to students.

> "From that point of view, I think the hands-on experience (discussion) with the teacher is more effective in that relatively short period, which is two weeks, taking into account the time constraints in form 5 that will face the exam" (R1).

> "If it's an exponent, I think a lot of time has to be sacrificed to make sure students understand" (R1).

> "Sometimes there are time constraints like when I teach this topic, sometimes it causes me to have to speed up as well" (R2).

> "I think project-based learning is possible, but it is not possible now due to time constraints" (R2).

> "My style is that I like to make models, so when I make models, I must not have enough time" (R3).

> "Because when I want to do something in 40 minutes, I can't achieve it. Because when the student is stuck, we have to explain again, and the time is up" (R3).

> "So we want to explain to the students that it takes time, so it's like my competence to teach feels like I'm not competent" (R4).

> "If the teacher wants to prepare the software, there is a time constraint" (R4).

> "PBL is suggested because if a problem is presented openly, it cannot be solved within one pdp session. It needs a long time because the question is an open question, possibly for the first pdp session, maybe just to identify and define the problem from the problem" (R5).

DISCUSSION

Based on the findings, it could be seen that all of the respondents were not able to overcome deficiencies in pedagogical knowledge and time constraints while teaching mathematical modeling. The results are in line with the study by Ball et al. (2001).

They mentioned that teachers often lack sufficient knowledge about appropriate mathematical models to guide their lessons and the ones they do have at hand need to be updated and modified for the classroom, requiring a great deal of additional work since there are not enough acceptable teaching resources and examples of mathematical modeling. As an aside, there are other kinds of instructors on the internet. While some emphasized formal aspects while assisting students with their modeling process and in discussions about problem-solving, others focused on aspects related to reality to validate results and assist students. According to Blum (2015), organization such as time constraint was included in suspected obstacles to teaching modeling because mathematical modeling takes a lot of time and doesn't fit into either the standard school or college association's curriculum, which is already overburdened or the standard mathematics syllabus (Bora & Ahmed, 2019). This study also noted deficiencies in content knowledge where teachers were only able to minimize a diverse amount of modeling topics into a smaller scope where they only knew a limited number of modeling problems appropriate for their lessons. This is also agreed by Schmidt (2011) since modeling competency is still relatively new in Malaysia.

Next, three of the respondents faced challenges in the assessment method for mathematical modeling. Students were assessed regularly in the classroom to determine their growth in mathematical modeling. Classroom-based management was utilized in the secondary school but most of the students were not able to reach higher scores although discussion was being made. This situation was explained by Stillman et al. (2013a). Since the mathematical modeling method involves six principles and anything that isn't examined will not be valued by instructors, mathematical modeling is difficult to evaluate. Instructors must determine if a given solution is sufficient for the work at hand, given that the modeling problem contains several acceptable answers that cannot be deemed correct or incorrect (Festinger, 1962; Stillman et al., 2013b). Uncertain answers in modeling, and deficiencies in pedagogical knowledge mentioned will also lead to insufficient students' interest in mathematical modeling topics. From the findings, four respondents found out students' interest in modeling is at a critical level and recommended enhancing basic knowledge first when involved in this topic. In previous research, Chamberlin and Parks (2020) agreed that students should understand the modeling to increase their interest. They help students understand mathematical material by encouraging them to develop mathematical models. In their perspective, solvers frequently have to "mathematize," or turn seemingly non-mathematical data into a mathematical form. Solvers may be able to recognize the mathematical nature of data that others would not consider mathematical in this way. Furthermore, by developing mathematical models, problem solvers may greatly enhance the efficiency of their understanding of the mathematical issue, enabling them to extrapolate it to other contexts.

In this study, the researcher used experienced teachers or lecturers as the first level before being interviewed. The competence of teachers in modeling was examined and challenges of teaching mathematical modeling were drawn out from the interview. When the teacher performs well in their teaching, students would be able to learn well and become experts in the subjects. They maximize their superior skills via technology to perform well in teaching and students become focused in class and learn well during the teaching and learning sessions. This will help them to understand more in some subjects whether they are teacher or student.

CONCLUSION

Appropriate use of mathematics modeling can help the learner to develop modeling competencies in their understanding of the problem situation and the realization of different stages in the modeling process. Findings from the case study indicate the challenges of teaching mathematical modeling, specifically within the Malaysian educational landscape that are content knowledge, pedagogical knowledge, assessment methods for mathematical modeling, insufficient student interest, and time constraints. This qualitative study reveals that to meet the requirements and needs to succeed in mathematical modeling, some changes are necessary to enhance teachers' competence. Teachers need training to increase their knowledge of mathematical modeling. Once the teachers show their effort to make mathematical models for their students, they will have self-efficacy in implementing online platforms or applications to increase students' interest in this chapter. Before that, the diagnosis of a learner's problems while modeling is the first step before giving teacher intervention or feedback. But diagnosis is only possible if the teacher has enough content knowledge and pedagogical content knowledge concerning the modeling task he or she had given the students, together with a strong focus on modeling. Additionally, teachers who received education in the theoretical background about diagnosis and feedback performed better with their learners (Blum 2011). Development of university courses or teacher training workshops for the teaching and learning of modeling in different grades could be carried out as a seminar in secondary school. Teachers will then learn how to think critically when facing different situations in real life which then help in overcoming the challenges in teaching mathematical modeling.

Limitation and Suggestion

The current research faces several limitations. For instance, the interviews were held via Google Meet and recorded for later analysis. Interruptions occurred due to factors such as inclement weather and unstable internet connections. Additionally, the study's small sample size, comprising only a few experienced teachers, limited its ability to represent the perspectives of the entire Malaysian secondary education context. To address these limitations, several improvements can be implemented in future studies. Researchers could employ a mixed-methods approach for a more comprehensive investigation of teachers' self-efficacy. This approach could include interviews, surveys, and observations. Increasing the sample size would yield more precise data, not only regarding the challenges of teaching mathematical modeling but also on other relevant aspects. Conducting larger surveys would enhance the reliability of the results by reducing the margin of error and standard deviation. Overall, these recommendations, if implemented, could lead to better findings and results, benefiting various stakeholders in the educational field.

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