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Challenges in Implementing Critical Thinking Skills in Chemistry According to Malaysian Educators

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Abstract

Malaysia education system aspires to develop students with critical thinking by introducing higher order thinking skills within the curriculum, therefore educators are encouraged to integrate critical thinking activities such as inquiry-based learning and problem-based learning during lesson. However, implementing critical thinking can be challenging to educators. Therefore, the purpose of this research was to explore educators' experiences when applying critical thinking during their lesson. This qualitative study was conducted with purposive sampling technique as a means of data collection. Data was collected through in-depth interviews with seven respondents (four teachers and three lecturers in Chemistry education) who have more than five years of experience in the academic field. The transcripts from the interviews were analyzed thematically to discover challenges in implementing critical thinking skills. The findings indicated that myriads of challenges experienced by the respondents' observations in employing critical thinking skills during teaching and learning lessons including not enough knowledge about critical thinking skills and students' relying on their teachers to think.

Keywords: Critical Thinking Skills, Teaching and Learning, Challenges

Introduction

Education plays an important role in nurturing the next generation with knowledge, skills, and competencies that are necessary for future workforce development. Thus, the first step is to integrate critical thinking skills, which are among the seven 21st century skills that are needed to face the challenges of the modern world. Critical thinking is important because it involves the ability to think clearly and rationally, evaluating arguments and evidence, and making reasoned judgments using appropriate evidence (Ministry of Education, 2018).

Thinking skills are among the aspirations outlined in the Malaysia Education Blueprint (Ministry of Education, 2012). Critical thinking skills were first introduced into the national curriculum through *Kurikulum Bersepadu Sekolah Rendah* (KBSR) and *Kurikulum Bersepadu Sekolah Menengah* (KBSM) in 1994. Following several reforms in the education system, the *Kurikulum Standard Sekolah Rendah* (KSSR) and *Kurikulum Standard Sekolah Menengah*

(KSSM) were established in 2011 and 2014, respectively (Parimaladevi & Ahmad, 2019). KSSM emphasized more on the importance of critical thinking skills in the learning outcomes, especially in chemistry as critical thinking enables students to analyze data, identify patterns, leading to solving chemistry-related problems. Nine critical thinking skills in chemistry were emphasized according to KSSM (Ministry of Education, 2018). They are characterizing, comparing and contrasting, collecting and classifying, sequencing, arranging by priority, analyzing, detecting bias, evaluating, and drawing conclusions. Further explanation is given for each skill such as evaluation requires students to make considerations and decisions using knowledge, experience, skills, and values, and providing justification (Ministry of Education, 2018).

In order to foster these skills among students, critical thinking is encouraged to be integrated during lesson through various teaching approaches such as problem-based learning (Uliyandari et al., 2021), project-based learning (Alawi & Soh, 2019), and guided inquiry learning (Maknun, 2020). Later, higher order thinking skills questions were introduced in *Sijil Pelajaran Malaysia* (SPM) starting from 2014 with 20% higher order thinking skills questions were asked, aimed at testing the candidate's ability to use skills in applying, analyzing, evaluating, and creatively and innovatively generating ideas in the process of solving problems systematically in new situations and real life (Ministry of Education Examination Board, 2023). Gradually, the percentage of higher order thinking skills questions increased, with 50% higher order thinking skills were asked in SPM 2023. Note that terms such as higher order thinking skills, critical thinking, good thinking, logical thinking are widespread and often used interchangeably (Schulz & FitzPatrick, 2016; Yusoff & Seman, 2018).

However, according to the data from Ministry of Education Examination Board (2023), the overall performance of the SPM candidates is at a minimum proficiency level in higher order thinking skills questions. This is appalling considering higher order thinking skills questions had already been introduced in SPM since 2014 and teaching strategies that can foster critical thinking skills within students had been encouraged, therefore improvements on candidates' performance were to be expected. Are there any issues faced by educators when incorporating critical thinking skills in their lesson, especially in a difficult subject of chemistry?

Therefore, this study was conducted to explore educators' experiences and thoughts regarding the challenges they experienced when implementing critical thinking skills during chemistry lessons.

Methodology

This study was conducted using qualitative method. Semi-structured interviews were employed to gain deeper understanding about teachers' and lecturers' experience in practicing critical thinking skills during lessons. The interview protocol was developed and sent to two experts for validation. Four chemistry teachers and three chemistry education lecturers with experience of more than five years in teaching were selected purposely as respondents. Details of each respondent were shown in table 1 below. In-depth interview was conducted through Google Meet due to the diverse demographic between each respondent. The data then were analyzed using thematic analysis by closely examined the data to identify common themes that come up repeatedly (Jowsey et al., 2021). Various strategies such as member

checking, peer examination, and triangulation were conducted to ensure the validity of the finding (Merriam, 2009; Cresswell, 2014).

Table 1
Details of the Respondents

Types of respondents	Code name	Institution	Field	Experience
Teachers	RT1	Institution 1	Chemistry	More than 10 years
Teachers	RT2	Institution 2	Chemistry	More than 10 years
Teachers	RT3	Institution 3	Chemistry	More than 10 years
Teachers	RT4	Institution 4	Chemistry	More than 10 years
Lecturers	R1	Institution 5	Chemistry Education	More than 5 years
Lecturers	R2	Institution 6	Chemistry Education	More than 5 years
Lecturers	R2	Institution 7	Chemistry Education	More than 5 years

Findings

The analysis of the findings revealed challenges faced by educators in embedding critical thinking skills in classrooms. Seven themes were identified from the data; difficulty in encouraging students to think, reliance of teacher/facilitator to think, syllabus and abstract nature of chemistry, gap between theory and practical, not enough knowledge, long and continuous process, and environment of the classroom.

1) Difficulty in Encouraging Students to Think

Critical thinking involves skills such as analysis, evaluation, and explanation (Facione, 1990, 2015). Students may find it challenging to move beyond surface-level understanding and memorization to engage deeply with content and apply it critically, as observed by R3, *"Based on my experience…you know like organizing…programs like workshop with the students, and what I find is…they actually lack critical thinking like…when you give them…new assignment for them to solve, they cannot…I would say that they…might not have enough exposure."*

R3's observation when conducting workshop that offers hands-on experiences that encourage students to think critically shows the students' difficulty in handling new assignments that requires them to analyze and evaluate the task at hand. This difficulty suggested that students may not have exposure to conduct critical thinking skills especially when presented with new assignments, therefore they might find it daunting to approach the assignments accordingly. RT1 concurred, stating that *"for high performance students, they could answer critical thinking questions well and we could let them explore things themselves, but for low performance students, we have to adjust the questions to easy questions and guide them one by one."* RT2 also shared the same opinion, stating that *"students often don't answer what is being asked, and instead they waited for us to think."* This indicates that students struggle to provide answers, especially critical thinking questions.

2) Reliance of Teacher/Facilitator to Think

Another challenge faced by teachers when implementing critical thinking during lesson is students' reliance on the teacher/facilitator to think. R3 shared her observation regarding this phenomenon, "*For example, they have to… discuss among themselves, they have to… analyse the situation. And somehow, they have to solve problem and make decision, but they are not able to do it well without the teacher's guidance."* R3 noted that students were required to discuss among themselves (about their tasks) and analyze the problem. However, the students struggled to solve problems and make decisions on their own and instead asking for some guidance. This indicates that the students were unable to apply critical thinking autonomously and instead relied heavily on teacher guidance to navigate the problem-solving process.

R3 further elaborated her observation, "*I organized a workshop among the students especially the junior level. So umm… we trained them in a way they have to come out with a… one innovation… as the output of the programme. So… without the guidance from the facilitator… When we ask them question, we guide them… to solve the problem umm… and I mean like… in STEM, there is also a component of sciences. We somehow ask them to apply their… knowledge, umm… like it's quite general science. So I think umm... they are having difficulties, they cannot… come up with the ideas, or they cannot solve the problem. So that's what I found.* R3 organized a workshop with the goal to encourage students to innovate as the outcome of the program. The objective suggested an emphasis on fostering critical and creative thinking skills among participants. Despite that, R3 noted that students struggle to generate an idea or solve problems without guidance from their facilitators. This highlights dependency on teacher or facilitator to navigate problem-solving process.

3) Syllabus and Abstract Nature of Chemistry

The objective of the curriculum is to impart knowledge and also essential skills such as critical thinking skills within students. However, teachers faced challenges in finding balance, as mentioned by R2,*"Our curriculum messes with teachers minds because they think that they have to finish you know… syllabus within certain time."* The statement from R2 highlighted the difficulty between the need to finish the syllabus within a specific timeframe and following the curriculum requirements. When teachers are compelled to strictly follow the timelines, there may be a tendency to prioritize content delivery, therefore the need to cultivate critical thinking skills might take a back seat. R2 further added, "*… If I'm a teacher, I want to finish the syllabus. If I don't finish the syllabus, I feel very guilty, you know."* The excerpt above shows that despite being aware of the need to foster critical thinking skills, a compromise needed to be done due to the guilt of not finishing the syllabus, therefore would lead to a focus on covering content rather than delving into development of critical thinking. This issue was also observed by RT3,*"We want students to develop 21st century skills, but many teachers prefer chalk and talk"*

When asked to elaborate further on the reason why, RT3 explained, *"They said it's to finish the syllabus."* RT3's observation was aligned with RT2's experience, *"To finish everything (content) in one hour, I can't. So sometimes, as a teacher, we have to focus on finishing the syllabus…Not that we don't want to practice critical thinking, but it takes time".* RT2 further elaborated that *"….in subjects like chemistry, we deal with abstract concepts. For instance, when teaching chemical reactions, it's not just about presenting A+B becomes C. We need time*

to explain how the reaction occurs, like how hydrogen ions interact in an acid-base reaction. But the syllabus is packed, and we often find ourselves rushing to cover all the materials. This makes it difficult to incorporate activities that foster critical thinking."

RT2 explained that exam-oriented mindset might influence how teachers conduct their lesson. *"Sometimes…for them to practice that (employing critical thinking) is hard, they still focus on exam…"*

Apart from finishing the syllabus, the subject chemistry itself is already challenging due to its abstract nature since it involves concepts that are not seen with naked eyes like atomic structures, chemical bonding, and chemical reaction as described by R1, "*… The challenges to integrate critical thinking into chemistry. Firstly, is how you want to encourage students to think. That is the most important part. Chemistry is involved in a very abstract concept, so, the students are not really keen to know about chemistry. Then how do you want to encourage students to think deeply, to think in a critical way in chemistry.* R1 emphasized the difficulty of motivating students to think deeply and critically about chemistry. This challenge stems from the abstract nature of chemistry, which can be challenging to grasp without a strong foundation which might lead to disconnect, and they might struggle to see the relevance of critical thinking skills in this context. RT4 shared the same sentiment, "*Chemistry is among hard subjects to learn. The challenge…When we see the nature of chemistry itself, it is abstract…"*

4) Gap between theory and practical

Another challenge when fostering critical thinking that should be taken into consideration is the gap between practical application and theoretical knowledge of critical thinking in chemistry. R2 shared her insight, "*I think we kind of like overstimulate our teachers and frighten our teachers with terms you know like oh "OK for critical thinking you have this five different." If a teacher… even if I'm as a teacher and if I see those five components, I think I'll give up.* R2 highlighted the approach of critical thinking as a series of steps which can be overwhelming due to too much information on the skills needed for teachers to cultivate critical thinking skills. This issue might discourage teachers from integrating critical thinking into their lessons.

In addition, some teachers might not be using *Dokumen Standard Kurikulum dan Pembelajaran* (DSKP) as reference for their lesson. This phenomenon was observed by RT3, *"There is so much information inside DSKP. The Bloom taxonomy, critical thinking, they are all already there. But the problem is, teachers don't read DSKP…"* DSKP is designed to provide a structured approach to curriculum, a much-needed resource for teachers to enhance their teaching strategies and make the lesson more effective. Failure to do have resulted in teachers unable to develop assessments that are aligned with learning objectives and standards, as observed by RT3 above and RT2,*"…if they(teachers) don't know DSKP, it's a mistake"*

5) Not Enough Knowledge

Misconceptions on critical thinking can impede development of critical thinking skills in education. R2 shared her experience on how her son once viewed critical thinking,*"My son… I think he was in Form 4, Form 5 and he came back home and he told me, "Mom, I'm going to*

fail my physics." And I asked "Why? Why are you going to fail your physics? You haven't even sat for your physics paper yet." Then he said, "You know there's KBAT (HOTS)," and I was that time haven't heard of it, so I said "KBAT? So what is so difficult about it?" He said, "Oh, my teacher said there's more than one answer." And in my head, I'm thinking, "OK. Look, for my entire life, school life, teachers always expected me to find one answer. Now your teacher is giving you, you can choose a few answers. Don't you think your chances of getting it right, it'll be much higher?" Then he said like, "No, no, my teacher said we all going to fail."

The student's belief on there should be only one correct answer reflected a common misconception of what constitutes critical thinking questions and answers. This might be due to his experience throughout his school year in which he had been conditioned to believe that success in examinations depends on finding the "right" answer stated by teachers or textbooks. In critical thinking assessment, students are encouraged to consider various solutions, interpretations, and giving justification on their approaches to the problems. This can be unsettling for students who are accustomed to straightforward questions with definitive answers which require them to analyze, evaluate, and justify their answers based on reasoned arguments rather than simply recalling facts and information. The misconception led him to fear of failure and might perceive that critical thinking assessments as more challenging and riskier.

It's interesting to note how the teacher mentioned that the students would all fail. This implies that the teacher might have a preconceived bias on critical thinking itself and believing that their students would not be able to succeed.

Another issue that hindered implementation of critical thinking in chemistry was misconceptions on the cognitive skills of critical thinking. Educators as the executioner in curriculum play a big role in ensuring that the objectives of the lesson when cultivating critical thinking among students are achieved. In order to do so, they must have a good grasp on how to implement the skills during lessons. However, the finding revealed that some misconceptions about what constitutes critical thinking might presence, as observed by R2, *"I think the problem is… I mean I have seen teachers, they give questions like, "OK, should a student eat, should a student eat junk food or eat a well-balanced diet." You are asking the students to evaluate but there is a clear-cut answer to it. Of course, nobody's going to ask a child to eat junk food. So even though the students are doing evaluation, and it looks like… I put in inverted commas "evaluating question", but there's actually no evaluation done, in that sense, because everybody knows you have to choose the balanced diet. So, I think many of us are behind the assumption, "Oh, I'm actually doing evaluation skills, you know, because I asked my students to choose between balanced diet or junk food. So, they have to evaluate the situation and let us know." But for me, I think no, it's such a clear cut. There are no evaluation skills needed in it."*

The excerpt raised a point on how misconception might have occurred when implementing critical thinking skills during lesson. R2 explained that during her observations, teachers posed a question that appears to require evaluation. For example, asking students whether they should eat junk food or a balanced diet. Despite asking students to evaluate which foods are supposedly better, this type of question does not challenge students to critically analyze information because "eat a balanced diet" is universally accepted as correct.

R2 believed that these questions do not require evaluation and instead merely test students' ability to recall or state what is already known to be the correct answer due to "clear-cut" nature of the question.

Another issue is when teachers were unsure about higher order thinking skills, as stated by RT3, "*…Teachers don't really see higher order thinking skill. One teacher asked me, "If I change this (referring to one of higher order thinking skills)" I told the teacher, "When you asked them to compare and contrast, that's higher order thinking skills."* The excerpt above indicated that some teachers may not fully grasp the concept of higher order thinking skills (by extension critical thinking), therefore it might lead to ineffective teaching strategies. By asking to compare and contrast, teachers are encouraging analysis and evaluation, key components in critical thinking.

This observation was also mentioned by RT4,*"Sometimes when we ask the teachers critical thinking, they are unable to give those examples like classifying and so on. They've done it before during lesson, but they don't know that those are critical thinking."* Meanwhile, some teachers believed that critical thinking questions mean asking hard questions, as observed by RT3 when she shared how a teacher that she met mentioned the difficulty of asking critical thinking questions,*"…the questions do not necessarily have to be hard. Questions involving application and above are considered critical thinking. And the teacher said, "Oh, that easy?"* The excerpt, *"Oh, that easy"* indicated that some teachers believed that it was hard to construct critical thinking questions.

6) Long and Continuous Process

Cultivating critical thinking can be challenging when the effect cannot be seen quickly. Therefore, R3 stated that developing critical thinking among students should start early, *"It's a long process. And it has to be, it has to start early."* R2 concurred with this viewpoint and stressed on the importance of starting early,*"It's not easy to have this kind of thinking skills and all and these thinking skills must come from primary school, kindergarten and all that, you know."*

RT1 concurred, stating that, *"if they were exposed early on, it makes the integration better since they were exposed early. That's why I asked the school to teach science in Form 1, so that I can expose critical thinking early."* This showed that fostering critical thinking couldn't be done within a short span of time. The long and continuous process of developing critical thinking skills can be challenging as it requires consistent effort over an extended period of time from all levels of educational systems. Concerted effort from all levels of the system could ensure that the progression remains steady and consistent throughout students' educational journey.

7) Environment of the Classroom

Another challenge that can hinder the development of critical thinking in lesson is the environment of the classroom, as mentioned by R2, *So I don't know maybe the class number, you know, I think some of the overseas schools they have like teacher assistants… Maybe the number of classes the students are too big. I mean, I sympathize with the teachers nowadays.* Big classrooms can hinder individualized attention and guidance from the teacher, therefore limit opportunities for meaningful students' participation. R3 shared the sentiment, *Problem*

that with our student is a chance, the opportunity for them to practice umm… this critical thinking skill is a main challenge.

As highlighted by R2 and R3, the effectiveness of critical thinking development within lessons is influenced by the environment of the classroom. A classroom with a large number of students would reduce the active participation and interactions between teachers and students, and that might inadvertently reduce students' opportunities to practice critical thinking as the lesson becomes more teacher oriented. This would lead to another issue, as the environment of the classroom becomes too authoritative, as mentioned by R2, *Because for them (the students) to be critical, they must feel safe, you know, if they feel the environment is too authoritative, they will be waiting for what the teacher will say. They don't want to give their ideas, they don't want to give reasons why they think like that, so that becomes an issue.* When the environment becomes too authoritative, students would not feel safe to participate actively, as they might perceive that there is little room for discussion. Instead, students would focus more on conforming teachers' answer for the fear of being wrong. This would likely result in students to wait for teachers' input rather than exploring the ideas or articulating and sharing their thoughts. Eventually, development of critical thinking skills slows down as students stop practicing critical thinking skills.

Discussion and Conclusion

This study was conducted to explore the challenges faced by secondary school chemistry teachers and chemistry education lecturers in cultivating critical thinking skills in chemistry during lessons. The analysis of the data revealed that challenges these educators observed and faced are difficulty in encouraging students to think, reliance of teacher/facilitator to think, syllabus and the abstract nature of chemistry, gap between theory and practical, not enough knowledge on what constitutes critical thinking, wrong understanding on cognitive skills of critical thinking, long and continuous process, and lastly environment of the classroom.

Encouraging students to think independently is one of the significant challenges. Dependency on teacher or facilitator guidance could stem from a lack sufficient exposure to tasks that encourage critical thinking. A study conducted by Yusoff and Seman (2018) showed that teachers always asked lower order thinking skills questions and spend more time on asking factual or recalling questions during lesson. This could be due to teachers not knowing questioning techniques and concepts of Socratic questions (Seman et al., 2017). It also could be due to teachers' insufficient knowledge regarding what constitutes critical thinking that is evident in the study conducted by (Seman et al., 2017). The gap between theory and practical application might have led to misunderstanding or misconceptions on the nature of cognitive skills required for critical thinking, causing educators to unable to employ effective strategies to integrate critical thinking in chemistry.

In addition, the syllabus and the abstract nature of chemistry pose another challenge. Chemistry involves complex and abstraction that can be difficult for students to understand and visualize it (Rusli & Ibrahim, 2021). Furthermore, focusing on finishing the syllabus can leave little room for the exploration needed to develop critical thinking skills in chemistry (Karpudewan & Kulandaisamy, 2018). Therefore, educators must find ways to integrate critical thinking activities within the constraints of syllabus and that can connect through the

use of real-life examples such as project-based learning that can connect abstract concepts of chemistry to practical applications such as the application of green chemistry in lesson (Karpudewan & Kulandaisamy, 2018) or separation of mixtures based on physical and chemical properties (Insani et al., 2018). Furthermore, the application also should be done in a less authoritative environment. This is because students who are given more autonomy during lessons perform better (Bara & Xhomara, 2020).

Developing critical thinking skills is a long and continuous process that requires sustained effort and practice for a long period of time. Unlike factual knowledge that can be quickly memorized, critical thinking skills develop gradually through repeated application and reflection through concerted effort from all parties involved. It can be challenging if critical thinking is introduced at later stages as the performance decrease with increasing age (Denney, 2007), thus delaying the development of critical thinking among students.

In conclusion, implementing critical thinking in chemistry can be challenging due to myriads of reasons. Educators must navigate the difficulties related to curriculum constraints, the abstract nature of chemistry, gaps in knowledge, and also students' attitudes in classroom. Addressing these challenges can help educators better equip students with critical thinking skills in chemistry.

Limitation

The research focused on a small sample of four chemistry teachers and three chemistry education lecturers as the respondents. Furthermore, the research relies on the personal perceptions and experiences of the respondents which may be subjective, therefore the experiences and perceptions of this group may not reflect those of educators in different contexts.

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