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Mapping Chemistry Learning Barriers in the Context of Islamic Higher Education: Insights from Pre-Service Chemistry Teachers

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Abstract
Learning barriers continue to be significant challenges for students in higher education, yet little is known about how these barriers are experienced within Islamic university contexts. This study investigates such barriers among pre-service chemistry teachers in an Islamic university background. This study was employed a qualitative study. Data from participants were thematically analyzed to identify recurring patterns of difficulty. The results indicated that organic chemistry was the course most frequently perceived as difficult according to Pre-Service Chemistry teachers (PCTs) in an Islamic University. Building on this finding, thematic analysis identified four main themes as underlying barriers to learning organic chemistry: (a) intrinsic content challenges, (b) high cognitive demands, (c) motivational barriers, and (d) lack of supportive learning tools and approaches. These results indicate that pre-service chemistry teachers' barriers in learning chemistry are multifaceted, extending beyond content knowledge to include cognitive and affective dimensions as well as contextual limitations in Islamic higher education The recommendation from this study is to design pedagogical strategies that infuse Islamic values into science learning to foster motivation and to offer accessible learning tools, such as tangible 3D molecular models and digital simulations, to support deeper engagement with complex concepts in organic chemistry courses.

Keywords: Learning barriers, Pre-service chemistry teachers, Islamic higher education, thematic analysis.

Introduction

Science students in Islamic universities often come from religious educational backgrounds such as *ma'had or madrasah*. Rather than being seen as a limitation, this background plays an important role to provide a potential insight for science educators to strengthen the contextualization of scientific learning. Many research found that religiosity influences learning motivation through students' positive reactions to educational experiences (Zumrah et al., 2020). The role of interpersonal religiosity in sustaining academic motivation and goal setting (Ramadhan, 2022). At the same time, when students transition into science courses such as organic chemistry, they often face challenges due to the abstract nature (Bongers et al., 2020) and representational complexity of the subject (Hutchison, 2017). Without sufficient support or contextualization, these difficulties may overshadow the motivational benefits of their prior educational experiences, leading to significant learning barriers. Integration of Islamic values along the learning process plays an important role to provide a spiritual boost to the student learning process *(afala ta'qilun, afala tatafakkarun)*, as well as instilling the mindset that difficulties in learning are part of scientific jihad (Sumin et al., 2023).

Scientific learning, especially in chemistry, biology, and physics, is part of broader reading of the cosmos (Zahoor & Khan, 2023), especially organic chemistry. Organic chemistry is essential in developing materials for modern life, from drugs to fuels and plastics (Holme, 2023), but sometimes it quite challenging because of its abstract nature. In the context of Islam, the abstract nature of these molecules can actually be a good opportunity to practice *tadabbur* (تدبر) and *tafakkur* (تفكر), because many kauniyah verses in the Qur'an are also abstract but full of meaning (An-Najjar, 2006; Setyawan, 2022).

Chemistry pre-service teachers who have a correct understanding of chemical concepts will be able to convey the correct information to students studying chemistry. Building a strong foundation of understanding for chemistry pre-services teachers is an important thing to do (Barke et al., 2019). Teachers who have a strong understanding of chemistry content will of course be able to provide a strong foundation of understanding for chemistry learning to the students they will teach in the future (Kolomuç & Tekin, 2011). It's crucial to comprehend the challenges encountered by pre-services chemistry teachers (PCTs) for enhancing the quality of chemistry education. Chemistry poses challenges for students due to its abstract nature (Fitriani et al., 2022) and complexity (Haas et al., 2024).

Most studies on chemistry learning barriers have primarily focused on cognitive difficulties, often identified through achievement tests or diagnostic assessments. While such approaches provide valuable insights, very few have examined students' lived experiences through qualitative approaches such as thematic analysis, particularly in contexts where learners come from distinct cultural and religious backgrounds. Therefore, this study has two main purpose, first, it seeks to identify which courses are perceived as most difficult by pre-service chemistry teachers in an Islamic university. Second, it aims to explore in greater depth the underlying barriers contributing to these difficulties, using thematic analysis to map the factors that shape the barriers.

Method

This study employed qualitative case study research to explore learning barriers in learning scientific concepts among pre-service chemistry teachers at an Islamic university in Central Java, Indonesia. Case study allow researchers to describe in depth in qualitative research that focuses on in-depth exploration in a bounded system in a real context (Creswell, 2013). Participants were pre-service chemistry teacher from Islamic University in Java, Indonesia. Participants came from different cities across Java, with the highest number from Semarang, Tegal, and Kendal. Participants were selected using purposive sampling with the following inclusion criteria: (a) enrolled as pre-service chemistry teachers at the Islamic University, (b) had completed all chemistry courses, (c) comes from Islamic background. Students who are not willing to participate in the in-depth interview are freely to decline without any consequences. Fifty-four students invited, there was fifty-three who agreed to participate while one declined due to health treatment reason. Participants profile presented in Table 1.

Table 1. Demographic of Participants

Aspect	Categories	Frequency (n)	Percentage (%)
Gender	Female	49	92.45%
	Male	4	7.55%
Age (years)	Mean	20.09 ± 0.90	-
	Range	18-24	-
Province	Central Java	33	62.26%
	East Java	12	22.64%
	West Java	1	1.89%
	DKI Jakarta	1	1.89%
	Yogyakarta Special Region	1	1.89%
Total	Participant	53	100%

Table 1 provides an overview of the participants' demographic characteristics. The majority of participants were female (92.45%), while only 7.55% were male. The participants' ages ranged from 18 to 24 years, with a mean age of 20.09 years (SD = 0.90), indicating that most were in their early twenties. In terms of regional background, participants predominantly came from Central Java Province (n = 33; 62.26%), followed by East Java (n = 12; 22.64%). The remaining participants were from West Java, DKI Jakarta, and Yogyakarta Special Region, each contributing one participant (1.89%). This distribution reflects the demographic context of the Islamic University where the study was conducted, which primarily serves students from various parts of Java.

Data were collected through open-ended questionnaires and in-depth interviews. 53 participants were purposively selected and provided data through in-depth interviews. The initial open-ended question asked participants to identify what courses they found most difficult. This was followed by semi-structured interviews to explore the underlying reasons. To explore the reason behind the difficulties, in-depth interviewed was follow up to get more deeper understanding the reason behind the difficulties. Participants were visited in person at their respective locations (such as boarding houses, campus facilities, or other agreed meeting places) to conduct in-depth, face-to-face interviews. The interview protocol included guiding questions such as: *"What courses is the most difficult during your study in Islamic University? Which topics in that courses did you find the most difficult, and why?"; "What kinds of support or resources do you wish had been available?".* These interviews were conducted in mixed Bahasa Indonesia and Java language, with each session lasting approximately 30–45 minutes. All interviews were audio-recorded, transcribed, and subsequently imported into NVivo 12 software for thematic analysis. The transcription then were analyzed using a 6-phase thematic analysis approach that refers to (Braun & Clarke, 2006, 2012), as presented in Figure 1.

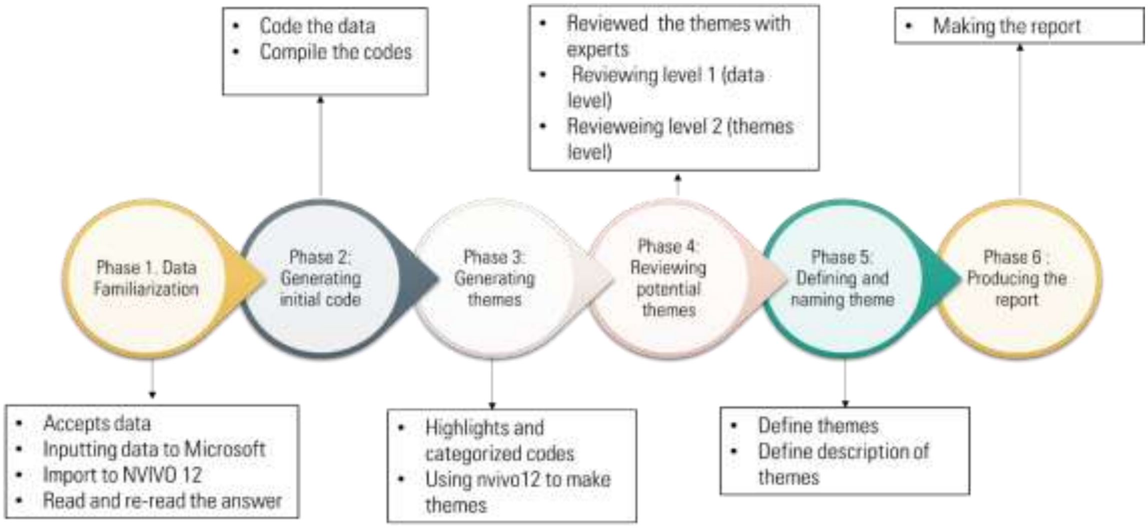

Figure 1. Thematic Analysis Process

Each phase was carefully followed throughout the data analysis process, from phase-1, familiarizing with the transcribed data, until determining and naming the final themes, and finally, to the phase-6 producing the report. This systematic procedure ensured the reliability and thoroughness of the thematic analysis.

Results and Discussion

Recent study shows that students' cultural background plays a central role in shaping how they interpret scientific concepts and engage with science learning. For example, research on Indigenous Knowledge Systems (IKS) demonstrates that learners' prior cultural experiences influence not only how they make sense of scientific ideas but also the kinds of difficulties they encounter in science classrooms (Mukwambo et al., 2023). The study highlights that when science instruction is disconnected from students' cultural background, learners often struggle with abstract concepts, reduced motivation, and perceive science as irrelevant to their lived realities. Align with that finding, Al-Jabiri's critique that intellectual stagnation can arise when one way of knowing dominates too strongly, whether it is the irfani approach that focuses on spiritual contemplation, the burhani approach that privileges analytical reasoning, or the bayani approach grounded in textual interpretation (Chasanah & Mustaqim, 2023).

Students who come from religious backgrounds are often accustomed to thinking within the *bayani mode*, which emphasizes spiritual reflection and meaning-making (Malik & Barizi, 2022). In contrast, chemistry learning typically operates within the *burhani mode*, which prioritizes analytical reasoning and symbolic representations. When such connections are limited, abstract topics such as organic chemistry may feel irrelevant to students' worldview, contributing to motivational barriers. This is reflected in the statement of Student-18, who explained why they found organic chemistry difficult: *".....I often wonder, is there any benefit for my future life or even for my afterlife?".* Therefore, this study seeks to explore the learning difficulties faced by pre-service chemistry teachers (PCTs) in an Islamic university to understand these hindering factors. Interestingly, even though the Qur'an contains numerous verses that refer to scientific phenomena (An-Najjar, 2006), these insights are underexplored in science classrooms. Yet several studies suggest that spiritually grounded contemplative practices can help reduce cognitive and emotional barriers in science learning, as shown in the Pakistani (Zahoor & Khan, 2023). This gap becomes even more significant in

Islamic universities, where chemistry students are expected not only to master disciplinary content but also to connect scientific knowledge with moral and spiritual values (Taufik et al., 2023).

The initial work attempted to explore the perception of participants regarding the most difficult of certain chemistry courses. PCTs were asked to give answers freely according to their opinions and it was emphasized that their answers would be kept confidential from other parties. This initial step was taken to explore pre-service chemistry teachers' perceptions of the difficulties of certain courses. Based on the answers that had been obtained, the researcher transcribed then entered the data into Excel and calculated the most difficult course appeared. Among all chemistry courses mentioned by the participants, organic chemistry stood out as the most frequently perceived as difficult, cited by 35.8% of the students (19 out of 53) during their time study at Islamic university. This was followed by structure elucidation course (14 out of 53 answers), physical chemistry course (12 out of 53 answer), instrumental chemistry analysis courses (3 out of 53 answer), inorganic chemistry (3 out of 53 answer), biochemistry (1 out of 53 answer), and basic chemistry (1 out of 53 answer). This pattern aligns with previous research showing that organic chemistry is regarded as one of the most challenging subjects due its high representational complexity and the cognitive demands associated with drawing and interpreting three-dimensional molecular structures on a two-dimensional surface (Cormier & Voisard, 2018).

To further explore why these courses were perceived as particularly arduous, the responses were examined thematically following the six-phase framework proposed Braun & Clarke (2006). In phase 1, the study attempted to engaged in a process of familiarization with the data by continuously reviewing the participants' responses. Following this phase, a preliminary coding procedure was conducted on the participants' responses. The initial coding technique in this study was supported by NVIVO 12, which facilitated the generation of numerous codes during the early stages of analysis. In this phase, participants' open-ended responses were segmented and categorized into nodes representing emerging concepts.

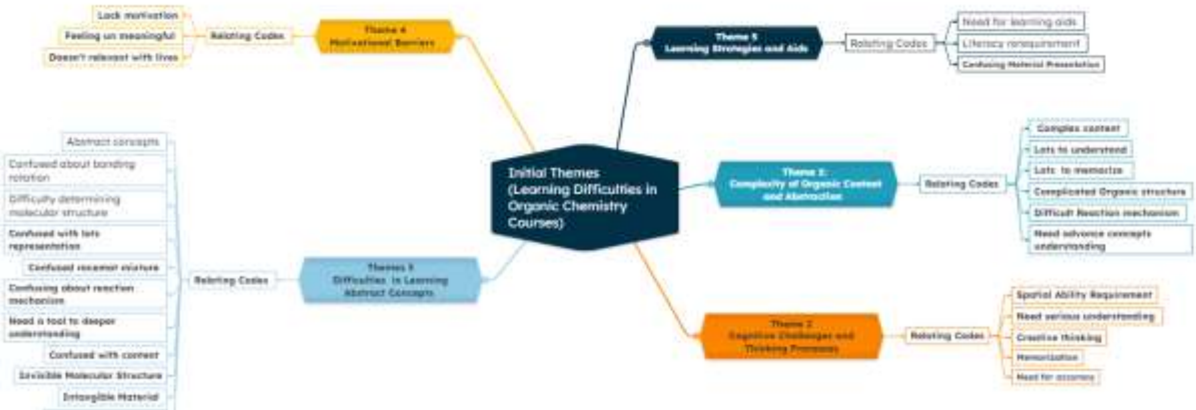

Figure 2. Visual Mapping of Initial Themes and Their Related Codes

As seen at Figure 2, each node corresponds to a specific theme or idea drawn from the students' narratives. For instance, nodes such as *"Confuse with 3D molecular structure" (Student-7, Student-15)*, *twisting molecules (Student-8)* reflect difficulties in visualizing molecular structures and comprehending with spatial ability of molecular structures, indicate that students face a heavy cognitive load when attempting to translate between macroscopic, submicroscopic, and symbolic representations. This aligns with Johnstone, (1993) well-established triplet model, which argues that learners often struggle when required to coordinate multiple representational levels simultaneously. This is aligns with the statements spatial reasoning, representational fluency, and multilevel conceptual integration contribute to the high cognitive load (Malanchini et al., 2020). These initial coding process revealed challenges encountered by students in mastering organic chemistry, including the complexity and abstract nature of the topic, the necessity for comprehensive knowledge, lack of motivation, variability in representation, and other technical obstacles.

Table 2. Initial Themes and Description

Initial Themes	Description
Theme 1: Complexity of Organic Content and Abstraction	This theme represents the idea that organic chemistry is difficult because it covers topics that are complicated, abstract and hard to understand.
Theme 2: Cognitive Challenges and Thinking Process	This theme shows how hard it is to think and remember things when you are studying organic chemistry.
Theme 3: Difficulties in Learning Abstract Concepts	This theme underscores the difficulty of acquiring knowledge regarding abstract or not clearly observable concepts.
Theme 4: Motivational Barriers	This theme especially addresses the emotional and motivational aspects that influence the process of learning.
Theme 5: Learning Strategies and Aids	This theme addresses the requirement for supplementary resources, approaches, or strategies to effectively promote the process of learning.

In Phase 3, existing codes were reviewed and grouped into potential themes. This process led to the identification of five initial themes, which are presented in Table 2. Each theme is supported by a cluster of related codes derived from the preliminary coding phase. Statements such as *"....it's difficult because the material is abstract, cannot be seen directly, but we are asked to predict the outcome (Student-8-interview)"* reflect students' struggles with learning concepts that operate at the submicroscopic level. These difficulties correspond to Theme 3 and also relate to Theme 1, indicating that students' challenges emerge not only from the invisible nature of chemical phenomena but also from the representational complexity of organic chemistry content. Following the identification of initial five themes, the next step is to review initial themes to ensure relevance, coherence, and clarity to answer the research questions. In this phase, the research team and panel of experts re-identified the initial themes to identify whether there is still redudancy between themes. This step is done by rechecking the themes that have been produced, together with experts.

Figure 3. Final Themes

Figure 3 presents the refined thematic map that emerged after reviewing and validating the initial themes. During this process, several adjustments were made to enhance conceptual clarity and minimize redundancy. Fisrt, theme 3 from the initial analysis, which addressed Difficulties in Learning Abstract Concepts, was found to overlap significantly with Theme 1, which concerned Complexity of Organic Content and Abstraction. Upon reviewing these themes, the research team noted that both categories captured similar aspects of students' struggles, particularly those related to the inherent complexity, abstractness, and representational demands of organic chemistry. Because the conceptual boundaries between the two themes were largely redundant, they were merged into a broader and more coherent category, namely "Intrinsic Content Challenges in Organic Chemistry". Second consideration, the decision to maintain "Motivational Barriers" as a separate theme was made based on input from the expert panel. Although motivational issues may influence cognitive engagement, they represent distinct affective or emotional dimensions of learning.

Keeping this theme separate allows for a more nuanced understanding of non-cognitive factors that hinder students' mastery of organic chemistry.

Taken together, these interpretations indicate that chemistry learning difficulties among PCTs in Islamic universities are shaped by the interaction of cognitive load, epistemological expectations, and affective engagement. Based on the final stage of the thematic analysis process, 4 main themes were obtained, namely:

1. *Intrinsic Content Challenges*

This theme highlights how the intrinsic characteristics of organic chemistry, such as its complexity, abstractness, and multiple-level representations (MLR), posed significant cognitive barriers to participants. Example nodes from Figure 4 like "*abstract content", "difficult to understand", "molecular spatial ability"* represent the intrinsic characteristic of organic chemistry. This aligns with Cognitive Load Theory (CLT), which posits that challenging content needs cognitive effort and can lead to the overload of working memory (De Jong, 2010). To minimize the burden on working memory, it is advisable to employ several sensory channels for complicated concepts (Mayer, 2024; Mayer & Fiorella, 2022). Multilevel Representation (MLR) in chemistry relating with the macroscopic level (observable phenomena), submicroscopic level (invisible molecular and particulate structures), and symbolic level like chemical formula (Gilbert & Treagust, 2009; Talanquer, 2011). The cognitive challenge lies in the need to fluidly translate between these levels. The difficulties experienced by someone studying organic chemistry often originate not only from within the student, but also external factors that play a role, such as the multidimensional nature of chemistry and complex language (O'Dwyer & Childs, 2017). Organic chemistry as abstract concepts, spatial ability, complicated reaction mechanisms, and various representations that can overload working memory, hindering learners' comprehension and retention of the subject matter (Elford et al., 2022; Qian et al., 2023). Interestingly, several participants expressed the need for tangible molecular models, even though digital simulations were already provided, to better grasp abstract structures and stereochemical representations. This preference highlights the importance of multimodal supports in reducing cognitive load, as physical models enable learners to externalize mental visualizations and strengthen the link between symbolic and spatial representations.

2. Higher Cognitive Demands

This theme focuses on the cognitive capabilities and mental processes for understanding and mastering organic chemistry, including spatial ability, creative thinking, precision, and higher-order thinking. Primary reason for individuals' challenges in mastering organic chemistry is the lack of a problem-solving algorithm, because of the absence of established procedures like those in mathematics or physics, students have to depend on flexibility thinking (Ellis, 1994). This flexibility thinking constitutes a feature of creative thinking (Torrance & Torrance, 1973).

Learners stated that the barrier to this course came from the need for a high level of imagination, such as in sigma rotation. This perspective is in line with the research done by (Salame & Kabir, 2022a), which found that the concept of organic chemistry is challenging due to the necessity of comprehending the spatial configuration of atoms within molecules. Learners expressed the reason why organic chemistry was difficult because it required spatial ability, as stated: *"Sometimes when I'm identifying the racemic mixture from a reaction mechanism, I get confused, because after the attack from behind or the front, the other groups remain upright or shift in the opposite direction"* (Student interview).

The results of the interviews show that the challenge of studying organic chemistry also comes from the need for spatial visual skills so that it requires high imagination. This is in line with previous research who found that stereochemistry is complex because it involves understanding the spatial arrangement of molecules and how it affects their properties (Salame & Kabir, 2022b). Stereochemistry includes the study of isomerism, including geometric isomerism (cis-trans) and optical isomerism related to chirality (Swamy et al., 2018). An overwhelming cognitive load frequently results in mental exhaustion, disorientation, and adversely affects students' academic performance (Harle & Towns, 2011). This findings is inline with (Bhattacharya & Basak, 2024) chemistry learning difficulties due to its need cognitive demands (Fernandes et al., 2021).

3. Motivational Barriers

This theme contains the psychological elements that affect students' engagement, interest, and motivation to learn organic chemistry. For some learners, organic chemistry may appear irrelevant to their lives because of the lack of connection between the subject matter and real-life situations, leading to unmeaningful learning (Rockenbach et al., 2024). This perceived irrelevance may diminish the inner drive to engage with the material. One respondent stated that they were required to live in the ma'had (Islamic boarding program) in their early semesters. Also, the department's program of chemistry education's vision is integrating science and Islam, but the integration of Islamic perspectives was largely absent in science lectures. This disconnect decreases their sense of meaning and motivation in learning. Student explained: *"….sometimes I feel unmotivated because the material is not real, the items are not visible. I often wonder, is there any benefit for my future life or even for my afterlife?"* (Student-18, Interview). Another respondent highlighted the difficulty in visualizing abstract representations: *"… the formulas keep spinning; we are asked to draw and imagine with the eyes placed behind, sometimes in front and that makes me really confused."* (Student-2, Interview).

Science students in Islamic universities often come from religious educational backgrounds such as ma'had or madrasah. Rather than being seen as a limitation, this background can be utilized by science educators to strengthen the contextualization of scientific learning. This perspective aligns with situated learning theory, which argues that learning becomes most effective when it is embedded in social and cultural contexts that are meaningful to learners' lives. Integrating scientific concepts with students' religious values and worldviews can therefore restore meaning, enhance intrinsic motivation, and foster deeper engagement in learning (Thomas et al., 2025). Therefore, lecturer in Islamic universities need to design pedagogical approaches that connect abstract scientific concepts with students' cultural and spiritual worldviews. Practical strategies may include contextualizing chemistry concepts with relevant real-life and Qur'anic examples, and complementing them with multimodal supports such as tangible 3D molecular models and digital simulations. Such integrative approaches can strengthen both cognitive engagement and intrinsic motivation, ultimately improving students' mastery of complex topics like organic chemistry.

Students who feel that chemistry is not helpful for the world or the hereafter show no meaning in learning. Students think chemistry has nothing to do with their afterlife (akhirah). The student's statement that "some of this organic chemistry is not really useful for either my worldly life or my afterlife" shows a negative attitude towards these courses, and this can weaken the student's desire to learn more about organic chemistry. Within the framework of the Theory of Planned Behavior (TPB), perceived behavioral control (PBC) is one of the main determinants that affect the intention to perform a behavior, including the desire to learn (Kenia & Uyun, 2023). Feeling forced to study without understanding in the spiritual meaning of the knowledge has clear impact for learning achievement. This integrated approach can help students to restore their intrinsic motivation. Integrating Islamic values into science lectures is a strategic approach to overcome motivational barriers. When chemistry learning is aligned with students' spiritual worldviews, it can restore meaning, foster intrinsic motivation, and support deeper engagement with complex scientific content.

4. Lack of Supportive Learning Tools and Approaches

This theme underlines the significance of supplemental resources, tools, and pedagogical methods to aid students in overcoming challenges in acquiring information in organic chemistry. The thematic analysis reveals that pre-service chemistry teachers frequently encounter difficulties in organic chemistry owing to insufficient supportive learning resources. As Rahma (pseudonym) explained: *"We mostly study organic chemistry from textbooks, which only provide two-dimensional diagrams, while in this subject we often need to imagine the molecule in 3D".* That perception was in line with the finding from Casselman et al., (2021) that two-dimensional diagrams in textbooks frequently fail to represent the three-dimensional characteristics of molecules. This constraint hinders students' ability to envision and comprehend intricate topics such as stereochemistry, molecular geometry, and reaction processes. In the absence of appropriate tools for visualizing these systems, students may experience disorientation or confusion (Carlisle et al., 2015). This hinder can be overcome by a computer-assisted approach to visualize molecular level in chemistry (Fernández et al., 2019). The absence of learning media becomes an additional burden, especially when it is not accompanied by emotional support or spiritual values. Students need to be convinced that the limitations of tools are not a barrier, if they have the intention, patience, and spiritually strong meaning of learning.

The results also showed that PCTs expressed a desire for a tangible model, that could enhance their ability to demonstrate complex chemical concepts as she sharing her experience of creating molecular models from clay: *"..sometimes to help me, I make a physical molecule model from clay. It helps a bit, but sometimes it bends or collapse, so the shape doesn't stay accurate, I hope in the future there are some physical models that I can hold firmly…".* Previous studies have also proven that the use of physical model has a positive impact on the quality of learning. Another study reported that physical molecular model kits can enhance representational competence in organic chemistry (Stieff et al., 2016). Similarly, the use of visual aids such as jelly and clay has been shown to improve visuo-semiotic reasoning skills (Nkosi & Mnguni, 2020). To foster stronger engagement, these results suggest that combining tangible molecular models with computer based can support visualization skills while also making abstract concepts more meaningful and motivating for learners. The collaboration of these two types of learning media allows students not only to visualize molecules digitally, but also to be able to manipulate tangible molecular models like the products from 3D prints, thus helping students obtain additional sensory tactile features in visualizing three-dimensional molecules. This recommendation supported by the study from neuroscience about mental imagination. Neuroscience study found that tactile stimuli, is able to activate several brain regions, including the primary somatosensory cortex, which plays a role in processing tactile information (Nierhaus et al., 2023).

Chemistry poses challenges for students due to complexity (Haas et al., 2024) and its abstract nature (Fitriani et al., 2022). In the context of Islam, abstraction can be approached through the lens of tadabbur and tafakkur, because many scientific concepts in Islam are abstract but meaningful. Students need to be helped to see that understanding the structure of molecules is also part of understanding the verses of kauniyah. *Tadabbur and tafakkur* can train students to see the relationship between the regularity and uniqueness of organic molecular structure as signs of the greatness of Allah SWT. For example, ants communicate through the specific properties of pheromone molecules. Because each species releases pheromones that are unique to its type and purpose, ants of different species do not share the same nest (Lopes et al., 2023). This phenomenon shows how Allah SWT gives chemical devices to ants as a means of chemical communication, so that ants never get lost into the wrong colony. This approach is able to invite Islamic students at Islamic universities to indirectly meditate, so as to have a further impact in overcoming cognitive and emotional obstacles in learning science. Integrating Islamic epistemology into chemistry education offers a promising avenue for holistic learning.

Many participants expressed a desire for learning approaches that integrate Islamic values or Qur'anic perspectives, so that chemistry is not only cognitively comprehensible but also spiritually relevant. Addressing these barriers requires pedagogical strategies that bridge scientific content with students' cultural-religious backgrounds. Practical steps may include incorporating real-life and Qur'anic examples to provide meaningful contexts, as well as employing multimodal supports such as tangible 3D molecular models and digital simulations to strengthen visualization and conceptual understanding. By integrating culturally responsive and spiritually meaningful approaches with innovative learning tools, chemistry education can foster deeper engagement, enhance motivation, and ultimately improve students' mastery of complex concepts in organic chemistry.

Conclusion

Through thematic analysis, four themes emerged: (a) intrinsic content challenges, (b) high cognitive demands, (c) motivational barriers, and (d) lack of supportive learning tools and approaches. These results indicate that pre-service chemistry teachers' barriers in learning chemistry are multifaceted, extending beyond content knowledge to include cognitive and affective dimensions as well as contextual limitations in Islamic higher education. The results provide insights for designing pedagogical strategies that infusing Islamic values in science leaning to lead inner motivation, and offer accessible learning tools such as tangible 3D molecular models and digital simulations to support deeper engagement for complex concepts like organic chemistry courses.

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