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Research Article

Learners' issues in the preparation and qualitative analysis of salts topics in chemistry: Teachers' perspectives

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ABSTRACT

This study examines learners' issues in learning the preparation and qualitative analysis of salts topic from Malaysian chemistry teachers' perspectives. The researchers adopted a qualitative design and conducted semi-structured interviews with sixteen informants who have experience of teaching chemistry for more than five years. They were selected via purposive sampling. Document analysis was conducted to verify and supplement findings obtained from the interviews. The study reports five issues that emerged from the data analysis: negative perceptions, dealing with the number of information, imagining abstract concepts, mastery of basic knowledge and solving problems, and fulfilling the grading criteria. The study results confirm the unanimity of past studies on students' unfavorable views on these topics and their struggle in learning abstract concepts involved in the salts formation and analysis. Besides, students' issues are also significantly rooted in having weak prior knowledge of salts, affecting their ability to solve related problems. The study suggested that teachers must practice various approaches and strategies deemed effective in aiding learners in learning and be more selective in choosing approaches tailored to the individual students' issues in learning these topics in class.

Keywords: learners' issues in salts topics, preparation of salts, qualitative analysis of salts, teaching and learning in chemistry, issues in learning chemistry

INTRODUCTION

Chemistry is a branch of science that encompasses facts, symbols, structures, and properties of matter and energy. In Malaysia, students have been introduced officially to this subject in form 4 at the upper secondary school level. Gradually, they will learn the fundamental knowledge of chemistry in the sequence of its importance and complexity and apply the basics in the latter part of the syllabus while learning the subject in more depth. However, though most of the topics in the syllabus are connected (Demircioglu et al., 2005), it is common for students to grasp a portion of the content taught. Consequently, it causes them to struggle more as the learning progresses, especially in topics where basic knowledge and skills are essential (Darling-Hammond et al., 2019). For example, when students learn 'preparation and qualitative analysis of salts' topics.

In Malaysia's new form four secondary school standard chemistry curriculum, these two sub-topics introduce to students in chapter 6, acids, bases, and salts. These topics are the continuation of acids base topics where students re-visit the chemical properties of acids and bases that they learned previously but mainly focus on the product of the acid-base reactions - salts. In addition, these topics cover properties of salts, which include aspects like solubility, colors, and reaction to heat or specific reagents–to name a few. The topics were introduced to provide students with the knowledge and skills to test, describe, and conduct related experiments for the preparation and qualitative analysis of salts within the scope of the syllabus. For many years, these topics have consistently been rated as among the most challenging topics by Malaysian students and teachers (Doraiseriyan & Damanhuri, 2021; Osman & Lay, 2020; Ting, 2016). Likewise, past and recent studies from other countries echoed students' similar issues and negative perceptions of learning the topics (Anim-Eduful & Adu-Gyamfi, 2022; Bouabdallah, 2021; Malkoc, 2017; Shidiq et al., 2019; Tan, 2005; Wisudawati et al., 2022).

Nevertheless, what could be the plausible reasons for the root of struggles among students in learning these topics? In general, many researchers emphasized that these topics involve much information and integrate many foundational skills and knowledge in chemistry, such as writing chemical formulae and equations, moles concept, ionic bonding, and acid-base reactions (Napes & Sharif, 2022; Shamsulbahri & Zulkiply, 2021; Tan et al., 2004). Despite these facts, Reif and Larkin (1991) asserted that most students viewed concepts and knowledge related to the topic of salts as a collection of facts and formulae that should be memorized rather than understood to ease them in solving the related problems. In tandem, such proclamation can be found in a study by Doraiseriyan and Damanhuri (2021), which discussed the tendency of students to practice rote learning and remember facts without understanding the abstract concepts in salts topic. Other studies revealed that unfamiliarity with the chemistry concepts in salts topics had led them to memorize chemical concepts in the description of the word but unable to fathom and explain the memorized words (Izzati & Rochmah, 2020; Salame & Nikolic, 2021; Wisudawati et al., 2022).

Studying through rote learning is not the sole issue here; a study by Ting (2016) also found that Malaysian students' mastery level of basic chemistry concepts is considered low, specifically in concepts of salts. With such a loose foundation, past studies asserted that students are prone to hold alternative notions and misconceptions related to basic concepts that manifest more difficulties in learning the subsequent topics that integrate the knowledge in understanding more complex concepts or solving problems (Elham & Dilmaghani, 2019; Salame & Nikolic, 2021; Ting, 2016). In the context of preparation and qualitative analysis of salts, it is evident that students not only struggle to learn the basics topics, but they also found to have misconceptions about the reaction of acids and bases (Damanhuri et al., 2016), ionic and covalent substances (Stojanovska et al., 2017), the concept of salts' solubility (Eisen et al., 2014; Izzati & Rochmah, 2020; Salame & Nikolic, 2021) and salts hydrolysis (Prianti et al., 2020; Shidiq et al., 2019) to name a few.

Additionally, past studies revealed that difficulties in learning salt topics are also rooted in the students' confusion on different levels of chemical representations. For example, a study conducted by Gkitzia et al. (2020) found that high school students have a low ability to move across the three levels of chemical representations, especially in translations concerning the 'chemical compound' and 'aqueous solution' concepts. Likewise, Izzati and Rochmah (2020) investigated students' comprehension and misconception of 'salt solubility' concurred that high school students struggled to comprehend the concept of solubility associated with sub-microscopic level and face difficulties in making a relation between macroscopic, symbolic images and chemical reactions.

Students mainly could reach the macroscopic level (what can be directly seen and tangible) and have problems moving to the sub-microscopic and symbolic levels (Taber, 2013; Upahi & Ramnarain, 2019). With such issues, it is common to see that students struggle to comprehend an explanation that encompasses the dynamic character of chemical processes (Farida et al., 2018). For example, at the symbolic level of chemical representation, students are more likely to understand a formula as representing one unit and interpret the formulas for compounds in an additive rather than an integrated perspective. Besides, in a study by Wisudawati et al. (2022), students struggled to accurately differentiate and use the terms Na+ ions, Cl- ions, H_2O molecules, and CO_2 molecules. In another study, students also experience difficulties interpreting the subscripts and coefficients in a reaction and balancing chemical processes from an algebraic standpoint without considering their' chemical meaning (Sana & Adhikary, 2017). Likewise, in learning about salts, students who have the similar issues mentioned above mostly have problems understanding chemical reactions, writing chemical equations, and understanding the outcome of chemical tests (Anim-Eduful & Adu-Gyamfi, 2022; Bouabdallah, 2021; Farida et al., 2018; Tan et al., 2004).

Furthermore, the particular perspectives of micro and macro-level phenomena in chemistry learning, to a certain extent, contradict learners' intuitive and everyday perceptions (Taber, 2013). In this view, Timilsena et al. (2022) contended that chemistry learning that is not connected to students' daily life contributed significantly to students' lack of understanding and motivation to learn the subject. Comparably, in preparation and qualitative analysis of salts, students do not encounter these topics in everyday life, have no virtual conceptions about the process, and only experience it in the laboratory (Izzati & Rochmah, 2020; Shamsulbahri & Zulkiply, 2021; Tan et al., 2004). Secken (2010), on a similar finding, contended that students have limited ideas about salts and associate the compounds with salts that they commonly use at home.

Another related issue is when students conduct the experimental procedures and record their observations without understanding the reason for using particular reagents in chemical tests and explaining the reactions that had occurred (Shamsulbahri & Zulkiply, 2021). Students' unfamiliarity with the phenomenon creates more reason for teachers to deliver their lessons in a manner that enables students to relate to what they learn and grasp the knowledge fluidly. Miranda and Smaka (2021) concurred that chemistry teaching must be contextualized and integrate theory, practice, and everyday life. It is to improve current practices that frequently emphasize procedural learning more than conceptual understanding while discussing chemistry (Pramesthi et al., 2019), consequently affecting students' understanding of basic chemical principles. For instance, past studies reported that students could not solve problems related to salts topics due to a lack of understanding of the underlying concepts of the chemistry process (Cardellini, 2012; Sana & Adhikary, 2017).

Though salts topics are imperative for students to understand chemistry (Doraiseriyan & Damanhuri, 2021; Osman & Lay, 2020; Treagust et al., 2018), studies about salts mainly discussed as part of research focusing on the teaching and learning of acids and bases. Only a handful of past studies focus on these specific topics at secondary and tertiary levels (e.g., Napes & Sharif, 2022; Osman & Lay, 2020; Pramesthi et al., 2019). Studies focusing on learners' issues related to these topics are scarce, particularly in the secondary education context; hence, venturing into a study that focuses on these topics is deemed significant. Based on these reasons, this study intends to examine learners' issues in the 'preparation and qualitative analysis of salts topics' from chemistry teachers' perspectives. The study's outcome would help teachers and stakeholders better understand how students learn these topics and the strategies that could be adopted to enhance their learning experiences.

METHOD

This study adopted a qualitative research design to examine the issues experienced by secondary school students (learners) in learning the preparation and qualitative analysis of salts in chemistry from the perspectives of chemistry teachers (Merriam, 2009).

Research Informants & Setting

The researchers selected sixteen chemistry teachers by employing purposive sampling as the study's informants to gain an emic perspective of the phenomena. They were selected based on their years of experience in teaching the subject. With more than five years of teaching experience, these informants are considered 'experienced' teachers (Araujo et al., 2016) as they are deemed to have vast knowledge related to the phenomenon of this study. Additionally, the researchers selected informants from various schools and states in Malaysia to obtain a wide range of data. Although all informants are considered experienced, the researchers purposively selected a higher number of teachers who either hold the title of excellent or senior teachers as they are regarded as informative informants for the study.

Data Collection Methods

One-to-one semi-structured interviews with the informants were conducted to gather data for the study based on a set of interview protocols validated through peer reviews. Each interview lasted between 70 to 120 minutes. The informants consented to the interview by signing the consent form provided by the

Table 1. Summary of the research findings (theme and the sub-themes)

Theme	Sub-theme	Codes
Learners' issues in preparation & qualitative analysis of salts topics	Negative perceptions	▪ Complex & challenging topics to be learned ▪ Students feel anxious & have a mental block ▪ Least favorite topic
	Dealing with number of information	▪ Too much information was presented on the topics ▪ The need to comprehend & memorize the information
	Ability to understand abstract concepts	▪ Weak understanding of the solubility concept ▪ Confusion on reactions that produce salts ▪ Difficulty to imagine observation of reactions
	Mastery of basic concepts/skills	▪ Confusion on the concept of ion ▪ Difficulty to write chemical formulas & equations ▪ Weak foundation on the reactions of acids
	Solving problems & fulfilling grading criteria	▪ Difficulty to solve contextual problems ▪ Struggle to answer questions in examination ▪ Left out key terms ▪ Feeling uncertain

researchers prior to the interview. The interview structure allowed the researchers to ask additional questions to the informants based on their responses during the interview to grasp the information better.

The interviews focused on uncovering students' responses to the topics in class, their performance, and the difficulties they encountered in learning the topics. Therefore, the data obtained from this study are solely based on the recollection of teachers' experiences and personal interactions with their students for the years they have spent teaching the subject. Additionally, the researchers conducted document analysis on the form four chemistry textbook and chemistry standard curriculum document and assessment. According to Merriam (2009), data yields from documents carry the same weight as data from interviews and observation. Besides, it can furnish descriptive information and verify emerging hypotheses or findings of a study. Through the information obtained from the two documents, the researchers could show clear examples or context of responses provided by the informants and the connection between each sub-theme in the findings. Also, the use of documents provides objective or 'unobtrusive' data due to the stable nature of documents, which is free from the influence of human presence, unlike the interview or observation (Merriam, 2009, p. 155).

Data Analysis Procedure

The recorded interviews were transcribed and read several times for data familiarization purposes (Creswell, 2009). The transcripts were then analyzed thematically to identify the issues experienced by the learners in learning the topics mentioned previously. Thematic analysis is a practical method for analyzing the perspectives of different research informants, summarizing critical features of an extensive data set by highlighting the similarities and differences of informants' views or generating unexpected findings (Nowell et al., 2017). Data collection and analysis were conducted simultaneously and iteratively for the researchers to construct suitable categories and themes from the emerging data pattern (Miles et al., 2014). Data analysis yielded five categories that have been grouped under one theme, which is learners' issues. A similar process has been conducted for document analysis where relevant sentences or figures have been coded based on their relevance to the data that emerged from the interview analysis. These codes were then included in the existing categories to supplement the findings. In addition, data triangulation, cross-checking process, and an audit trail were adopted to ensure the trustworthiness of this study.

FINDINGS

By using learners' issues as the central theme, the researchers will discuss five issues commonly experienced by students in the topics. The summary of the findings is shown in **Table 1**. Each sub-themes are discussed separately in the subsequent sub-headings.

Negative Perceptions

This first issue is formed from several codes that emerged from the analysis, such as 'challenging topic', 'complex', 'complicated', and 'topic that students dislike'. Even though most of the informants indicated the

Table 2. The list of sub-topics and learning outcomes for preparation and qualitative analysis of salts topics in standard chemistry curriculum form 4

Sub-topics (content standard)	Learning outcomes (learning standard)
6.9. Preparation of salts	6.9.1. Test the solubility of salt in water and classify them into soluble and insoluble salts through experiment. 6.9.2. Describe the preparation of a soluble salt through activity. 6.9.3. Describe the preparation of an insoluble salt through activity.
6.11. Qualitative analysis	6.11.1. Identify the cation and anion present in salts through experiment. 6.11.2. Describe the confirmatory tests to identify cations and anions.

preparation and qualitative analysis of salts topics as interesting and did not involve a lot of complex concepts, however, the informants agreed that most of their students have negative perceptions and frequently mentioned these topics as one of the most complex topics in chemistry. In addition, some informants mentioned that students easily feel anxious or have a mental block when learning these topics. The following excerpts are examples of the responses provided by informants A, C, E, and P about the issue:

> "… but for my students, they usually tell me that the topic electrochemistry (chapter 6) and salts (previously chapter 8 but with the current syllabus is in chapter 6) as the most difficult topics in form 4 chemistry syllabus …" (A, ln. 105-106).

> "I think when students learn about salts, especially the preparation and analysis part, they will usually feel anxious … they told me that these topics are difficult … every time I will get the same input from my students, these topics are among the difficult topics in chemistry …" (C, ln. 166-168).

> "… like when they try to analyze the presence of nitrate ion, supposedly they will get a thin layer of a brown ring, but if they are too rushed and did not follow the procedure properly, they will not be able to get such observation … then they will question and have the idea that the qualitative analysis topic is complex and difficult …" (E, ln. 470-472).

> "These (preparation and qualitative analysis) are among the least favorite topics for my students, be it in class or the exam. They do like to do experiments, but when it comes to an understanding the ions and testing the concepts behind the preparation of soluble or insoluble salts, they will have a mental block … they said it is too complicated … even in exams, only few will choose to answer questions about salts …" (P, ln. 409-413).

Based on responses, the researchers found that negative perceptions of students are rooted primarily in their struggles in learning and the assessment of the topics. It explained why some informants claimed that these are among the least favorite topics among students in chemistry. Additionally, a few informants mention that some students have negative notions even before they learn the topics due to the influence of their seniors or private tutors, indicating that these topics are complex and challenging (teacher A, E, and F). Nonetheless, data yielded from the analysis have assisted the researchers in establishing a clear understanding that students' negative perceptions towards these topics were the results of their struggles in facing the subsequent issues presented in this section.

Dealing with the Number of Information

This sub-theme is the central issue the learners face in learning these topics. The informants agreed that students find these topics comprising too much information to be acquired and caused them to feel overwhelmed. In understanding the claim, the researchers analyzed the curriculum document to identify the expected outcomes students need to achieve in the 'preparation and qualitative analysis of salts' topics.

Data from the analysis of the learning outcomes presented in **Table 2** showed that three out of five learning outcomes from these two sub-topics require students to describe procedures of salts' preparation and confirmatory tests. Also, another two learning outcomes set were for students to be able to conduct experiments to test the solubility of salts and to conduct anion and cations identification present in salts.

From this data, we found that these topics not only required students' understanding of the content, but they also expected to acquire practical knowledge and skills to conduct and describe related procedures

Reaction I :	Acid + alkali	→	Salt + Water
Reaction II :	Acid + metal oxide	→	Salt + Water
Reaction III :	Acid + reactive metal	→	Salt + Hydrogen gas
Reaction IV :	Acid + metal carbonate	→	Salt + Water + Carbon dioxide

Figure 1. Four types of neutralization reactions for preparation of soluble salts (Source: Authors' own elaboration)

involving salts' preparation and testing. Moreover, although the number of learning outcomes is not much for both topics, the researchers found that the content covers a wide range of information for students. For example, in the preparation of salts topic, the information includes the solubility of four different types of salts (nitrate, sulphate, chloride, and carbonate salts), understanding the preparation of salts through four different neutralization reactions as shown in **Figure 1**, and understanding the double decomposition reaction for preparation of insoluble salts.

Though some students do not have problems understanding the facts and procedures presented in these topics, the informants asserted that most students tend to forget or are confused with the information during the examination. On the contrary, most students opted to memorize with a superficial understanding for examination purposes. However, they failed to solve the questions as they lacked sufficient understanding of the processes and procedures involved in both topics. The following excerpts depict comments by teachers on students' difficulties in memorizing related facts like properties of salts, testing diagrams, procedures, and others.

> "… when we teach them about the soluble and insoluble salts, the students complain that there are a lot of facts that they need to understand and remember … even I, as a teacher, sometimes tend to forget some of the facts, that is why students think this topic is a critical topic for them …" (B, ln. 273-275).

> "… When I asked why they struggle with this topic (qualitative analysis), among the answers was that there are a lot of colors, observations, reagents, testing steps, and so on to be memorized. That is what they think, to me it is not entirely wrong, what I do as a teacher is, I try to teach them acronym or the simplest way to remember those facts, if they can remember then it will be a lot easier for them …" (E, ln. 323-326).

> "Because students told me there are a lot of colors and diagrams … even the processes within each diagram are a lot. We are talking not about one diagram only, but multiple diagrams. Preparation for soluble and insoluble salts, heating of salts, the anion, and cation testing … each diagram is different, and the process, procedure, or observation in the diagram also differ between one another …" (G, ln. 409-412).

Analysis of the textbook also validates claims presented by teachers that there is much information covered on these two topics. For example, the students need to understand and remember all the nine cations and four anions alongside the preparation, testing procedures, and other related information involved in the preparation and qualitative analysis process (see learning outcomes of qualitative analysis of salts 6.11.1 and 6.11.2 in **Table 2**). Besides, these cations and anions come with different properties in terms of color, solubility in water, and effects on heat. There are also four other tests involved in qualitative analysis: gas tests, anion tests, cation tests, and confirmatory tests to differentiate the ions that reveal similar observation results like NH_4^{+}, Fe^{2+}, Fe^{3+} ions, and between Pb^{2+} and Al^{3+} ions. Each test follows specific procedures and uses specific reagents to yield a definite result or observation for a specific anion/cation.

Figure 2 illustrates the flow of the multifaceted cation test for salt A solution by using sodium hydroxide, NaOH (reagent), as a reference to what was mentioned earlier. However, if the exact solution is tested using ammonia solution, NH_3, the test result will be different for most of the cations shown in **Figure 2**. For example, Al^{3+} and Mg^{2+} ions will be insoluble when tested in excess NH_3 solution, while Ca^{2+} ions will not show any changes or precipitation. The similarities and differences between the cation tests are good examples of what

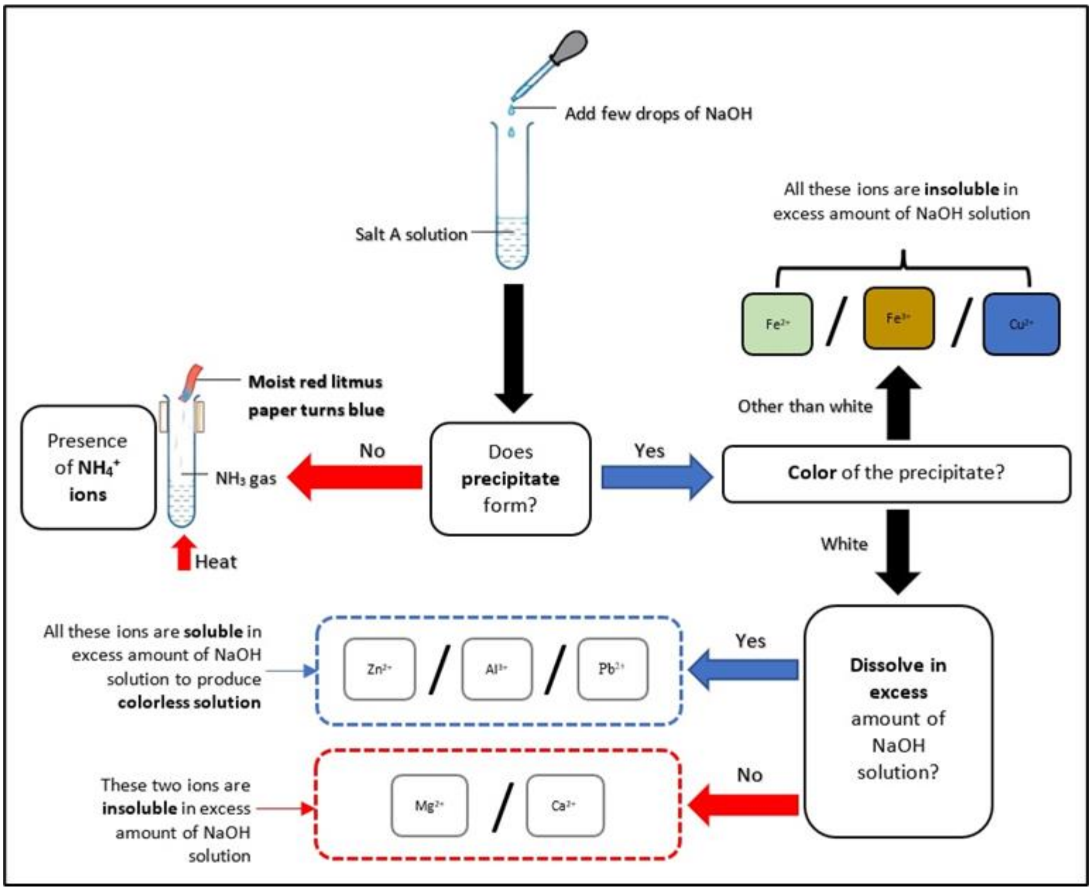

Figure 2. Flowchart of multifaceted cations tests for salt A solution by using NaOH solution (Source: Authors' own elaboration)

students mean when they must deal with a vast amount of information in learning these topics. Students must comprehend and memorize all this information to describe the process and results of the test successfully. As a result, students tend to feel overwhelmed and are not keen to memorize important information, as described by teacher F (ln. 321-325*)*, J (ln. 131-134), and M (ln. 358-360).

Ability to Understand Abstract Concepts

In the preparation and qualitative analysis topics, the informants emphasized the need to introduce students to the theoretical aspects and the practicality of the concept through the experimentation process due to the nature of the topics that require concepts reinforcement and validation through experiments (as discussed in the previous sub-theme). Besides, it is also to ease struggles encountered by students to understand abstract concepts like chemical changes or processes involved in these topics. Most informants asserted that only explaining to students or showing videos of experiments is insufficient. For instance, prior to learning the preparation of salts, the students must understand the concept of salts' solubility in water. Though informants claimed it is a simple key concept, most students still struggle to understand or even have confusion about the concept of solubility itself (teacher A, F, M, and O). Although teachers use examples like dissolving salts or sugar in water to depict the solubility, the students find it challenging to understand the concept unless the teacher demonstrates the solubility of a specific salt in water during class. As mentioned by teacher F:

> "They (students) do not understand the word 'soluble' even when I said it is exactly like when you dissolve the salts you have at home in the water, and you'll get a colorless solution. They still look confused afterward. So, when I teach solubility, the salts and water must be presented to the students directly to show them what solubility is. This is how salts are considered to be soluble …" (F, ln. 667-672).

$$Ba^{2+}\ (aq) + SO_4^{2-}\ (aq) \longrightarrow BaSO_4\ (s)$$

Figure 3. Sample of an ionic equation for the formation of insoluble salts barium(II) sulphate (Source: Authors' own elaboration)

$$BaCl_2\ (aq) + Na_2SO_4\ (aq) \longrightarrow 2NaCl(aq) + BaSO_4\ (s)$$

Figure 4. The complete equation of the formation of insoluble salts barium(II) sulphate (Source: Authors' own elaboration)

Another example of an abstract concept provided by the informants is the chemical reaction. For example, some informants claimed that students have difficulty understanding the vast reactions of acid that produce different salts (e.g., teacher B, C, and D). They concurred because students were only familiar with sodium chloride (cooking salts) and had insufficient knowledge about other salts (teacher D, ln. 307-309). Therefore, they found salts as the product of reactions of acids to be 'unusual' or against their' preconceived idea. For example:

> "... chemical reactions are difficult for students to comprehend, as they cannot see what happen when the compounds react, like when they learn about acid-base reactions, which produce salts and water or reaction between acids and other substances like metal, metal oxide or carbonate ... when salts are produced from the reactions, they do not even know what happened. They only know sodium chloride, the cooking salts they use at home. So, it is quite difficult for them to understand when they are introduced to the topic ..." (B, ln. 88-92).

Another issue that students face is understanding the preparation of insoluble salts by using a double decomposition reaction (DDR) to produce insoluble salts such as barium(II) sulphate, $BaSO_4$, and lead(II) chloride, $PbCl_2$. In the textbook, the following statement is used to describe the double decomposition reaction.

> In the double decomposition reaction, the ions in both aqueous solutions exchange with each other to form a new aqueous solution and a precipitate (form 4 chemistry textbook, p. 187).

According to the informants, students usually asked why DDR must begin with two soluble solutions (aqueous) and why the reaction products are insoluble and soluble salts. The informants obtain these two common questions from different students almost every year. As an effect of the struggle to understand this reaction, students will usually have problems writing an ionic equation for forming an insoluble salt in DDR. Even if it is a simple equation (as shown in **Figure 3**, for example), students who struggle with this concept have problems comprehending the reaction and ionic equation shown to them (e.g., teacher B, C, N, and O).

To understand the abstract nature of a simple equation shown in **Figure 3**, which causes struggles for many students, the researchers analyzed the explanation and illustration of the formation of barium(II) sulphate from the reaction between barium(II) chloride, $BaCl_2$, and sodium sulphate, Na_2SO_4 provided in the textbook and found the essential concepts that must be comprehended to solidify students' understanding of the DDR:

(a) They must understand that both reactants ($BaCl_2$ and Na_2SO_4) involve in DDR are in an aqueous state and comprise free-moving ions (Ba^{2+} and Cl^- ions in $BaCl_2$, Na^+, and SO_4^{2-} in Na_2SO_4).

(b) They must understand the formation of ionic compounds, bonding, and chemical formulae to identify the ions present in each reactant and assign them with correct charges.

(c) To write a balanced ionic equation of the DDR, the students must also understand that the Na^+ ion and Cl^- ion are spectator ions that do not involve in the reaction. Thus, these ions are cancelled out in the equation.

(d) Lastly, they must know that the products of DDR are an aqueous solution (sodium chloride, NaCl) and a precipitate of the insoluble salts ($BaSO_4$), as shown the **Figure 4**.

Even though the description of the DDR on page 187 chemistry textbook mentioned above is simple, understanding each DDR involves layers of abstract concepts and requires the students' ability to reach all three levels of chemical representations. Part of the findings from the document analysis above also supports the assertion of the informants that students have problems visualizing changes during reactions involving aspects like color, precipitation formation, and solubility in the excess reagent in both the preparation and qualitative analysis of salts.

Regarding the ability of students to imagine abstract concepts, Teacher P asserted that the student's imagination of the reaction and processes involved in this topic plays a significant role in supporting their understanding of the overall topics. He mentioned that students who can visualize similarly to the description in the textbook or by the teachers would generally perform better in learning the topics. However, he admitted that the ability to imagine abstract concepts differs among students, thus resulting in differences in how students process the information.

> "Let's say, if the observation said the reaction emits brown or colorless gases or yellow precipitate and colorless solution formed, and the students could imagine that I think they will definitely understand the topics better. But I know it is not easy for everyone … even my imagination and students is different … so the outcome will be different …" (P, ln. 395-398).

The informants in the study agreed that the best way to approach students' issues related to understanding the abstract concept is through experiential learning, which allows students to experience the preparation and conduct the qualitative analysis of the salts. Without real exposure, students do not have the chance to feel, observe, and experience the process, which will affect their ability to make sense of what they have learned in theory. The situation is depicted in the following excerpts:

> "… that is why for these topics, I will always conduct experiments with my students so that they know what salts look like, where they can find the salts containers in the lab, I can show them the color of salts and how to prepare them. But sometimes, when the chemicals or apparatus are insufficient, I cannot allow the students to run the experiment. So, they will complain it is difficult to imagine the color changes, or they will ask me how the precipitate form through the reactions, etcetera. They just feel difficult to imagine those things …" (C, ln. 713-718).

> "So, they generally struggle to imagine when they cannot see it directly and do the procedures. That's why students always say that it is difficult for them. However, when they can do it themselves, it will be a lot easier for them to understand … like when students prepare copper (II) nitrate salts on their own, they will be able to tell it is a blue color solution whenever I ask … they responded faster and easily remember related information because the experience …" (N, ln. 552-558).

> "I let them do the qualitative analysis on their own … once they do the procedures, they will be able to observe color changes, solubility in excess reagent, and the brown ring … then I inform them to write the observation. It is a lot easier for me to do it this way rather than immediately teach them the theoretical part. It is difficult for them to imagine these things solely based on my explanation …" (L, ln. 489-493).

Mastery of Basic Concepts or Skills

Another issue that students commonly have in learning these topics is the mastery of basic concepts or skills. In learning preparation and qualitative analysis of salts, the informants agreed that basic skills like writing chemical formulae and equations, moles concepts, chemical bonding, and knowledge about acid and base reactions are essential to ensure the ability of students to learn these salt topics effectively. However, most informants reported that many of their students struggle with basic concepts and are confused with essential concepts like ions.

> "Sometimes students tend to confuse what an ion is. I have a group of students who are still confused between chemical and ionic formulas even though they are in form 5. They have confusion about these two. Even some of them do not know how to describe the differences

> between ions and molecules … I think these things are fundamental before they learn about topics in salts …" (H, ln. 334-340).

> "I think the anion and cation part is crucial. Some students are still confused between the positive and negative charge ions. And those who do not know the symbol of chemical elements will struggle more. I think students must have strong basic knowledge about ions when they learn these topics …" (O, ln. 443-445).

Additionally, the researchers found that students have problems writing and balancing chemical formulas, chemical equations, and ionic equations, especially for the formation of salts. Excerpts from the interview of Teacher B, D and P illustrate students' issues related to basic concepts:

> "For example, in the reaction between magnesium carbonate and sulphuric acid, the students asked how come the reaction products were Magnesium sulphate, water, and carbon dioxide gas. Especially the magnesium sulphate part, I have to re-visit the basic concept, teach them on cross-link method again, and let them do the formula. Only then I can proceed with the lesson …" (B, ln. 471-475).

> "I took chemical equation as an example; if the students cannot write chemical formulae correctly, how can they write a balanced chemical equation for the reaction? These concepts are strongly related. Once they write a wrong formula, the subsequent questions related to the formula also will be affected … I found many students still have a major issue in this part …" (D, ln. 156-161).

> "I think weak memorization of anions and cations leads to problems writing chemical formulas and equations. That's why I have students who still dare to ask me for marks when they write sodium chloride as $NaCl_2$ instead of NaCl. They even argued it was only a small difference and nothing much. They don't understand that the problem is not as simple as what they think …" (P, ln. 528-532).

Furthermore, the researchers found that students with issues in learning preparation and qualitative analysis of salts topics generally have a weak understanding of acid-base reactions. As mentioned earlier, the informants stated that students are confused about the reactions of acids that would most likely fail to identify the salts produced from the reaction. In fact, they are even unsure why the product is considered salt and how the reaction occurs between the chemical substances. As mentioned by teacher H, students even struggle to understand the definition of base and alkaline (H, ln. 390-396). The following shows examples of the same problem from other informants:

> "How they want to prepare salts if they still struggle to understand the reaction of acids and bases. I found this very challenging because I have to repeat this part like I am teaching the whole topic from the beginning. Next, I need to make them understand the salts …" (J, ln. 278-281).

> "… I think from the beginning, they are unable to grasp the reaction of acids and bases … it shows when they learn about the preparation of salts, they are still confused about whether the reaction involves the reaction between acids and bases. When I said metal oxide is a base then reacts with an acid (e.g., HNO_3), they ask me as though they have yet to learn about it …" (I, ln. 707-709).

> "… there were students who are not even sure whether reaction between acid and base itself will produce salts. And they asked me why the reaction produced salts and water. I can see they do not understand the concept of neutralization …" (D, ln. 623-626).

Data from the document analysis reported in the previous sub-theme also support the findings on learners' issues with mastery of basic concepts or skills reported in this section. For example, in **Figure 1** above, students' mastery of acids, bases, and neutralization reactions is essential to enable the students to suggest specific acids and bases/alkalis in producing the targeted salt from any reaction pathways. General equations in **Figure 1** serve as a guide; however, students should be able to relate and apply what they have learned in the previous topics. Likewise, in discussing students' issues in understanding abstract concepts in

DDR, the researchers highlighted how mastery of the basic concepts, such as understanding ionic compounds, bonding, and writing ionic and chemical formulae, is essential in comprehending the whole reaction process in the previous sub-theme.

Solving Problems and Fulfilling the Grading Criteria

The last issue under this theme is the ability of students to solve problems related to the topics and fulfil the grading criteria of the examination. The researchers found that, even though teachers emphasized the importance of conducting experiments in assisting students to understand the topic, the teachers' primary concerns are whether students can solve the questions related to the topic, especially during the examination. In overcoming the issues, the informants stated that the students are mostly provided with actual examination questions to familiarize them with the questions and strategies to solve the questions. However, due to the nature of 'drill and practice' adopted by teachers in the classroom, the informants reported that the students struggle to solve questions involving contextual problems, application of knowledge, or questions different from what they have practiced in class. As mentioned by teacher D and P, as follows:

> "But in exams, sometimes the question did not give the students NaCl; instead, they wrote YCl to make the cation unknown. But students tend to panic when they get this kind of question. Because they only learned NaCl and are not familiar with YCl. They cannot cope with this kind of change even though the information and reaction provided will be able to tell them what Y is …" (D, ln. 323-325).

> "But the problem is if we teach students copper(II) sulphate in the sample, but if the question changed to other chemicals, they do not know what to use. Like in the 2020 examination, the question asked students to prepare lead (II) chromate, $PbCrO_4$, an insoluble salt. Even though they knew how to prepare lead(II) iodide, PbI_2, which is also an insoluble salt, they were automatically clueless …" (P, ln. 465-468).

Even in the examination, some informants claimed that aside from struggling to answer questions related to the question correctly, the students also tended to avoid answering the questions if they were optional. Furthermore, based on informal conversations of teachers with the students, the students claimed that the questions on these topics as high risk (in terms of the tendency to lose marks):

> "Students always mentioned that these topics are among the most challenging in the examination whenever I asked why they did not answer the questions or only answered part of it" (E, ln. 557-562).

> "If there are any questions related to salts topics in the exam, I can guarantee that most of my students will not score or, if the question is optional, they definitely will not choose the question. They will avoid the questions" (D, ln. 439-442).

> "When I asked many of them why they did not choose salts-related questions? They said, "I was scared I gave the wrong anion. I described sulphate, but the answer is chloride, so all marks are gone. The risk is too high"" (P, ln. 449-452).

Additionally, the preparation and analysis of salts topics focus on the practical and related procedures in preparing and conducting salts analysis; hence, the nature of the examination questions focuses on the same aspects. However, according to the informants, the students usually perceive providing a detailed description of the preparation and testing processes with essential key points as a hassle. The informants concurred; that students also frequently reported leaving out important key points in describing procedures or providing inaccurate observations in the experiment. **Figure 5** shows the eight procedures involved in preparing soluble salts type II (other than Ammonium, Sodium, and Potassium salts) as a reference to the issue reported. As mentioned by most informants, in describing procedures of an experiment in the examination, the action verbs, degree of the action, substance/chemicals, units, and apparatus that are important in clearly describing a procedure should be evident in students' answers (refer to any procedure shows in **Figure 5**).

Step (1) - Pour 20 cm^3 of 20 mol dm^{-3} nitric acid, HNO_3 into a beaker. Heat the acid using medium heat.

Step (2) - Add copper(II) oxide powder, CuO gradually into the acid using a spatula. Stir the mixture with a glass rod.

Step (3) - Continue adding copper(II) oxide, CuO until it is no longer dissolved.

Step (4) - Filter the excess copper(II) oxide powder, CuO from the mixture.

Step (5) – Pour the filtrate into an evaporating dish and heat the filtrate till a saturated salt solution is obtained.

Step (6) – Let the resulting saturated solution cool until salt crystals are formed.

Step (7) – Filter the content of the evaporating dish to obtain the salt crystals. Rinse the crystals with a little amount of distilled water.

Step (8) – Dry the salt crystals by pressing them between two pieces of filter papers.

Figure 5. Procedures for preparing soluble salts other than ammonium, sodium, and potassium salts (Source: Authors' own elaboration)

In other words, students should write the exact procedures they have seen in the textbook to score well. Additionally, the informants mentioned that the inability of students to fulfill the grading criteria always leads to losing a lot of marks in the examination, as depicted in the following excerpts:

> "… when they describe, there are certain criteria that are required. For example, when they perform a procedure, there must be a word in the form of instruction like 'pour', 'stir' or 'heat', then for how long? Or to what extent? For example, heat, does it heat strongly or gently? Or heat until saturated, that is the instruction. And then filter, filter using a filter funnel and filter paper, they need to mention the right apparatus and can't simply state filter the substance … they will lose marks" (A, ln. 242-245).

> "In the exam, I grade my students' answers based on the guideline of the Malaysia examination syndicate. For example, if the answer is "cool it at room temperature until crystals are formed", the students cannot simply write cool at room temperature … the absence of certain keyword will make a huge difference to their score" (G, ln. 435-438).

> "… In the 2019 examination, the question asked about copper(II) ion, this ion will produce a blue precipitate when added to ammonia, and in excess, it will produce a dark blue solution. I think most students were wrong as they only wrote blue solution and left out the word 'dark'. Automatically they got zero for that question" (E, ln. 565-571).

Lastly, the informants revealed that many students reported their tendency to feel uncertain about the information they have and were not fond of questions that resemble riddles or puzzles that need to be solved by integrating all the knowledge from the topics. **Figure 6** shows an example of a diagram used for structural questions to support the issue highlighted by the informants.

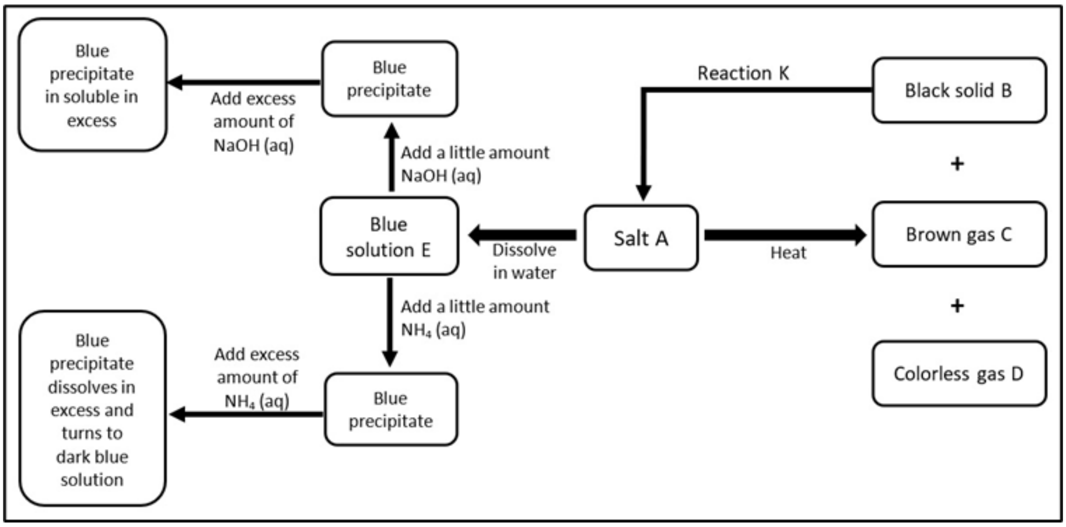

Figure 6. Sample of a diagram used for structural questions in salts topics (Source: Authors' own elaboration)

The document analysis shows that the structural questions that need to be solved by the students based on the diagram are interrelated and require students to connect the information they learn from the entire topics to solve the questions such as:

(a) Identify salt A, solid B, gas C, gas D, and blue solution E.

(b) Write a chemical equation to represent the decomposition of salt A by heat.

(c) Describe the confirmatory test for anion in salt A.

(d) Suggest the chemical reaction K that can change the black solid B to salt A.

Consequently, as asserted by the informants, the situation makes students less keen to answer salts-related questions during examinations. As depicted in the excerpts by teachers C and F:

> "Students see questions about salts in the exam just like solving riddles. They will be provided with situation and clues; let's say salt A was heated and produced brown gas … then the brown gas is tested with … they need to know all the tests and observations involved, what are the observations, the products etcetera … most students rarely like this kind of questions and are still confused …" (C, ln. 168-173).

> "Because these topics require students to memorize lots of facts, they know that every piece of information is important because they need it to solve exam questions. Like pieces of puzzles, if students miss several parts, they cannot complete the picture. The same goes for this topic in the exam; if students miss one or two pieces of information, they might end up with wrong answers" (F, ln. 302-305).

DISCUSSION

Based on the findings on the learners' issues in learning the preparation and qualitative analysis of salts topics, most informants agreed that these two topics were commonly perceived negatively and challenging by most of the students. The informants' remarks on how their students perceived these topics also support the findings from related studies with similar scope and focus areas (Anim-Eduful & Adu-Gyamfi, 2022; Bouabdallah, 2021; Malkoc, 2017; Osman & Lay, 2020). Mahdi (2014) argued that it is central to understanding students' perceptions of learning chemistry as it provides teachers input to students' needs and promotes positive attitudes in learning. Taber (2019) concurred that perception is a precursor to motivation in learning that drives students to progress and develop meaning in their learning experiences. Therefore, understanding the causes for students to have unfavored feelings towards the topics and label them as complex and challenging is crucial in aiding scholars and teachers to suggest ways to improve the curriculum content and teaching and learning related to these topics.

Data from document analysis certainly informed that, in general, the number and level of learning outcomes set for these topics are reasonable for students to acquire. However, the combination of the need for students to master related concepts and practical skills in preparing and carrying out qualitative analysis of salts raised a significant challenge for students. Furthermore, though it is crucial to fulfilling both knowledge and skills for the topics, the way assessment is carried out to assess students' understanding of chemistry subject still focuses heavily on examination (Salleh et al., 2022a). Hence, the informants' experiences of students' difficulties rooted in their inability to understand and recall many important facts presented within the topics could be the repercussion of such practice and how knowledge is emphasized to students during teaching and learning. However, memorization is vital in ensuring students' effective learning, in line with the utterance of most informants of the study. Hartman and Nelson (2015) argued that the brain relies on working memory to process small elements of knowledge sequentially during problem-solving. Moreover, it can hold and manipulate virtually all elements that can be recalled 'with automaticity' from long-term memory.

Nevertheless, despite its importance and role in learning, data from the interviews and document analysis showed that the preparation and qualitative analysis of salts indeed have a vast amount of information that, to a certain extent, could overwhelm the students. For example, the need to remember all 13 ions with specific properties like colors, solubility, effects on heat, their test, and confirmatory test not only can be confusing but also demotivates students from trying to conquer the topics. In tandem, past studies asserted that memory work that students must go through to describe testing procedures and observations accurately is undeniably a significant contributor to students' negative feelings towards the topics (Doraiseriyan & Damanhuri, 2021; Napes & Sharif, 2022). Furthermore, Tan (2005) emphasized that excessive memory work in learning salts topics could trigger cognitive overloading and affect students' learning. Therefore, teachers need to look for strategies to help students systematically remember the facts not only to score in the examination but to ease students' memory work and create an enjoyable learning environment for them (Izzati & Rochmah, 2020; Osman & Lay, 2020; Salame & Nikolic, 2021). For example, some informants of this study use acronyms or mnemonic methods in their classrooms to reduce students' cognitive load and increase their memory retention of the topics. However, the researchers argue that memorization techniques should not be the first thing to be introduced and emphasized to students to prevent them from 'mastering' the facts without fully understanding the concepts (Doraiseriyan & Damanhuri, 2021). Instead, the teaching should focus on helping students build a solid comprehension supplement using strategies to enhance their long-term memory.

Additionally, the struggle students face in understanding the abstract nature of salts topic, as reported by the informants, should be confronted with appropriate teaching approaches that can provide students with ideas and understanding of the 'unseen' phenomena in chemistry. Past studies asserted that the formation of salts, which involves chemical reactions and changes through various chemical representations, could be too abstract for many students (Sana & Adhikary, 2017; Shamsulbahri & Zulkiply, 2021; Taber, 2013). Besides, students' difficulties in the three levels of representations of the chemical concepts hinder them from an in-depth understanding of the preparation and qualitative analysis of salts. When students only can reach the microscopic level of chemical representation, they will struggle to understand even simple concepts like solubility, ions, molecules, chemical compounds, or even aqueous solution (Farida et al., 2018; Gkitzia et al., 2020; Izzati & Rochmah, 2020; Upahi & Ramnarain, 2019). Likewise, such cases can be seen in the responses from the informants of the study, which revealed students' issues in visualizing changes during reactions such as colour, formation of precipitation, and the solubility of salts in excess reagents, for example.

Henceforth, helping students visualize the abstract concepts in these salts topics is crucial as it strengthens students' conceptual knowledge and sustains their interest in learning the topics by making a relationship between the theory and application of the knowledge (Miranda & Smaka, 2021; Napes & Sharif, 2022). Teachers can adopt various strategies as shared by the informants, such as using multiple representations in teaching (Farida et al., 2018; Kuit & Osman, 2021) or incorporating games to help students to visualize the process or abstract concepts while having fun learning (Álvarez-Herrero & Valls-Bautista, 2021; Doraiseriyan & Damanhuri, 2021; Osman & Lay, 2020). Also, the role of 'hands-on' in learning, as emphasized by the informants, should not be side-lined as it provides experiential learning to students rather than solely focusing on concepts memorization (Miranda & Smaka, 2021; Timilsena et al., 2022). Many informants also agreed that conducting experiments could assist students in learning the topics better by overcoming the complexity and abstract nature of the salts topic and validating the theories they have learned in class (Napes & Sharif, 2022; Shamsulbahri & Zulkiply, 2021). It also helps students to achieve the learning outcomes of these topics that emphasize their ability to prepare salts and conduct qualitative analysis to identify the anions and cations in salts. Additionally, learning these topics can be contextualized by showing students the applications of the knowledge as it helps them to make sense of their learning and encourages them to explore the knowledge further (Majid & Rohaeti, 2018; Timilsena et al., 2022).

As mentioned, preparation and qualitative analysis of salts topics rely heavily on students' basic knowledge and skills, especially on the reaction between acids and bases and writing chemical formulae. However, as the informants highlighted, students' weak understanding of the chemical properties of acids and bases leads to their inability to fathom the formation of salts from the reaction of the two compounds. It also explains why some students failed to propose a specific pathway to produce a known salt or to name the salts produced from acid-base reactions. Data from document analysis also shows that understanding ionic compounds, ionic charges, and chemical formulae are essential in helping students comprehend salts' preparation, such as double decomposition reactions. The findings of this study on students' weak prior knowledge are in tandem with past studies that reported similar issues that students experience in learning chemistry, which caused them to struggle in solving complex tasks that require mastery of basic knowledge (Cardellini, 2012; Napes & Sharif, 2022).

Therefore, assessing students' basic knowledge before advancing to new topics is a critical practice that should be cultured in teaching and learning activities. However, the practice only benefits the students if the teachers critically look at the assessment data and reflect on the improvement they could make in teaching to provide students with the necessary assistance (Salleh et al., 2022b). Besides, based on data from the assessment practice, teachers could re-visit essential concepts related to the topics, strengthening students' understanding and allowing them to correct misconceptions or alternative conceptions that the students have before learning the salts topics in-depth (Elham & Dilmaghani, 2019; Salame & Nikolic, 2021). Furthermore, the practice allows teachers to devise a differentiated instructional plan for various groups of students by selecting suitable approaches and learning materials tailored to students' existing needs in learning the topics (Salleh et al., 2022a).

Lastly, in enhancing the capacity of students to solve problems related to the topics, teachers should re-look at the way assessment is staged in class, especially on the types and context of the problems that have been exposed for students to work on (Majid & Rohaeti, 2018; Tsaparlis, 2015). Tan (2005) argued that students could be trained to provide 'right' answers; however, the drawbacks of the practice could make students lose the 'essence' of learning and the meaning of the knowledge, and they still struggle to score well in the examinations (Napes & Sharif, 2022; Sana & Adhikary, 2017). Therefore, the way assessment is graded, which focuses more on the technical words in reporting experiments, can be revised to allow flexibility for students in providing their answers during the examination to provide room for students' creative and critical thinking (Kulasegaram & Rangachari, 2018). Additionally, the inability to solve complex and routine problems in the students' examination provides insights to teachers and stakeholders on enhancing students' problem-solving capacity and moving beyond teaching to the test approach.

CONCLUSION

This study investigated learners' issues in the preparation and qualitative analysis of salts topics at the secondary school level in Malaysia. Though most teachers perceived these topics as 'straightforward' and did not require an extensive understanding of complex processes, most students viewed them differently. The study found that students have negative perceptions of these topics due to the complexity and amount of information that requires in-depth understanding and memorization. In addition, students mostly struggle to understand abstract concepts and require 'hands-on' experience to overcome their limited ability to visualize the reaction or process. The finding supports the importance of conducting experiments and contextualizing lessons in teaching the preparation and qualitative of salts topics. Additionally, the study reveals the consequences of not providing sufficient practical experience to students by discussing issues highlighted by the informants and in past studies.

The study also concludes that understanding the preparation and qualitative analysis of salts topic builds up from the foundational knowledge that students learned at the beginning of the syllabus to the acid and bases topic that introduced prior learning about salts. If students' foundation is not solid, the consequences will affect them and the teachers. Accordingly, teachers need to invest their time and energy to restrengthen the understanding and skills of students in assisting them in learning the topics effectively. Additionally, in overcoming the issues discussed in this study, the researchers suggested that teachers must practice various approaches and strategies to aid learners in learning these topics. Providing students with a vast variance of salts and their applications in daily life should be considered to broaden students' horizons on the topics. Teachers must also be more selective in choosing approaches that align with the student's needs, which is more practical in providing them with an optimal learning experience.

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