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EXAMINING THE EFFECT OF DIRECTED ACTIVITY RELATED TO TEXTS (DARTs) AND GENDER ON STUDENT ACHIEVEMENT IN QUALITATIVE ANALYSIS IN CHEMISTRY

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ABSTRACT

Purpose – The present study examined the effect of Directed Activity Related to Texts (DARTs) and gender on student achievement in qualitative analysis in chemistry. It focused on the qualitative analysis component of the Chemistry course, which for students has been perceived as being the most difficult aspect of their mastery of the subject.

Methodology – The study involved 120 secondary four science stream students from two local fully residential schools. In a quasi-experiment, participants studied the topic of qualitative analysis of salt, using one of the following three instructional methods: Experiment, DARTs, and Combination of Experiment and DARTs. The participants in the three groups were then tested on their knowledge about salt.

Findings – Results of a two-way independent ANOVA performed on the experiment data revealed a significant main effect corresponding to the type of instructional method that the three groups were treated to — the mean scores for the Combined method group was the highest, followed by the DARTs group, and then the Experiment group. Further analysis using an independent t-test showed that the difference in mean scores between the DARTs and Experiment groups was significant. It is argued that participants' learning in the Combined method group might have been enhanced by the DARTs instructional method. The effect of gender and the interaction effect between the variables were not significant.

Significance – The findings of the study has provided clear experimental evidence regarding the role of the DARTs instructional method in enhancing qualitative analysis learning in chemistry. These findings also provided important insights to educators on DARTs as an alternative method of teaching and learning the topic on qualitative analysis in chemistry.

Keywords: Directed activity related to texts, qualitative analysis, chemistry, student learning, salt, gender.

INTRODUCTION

Chemistry is an important subject to be mastered by science stream students. Nevertheless, chemistry is regarded as a difficult subject to learn among students (Chu & Hong, 2010; Osman & Sukor, 2013; Woldeamanuel et al., 2014). As a result, students tend to have a negative attitude towards chemistry (Yunus & Ali, 2013), such as not being interested in it, and having no motivation to learn the subject (Broman et al., 2011). Qualitative analysis is one of the components of Analytical Chemistry which has been perceived by students as being difficult to understand (Lay & Osman, 2015). The learning of topics about qualitative analysis in chemistry involves both process skills and the understanding of many other concepts within the broader field of chemistry (Hikmah et al., 2018). Qualitative analysis is a method used to identify the components of a substance, such as the presence of ions in an unknown compound using a chemical test. For example, students are able to identify the presence of the zinc ion in an unknown salt solution when the salt solution forms a white precipitate that is soluble in excess sodium hydroxide solution or excess ammonia solution.

The common approach to learn qualitative analysis in schools includes both learning the theoretical knowledge in the classroom (non-experimental method) and conducting a practical session in the laboratory (experimental method). Qualitative analysis in chemistry is commonly assessed in the national examination for upper secondary students world-wide, such as in the General Certificate of Education (GCE), Ordinary Level (O-level) examination in Singapore. In the context of the Malaysian education system, qualitative analysis is an important component in the chemistry syllabus for formal assessment in a public examination. The achievement of students in qualitative analysis in the chemistry examination will to a certain extent determine the critical development of Science, Technology, Engineering and Mathematics (STEM) education in Malaysia, since qualitative analysis is an essential method used in many fields such as forensic, clinical, agricultural, pharmaceutical and metallurgical fields (Lay & Osman, 2018).

Causes of Difficulties in Learning and Understanding Qualitative Analysis in Chemistry

Students' lack of understanding of the procedures and reactions involved in qualitative analysis in chemistry is one of the reasons the subject is often perceived as difficult (Lay & Osman, 2015; Tan et al., 2001; Tan, 2005;). Learning qualitative analysis in chemistry requires students to understand an abstract and complex concept in the field that they have never before encountered in their daily lives (Tasker & Freyberg, 1985), as they have virtualy no conception of it. Students tended to define the concept based on their own understanding (Pintrich et al., 1993) and often failed to interpret the real concept accurately (Berger, 2015). Learning theoretical knowledge of qualitative analysis in the chemistry classroom was unexciting because the students did not know what to think about the topic and what notes to take (Tan et al., 2001). When it comes to conducting the practical session in the laboratory, students found it hard to connect the theoretical knowledge they learned in class to the experiments performed (Hodson, 1993; Tan et al., 2001). This led to the unacceptable situation in which students carried out the experimental procedures and recorded their observations without understanding the reason for mixing essential reagents together and the explanation behind all the reactions that had occurred. It has been argued that when conducting the chemistry experiments, student attention seemed to be focused more on the mechanical aspect of laboratory procedures such as assembling the apparatus, making measurements and recording the results (Gunstone, 1991); a learning orientation which involved little intellectual understanding about the procedures and reactions involved in conducting a qualitative analysis as required by the syllabus (Tan et al., 2001). Qualitative analysis in chemistry has also been argued as involving a lot of memory work (Tan et al., 2001). This was because when the students should be learning about the processes involved in a qualitative analysis, they instead tended to memorize all the information (i.e., formulae and observations) because they believed this would help them perform well in the tests later (Reif & Larkin, 1991). This common student practice however, had often led to frustrations as memorizing all the facts was not easy. Students viewed knowledge qualitative analysis as a valuable collection of facts and formulae to memorize, rather than as a conceptual structure (Reif & Larkin, 1991) that needed to be understood in order to solve theoretical problems of qualitative analysis in chemistry.

It was also reported that the excessive use of memory work in learning about qualitative analysis had resulted in cognitive overloading among students (Johnston, 1999; Tan, 2005; Tan et al., 2001; Tsoi, 1994). When conducting laboratory experiments, students had to deal with multiple tasks at hand and at the same time rely on their working memory to process and manipulate verbal instruction, process skills, and unfamiliar labelling of reagents and inputs from the experiment itself (Nakhleh & Krajcik, 1994). When students had to multitask and perform intellectual thinking (i.e., to understand what they were doing) simultaneously, often it was the latter that gave way (Johnstone, 1999). Another cause of difficulties in learning proper qualitative analysis was due to the students' low motivation (Tan, 2005; Tan et al., 2001). It has been argued that in doing qualitative analysis experiments, students can be 'trained' to write the 'right' answers. This was because examination questions about experiments did not differ much in their orientation towards knowledge about qualitative analysis in chemistry (Tan, 2005; Tan et al., 2001). This common approach in teaching to the test could help students to obtain good marks; however, the backwash effect was that the students might not be able to see the importance of understanding the procedures and reactions involved in qualitative analysis. Students taught this way tended to just follow instructions without much thought (White, 1990). In addition, studies have found that students experienced low motivation in the qualitative analysis classrooms because of the demanding nature of the qualitative analysis lessons, whereby students said that they felt 'irritated' with the demanding memory work (Tan, 2005; Tan et al., 2001) and the presence of too much 'noise' (due to the demand of handling many things at once) during the practical session in the laboratory (Gebrehiwot, 2017). Such simultaneous cognitive demands resulted in a loss of interest in the practical task of learning about how to carry out a qualitative analysis.

Directed Activity Related to Texts

Directed Activity Related to Texts (DARTs) is a text processing method which comprises a wide range of text-based activities that enable students to actively engage with the text. The method has been used to scaffold instructions during learning (Hammed, 2017). In a typical study investigating the role of DARTs in facilitating learning, participants were exposed to a variety of DARTs activities consisting of reconstruction and analysis. Reconstruction activities included text completion, drawing and diagram completion, table completion, sequencing and prediction, whereas analysis activities included underlining or highlighting, labelling, tabular representation and questioning (Hameed, 2017; Zainab, 2012). When conducting DARTs activities, participants were asked to work in groups or at least in pairs throughout the lesson to create a student-centred learning environment where the teacher acted as a facilitator. Later, the participants' understanding regarding the lesson covered through DARTs activities would be assessed (e.g., Hammed, 2017; Hernández & Solano, 2017).

Past studies have examined the role of the DARTs method in learning the English language, for example in Hammed (2017) and Ni'mah (2016). DARTs has been found to improve students' writing skills in terms of relevance and adequacy of content, and cohesion (Hammed, 2017). It could also enhance students' reading comprehension skills (Hernández & Solano, 2017; Ni'mah, 2016; Reiser, 2004; Safadi & Rabab'ah, 2012; Walqui, 2006), and facilitate better English language learning among students with Limited English Proficiency (LEP) (Kim & Wai, 2007; Pamelasari & Khusniati, 2013). In another study by Hernández and Solano (2017) on reading comprehension, DARTs was applied in different stages of reading, namely pre-reading, during-reading and post-reading, and involved activities such as underlining or highlighting text to identify important ideas. In helping students to make connections between newly acquired information and their existing knowledge, to summarize a section of text by clarifying the logical relationships between various sections of text, to illustrate the connection of various sections of the text using flow charts, to draw diagrams, to construct tables, to create questions and sequence procedures, these DARTs activities were found to facilitate deeper reading comprehension of the text in the students. The benefits of the DARTs method has also been observed in the following studies: enhancing the learning of a contaminated environment in the Biology course (Ichwan et al., 2015), facilitating students' abilities and willingness to read and write science-related text (Grady, 2010; Pham & Hoang, 2016; Wellington & Osborne, 2001; Zainab, 2012), developing students' critical thinking and learning in an Invertebrate Zoology course (Haryanti et al., 2013) and lowering the language barrier and difficulties in teaching and learning science subjects in English (Kim & Wai, 2007). A recent study by Imaduddin and Haryani (2019) observed that the use of a DARTs training strategy helped improve pre-service chemistry teachers' critical thinking when teaching a basic chemistry subject. However, the basic chemistry subject only covered general knowledge aspects of the field, and did not include the qualitative analysis component of chemistry.

It is important to note that, as far as the research on learning chemistry is concerned, no empirical studies in the existing literature have reported on the use of DARTs for learning qualitative analysis, the component that was claimed to contribute to the difficulty in fully understanding chemistry (Goh et al., 1987; Lay & Osman, 2015; Tsoi, 1994). The literature review has highlighted the fact that the topic on the qualitative analysis of salt in the chemistry curriculum was ranked by students as the most difficult (Lee & Osman, 2014). The salt topic was not only difficult for students to learn but was also difficult for the teacher to teach (Lay & Osman, 2015). As mentioned earlier, learning qualitative analysis can be carried out by doing a practical session in the laboratory, i.e., using an experimental method; or by learning the theoretical knowledge about the analysis in the classroom, i.e., using a non-experimental method. In light of the difficulties students faced when learning qualitative analysis (Goh et al., 1987; Lay & Osman, 2015; Tsoi, 1994), the study reported here was aimed at exploring alternative non-experimental activities that might be able to facilitate better student learning of the qualitative analysis component of chemistry. Specifically, the study intended to examine further the role of Directed Activity Related to Texts (DARTs) in enhancing the learning of the qualitative analysis of salt. The study compared the DARTs instructional method with two other methods—experimental method, and combined method (Experiment + DARTs). In particular, the qualitative analysis of salt in the study focused on the confirmatory test for cation using sodium hydroxide solution and ammonia solution.

Instructional Methods and Gender Effect on Understanding in Chemistry

Past studies have examined chemistry learning which used various instructional methods such as the inquiry role instructional model (Aniodoh & Egbo, 2013), cooperative learning (Adesoji et al., 2015), competitive learning (Okereke & Ugwuegbulam, 2014) and the Virtual Chemistry Laboratory (Darby-White, Wicker, & Diack, 2019). Nonetheless, as was pointed out earlier, no empirical studies in the existing literature have reported on the use of DARTs for learning qualitative analysis in chemistry. Furthermore, several past studies have shown mixed findings in terms of gender differences in achievement in chemistry, with some studies reporting that male students performed significantly better than female students in the subject (Amunga et al., 2011; Obrentz, 2012; Veloo, Lee, & Seung, 2015), while other studies found no significant gender difference in achievement (Afuwape, 2011; Olatoye & Adekoya, 2010; Oludipe, 2012). However, all these studies only focused on general chemistry and did not include qualitative analysis in their investigations. In the context of memory research, males were observed to outperform females in visual-spatial memory tasks; whereas females were better than males in dealing with a variety of verbal tasks (Lowe et al., 2002; Merrill, Yang, Roskos, & Steele, 2016; and Zulkiply, Adruce, Ghani, & Chen, 2008). Furthermore, it has been argued that males have the strength in processing information about one's environment and its spatial orientation (Andrade, 2001), while females have better ability in assigning structure to sentences and understanding the composition of language (Groome, 1999).

DARTs activities which are grouped into two main categories, namely reconstruction and analysis (refer Table 1) make students interact and engage with text, hence are verbal in nature. On the other hand, the experimental method involves students carrying out procedures, performing visual thinking and making predictions based on observation, hence are visual-spatial in nature. Thus, the present study also intended to determine whether DARTs had a different effect on male and female students who were learning about qualitative analysis in chemistry. In sum, the study was also concerned with whether the benefits of using DARTs in the learning of qualitative analysis in chemistry would also be enjoyed by the female students.

Past research on chemistry learning have also revealed various patterns of interaction between different types of instructional method and gender. For example, it was observed that female students performed better than male students when taught using the inquiry role instructional model (Aniodoh & Egbo, 2013) and cooperative learning strategies (Adesoji et al., 2015). Male students were found to outperform their female counterparts in competitive learning strategies in chemistry (Okereke & Ugwuegbulam, 2014) and Virtual Chemistry Laboratory strategies (Darby-White et al., 2019). Other studies found that the type of instructional method used to learn chemistry did not show any gender difference in its impact. This was clearly shown in the following studies examining a variety of instructional models and their impact on both male and female students: cooperative learning strategy (Banerjee & Vidyapati, 1997; Gabriel et al., 2018; Olatoye & Adekoya, 2010; Oludipe, 2012), individual learning strategy (Gabriel et al., 2018, Olatoye & Adekoya, 2010), cooperative class experiment (Wachanga & Mwangi, 2004), concept map (BouJaoude & Attieh, 2008), project-based learning (Olatoye & Adekoya, 2010), think-pair-share strategy (Bamiro, 2015), self-regulated learning (Veloo et al., 2015), hands-on activity (Ajayi & Ogbeba, 2017) and blended reality environment (Hodges et al., 2018). Despite the findings of these previous studies, the research reported here was a different attempt to further explore the effect of interaction between gender and different types of instructional methods.

Theoretical Framework

The theoretical framework underpinning this study was based on the work of Lunzer and Gardner in the 1970s. In particular, their work on Directed

Activity Related to Texts (DARTs) as an approach to learning by processing texts. They had argued that breaking down the text through the reconstruction and analysis of activities in DARTs would help learners to see the relevant structure of the text and in turn, the ability to grasp the key ideas and their interrelationships. As documented in past studies students often faced several challenges or seemingly insurmountable difficulties in learning the qualitative analysis topic in chemistry. For example, students had the following issues: the difficulty in understanding underlying concepts, the considerable amount of memory work required, the potential of cognitive overload, and the lack of motivation, (Tan, 2005; Tan et al.,2001). The present study was thus aimed at determining whether the DARTs instructional method (a non-experimental method) could address these range of difficulties in learning qualitative analysis in chemistry. It was also to investigate whether the DARTs pedagogical approach could enhance the learning of qualitative analysis in chemistry, and whether the DARTs the instructional method would favour a particular gender, or was beneficial to both genders.

Research Questions

The general aim of the study reported here was to investigate the effect of different types of instructional method (Experiment vs. DARTs vs. Combination of Experiment + DARTs) and gender on students' achievement in chemistry (i.e., the qualitative analysis of salt). The research questions of the present study were as follows:

1. Is there any significant difference in students' achievement in the learning of the qualitative analysis of salt in chemistry when they were exposed to different types of instructional methods (Experiment vs. DARTs vs. Combination of Experiment + DARTs)?
2. Is there any significant difference in achievement between genders in the learning of the qualitative analysis of salt in chemistry?
3. Is there any significant interaction effect between gender and the different instructional methods used to learn the qualitative analysis of salt in chemistry?

METHODOLOGY

Participants and Design

One hundred and twenty secondary four science stream students comprising 60 females and 60 males from two local fully residential schools participated in the study reported here. The average age of the participants was 16 years. To ensure high internal validity, participants from fully residential schools were selected. This was because such a purposive sampling allowed the researchers to control the experimental manipulation and prevented the occurrence of extraneous variables. For example, participants having access to the internet and other related resources which could affect the students' chemistry achievement in the experiment. The participants were identified to have a low-level of knowledge in the salt topic. This was determined by a pre-screening test, a measure explained further under the procedure section. Such a condition was also confirmed by the school teachers who provided evidence in the form of their lesson plans, which indicated that the students had not learned the salt topic when the present study was carried out.

This study used a quasi experimental design. Specifically, the present study used the following three instructional methods: Experimental control group vs. DARTs as the first treatment group vs. a combination of Experiment + DARTs as the second treatment group; and a two-gender, female and male between-subjects design. Both the instructional method and gender groups were varied between participants. An equal number of female and male participants comprising 20 females and 20 males participated in each of the three instructional method conditions. It is important to note that there was no issue of pre-test treatment interaction in the context of the present study. This has improved the external validity of the study, since all of the participants were given a pre-screening test before they got involved in the actual experimental manipulation, i.e., in one of the three instructional methods. Therefore, any differences observed in the participants' performance in the post-test later were due to the effect of the instructional method used in the experimental manipulation.

Materials

The materials used in the present study were as follows: i) Handout on experimental procedure and discussion, ii) DARTs sheet handout, and iii) Cation assessment test paper. Specifically, the materials were about the confirmatory test for cations under the salt topic and were prepared in line with the two learning objectives for the salt topic, as was stated in the curriculum specification for chemistry for secondary Four. These learning objectives were as follows: i) to state the observation of reaction of cations with sodium hydroxide solution and ammonia solution; and ii) plan a qualitative analysis to identify cation in the unknown salts solution. During the study phase, the handout on experimental procedures and discussion was used in the experimental method condition and the DARTs sheet handout was used in the DARTs method condition. The combined method (Experiment + Darts) used both the experimental procedures and discussion handout, and the DARTs sheet handout. During the test phase, all participants were given the Cation assessment test to assess their knowledge and understanding on the salt topic. All the materials were prepared in both English and Malay. What follows below are the details about each of the materials used in the experiment.

Handout on experimental procedures and discussion. The handout on experimental procedures and discussion regarding the confirmatory test for cations was taken from the secondary Four practical textbook for chemistry which followed the Malaysian Secondary School Chemistry Curriculum. It was the main source of reference used by all teachers and students in Malaysia to learn practical chemistry during the laboratory sessions (See Appendix A for the experimental handout). The experimental handout included important details about the aim of the experiment, the procedures to carry out the experiment, and most crucially specific sections that guided participants in analysing and interpreting the observation and data, as well as discussion questions.

DARTs sheet handout. The DARTs sheet handout was developed by the researchers, and it was in line with the objectives of the qualitative analysis lesson. The lesson content was also validated (to ensure high internal validity) by four expert panels in the field of chemistry education. In particular, the four expert panels comprised chemistry teachers with over 10 years of experience in teaching the subject, they had a qualification in chemistry education and a minimum of five years of experience as an examiner for the chemistry paper in the Malaysia Certificate of Education. The DARTs sheet handout consisted of 11 activities as is shown in Table 1. DARTs activities consisted of analysis and reconstruction. In particular, the DARTs sheet handout consisted of a series of instructions and a total of 21 questions for DARTs activities (See Appendix B for examples of instructions and questions for DARTs activities). DARTs Sheets 1 to 5 were developed to guide the participants in stating their observations of the reaction of cations with sodium hydroxide solution and ammonia solution. DARTs Sheets 6 to 9 were used to facilitate students' understanding in constructing and planning the qualitative analysis to identify the cation in unknown salts solution, whereas DARTs Sheets 10 and 11 were intended to test students' ability to apply the knowledge they have gained in previous DARTs activities, whereby they learn to construct relevant questions and answers about the confirmatory test for cations. Throughout the study phase, i.e., while the students were performing these DARTs activities, the teacher facilitated their students' learning of qualitative analysis in chemistry.

Table 1

Handouts on DARTs Activities

Handout Number	DARTs Activity	Task	Type of DARTs Activity
1	Underlining or highlighting texts	Find important information about the reaction between cations and sodium hydroxide, NaOH solution from given text	Analysis
2	Underlining or highlighting texts	Find important information about the reaction between cations and ammonia, NH_3 solution from the given text	
3	Table /Diagram construction	Construct table / diagram based on the task in Darts handout 1 & Darts handout 2	
4	Table completion	Complete an incomplete table using the table constructed in Darts handout 3 as reference	Reconstruction
5	Text completion (fill in the blanks with a single word, i.e., cation formulae)	Complete cation formulas, number of moles and ionic equation	
6	Sequencing	Arrange in an orderly diagram the disordered text on the procedures in conducting the experiment	
7	Text completion (fill in the blanks with a single word)	Complete apparatus, materials, procedures and observation based on aim of experiment given	
8	Text completion (fill in the blanks with a phrase or a sentence)	List the apparatus, materials, procedures and observations based on the aim of the given experiment	
9	Text completion (fill in the blanks using a sentence) + Diagram construction + Labelling	Write the complete procedure and observation with drawings, and label the diagrams based on the aim of the experiment	Reconstruction and analysis
10	Question-setting	Create one question with the suggested answer	Analysis
11	Question-setting	Exchange and answer questions in pairs	

Cation assessment test. The Cation assessment test was used in the pre-screening test (conducted before the experimental manipulation) and in the post-test. The test consisted of ten objective questions (1 mark for each question), one structured question (7 marks) and one essay question (13 marks); hence, the total marks one could obtain for this test was 30 marks (See Appendix C for samples of the test questions). The questions were taken and adapted from the Malaysian Certificate of Education, 2012 to 2018 examination papers for chemistry, and also from a collection of trial examination papers of the same level from different states in the country. The content of the Cation assessment test was validated by four expert panels in the field of chemistry education. The analysis on the Cation assessment test used in the present study showed that Cohen's Kappa value was 0.81 (almost perfect agreement), the Cronbach's Alpha was 0.73, difficulty index was p = 0.56 and discrimination index was d = 0.72. Thus, this Cation assessment test paper was considered as sufficiently valid, reliable with moderate difficulty items and a high discrimination index when used to evaluate students' achievement in qualitative analysis in chemistry.

Procedure

Prior to data collection, permission was obtained from the Ministry of Education (MOE), Malaysia, the Sarawak Education Department and the principals of the two local fully residential secondary schools selected as the research sites. For reasons of protecting participant identity, the schools would remain anonymous and be identified only as School A and School B in the following discussion. Both schools had been categorized as high-performance schools by the MOE, Malaysia; hence, participants from both schools were generally similar in terms of their academic background. In addition, for the purpose of data collection (which took into consideration factors such as the students' chemistry class timetable and access to the school laboratory), the researchers conducted a briefing session on the aims and experimental details of the study for the school's chemistry teachers. This was done to obtain their assistance in conducting the actual experimental manipulations using different types of instructional methods to teach the confirmatory test for the cation of salt topic. In particular, the researchers demonstrated and then guided the school's chemistry teachers in terms of the appropriate procedures to implement the DARTs instructional method (i.e., using the DARTs handout sheets). The practical session for teachers was carried out using peer learning coaching (PLC), a one-to-one session to ensure that the school's chemistry teachers fully understood the implementation of the DARTs instructional method. The researchers also explained the procedures to carry out the experimental method (i.e., conducting the experiment in the laboratory), using the handout on experimental procedures and when necessary follow up discussions with the researchers.

The researcher also explained to the school's chemistry teachers the way to implement the combined method (which included both the experiment and

DARTs). Proper explanation and guidance given to the chemistry teachers were crucial as it helped to ensure consistency in terms of the instructions and learning materials delivered to the participants during the experimental manipulation. This in turn, could also increase the internal validity of the study.

Before the experimental manipulation began, all participants were given a pre-screening test (i.e., the Cation assessment test) with the intention of selecting only the most qualified participants, that is, those who had a low-level of knowledge on the topic of salt. The participants who scored ten or below (out of a total mark of 30) were selected for the actual experimental manipulation. As it turned out, all 120 participants scored 10 and below (i.e., with an average of 3.66 out of 30 marks), which was the requirement that had been set, and thus they were selected for the actual experimental manipulation.

Participants were then classified into three groups: control group (experimental method), first treatment group (DARTs method) and second treatment group (Combination of experiment and DARTs method). There was an equal number of participants for each group (i.e., 40 participants) as well as gender distribution (i.e., 20 females and 20 males in each group). The control group consisted of the participants from School A, while both treatment groups consisted of participants from School B.

During the study phase, student participants from the three groups were instructed by their respective chemistry teachers to learn in pairs about the confirmatory test for cation (i.e., observation of reaction of cations with sodium hydroxide solution and ammonia solution; and plan a qualitative analysis to identify cation in unknown salts). In particular, the control group used an experimental method, whereby participants carried out a laboratory experiment following the instructions given in the experiment handout. The DARTs group was engaged in a series of DARTs activities which comprised analysis and reconstruction lessons following the instructions provided in the DARTs sheet handout, whereas the Combined group carried out the laboratory experiment first, which was then followed by the DARTs sheet activities. The duration for the implementation of each instructional method was as follows: experimental method (a total of 90 minutes in three sessions, with a maximum of 30 minutes per session), DARTs method (a total of 150 minutes in five sessions, with a maximum of 30 minutes per session) and combined method (a total of 240 minutes in eight sessions, with a maximum of 30 minutes per session). The time difference across the three instructional methods was due to the different processes and steps in the activities involved for each of the methods. Later in the test phase, the participants from the three groups were given the same Cation assessment test that had been administered during the pre-screening test session; this test served to probe their knowledge and understanding on the confirmatory test for cation for the salt topic that they had learned during the study phase. The participants were given 40 minutes to answer all the questions of the test. At the end of the data collection, the student participants were debriefed about the experimental manipulation they had been involved in. It is important to note that, the pre-screening test, the actual data collection (experimental manipulation), and the post-test were conducted during the chemistry class sessions, and the participants were not told that they were involved in a research. Therefore, there was no issue that the participants in the present study might have acted differently from their normal behavior, thus enhancing the external validity.

RESULTS AND DISCUSSION

The data (i.e., post-test scores) were analysed with a two-way independent ANOVA. The result showed that there was a significant difference in participants' achievement in chemistry (i.e., in the Cation assessment test) across different types of instructional methods (Experiment, DARTs, Combination of Experiment & DARTs), $F(2,114) = 75.451$, $p < 0.001$. The Combined group scored highest in the Cation assessment test ($M = 24.88$, $SD = 3.582$), followed by the DARTs group ($M = 21.73$, $SD = 3.994$) and finally the Experiment group ($M = 15.13$, $SD = 3.156$). This study also found no significant effect of gender on participants' achievement in the Cation assessment test, $F(1,114) = 0.534$, $p = 0.466$, indicating that regardless of the instructional method used, female and male participants' achievement were equivalent. In addition, the interaction between the variables (instructional method and gender) was observed as not significant, $F(2,114) = 0.284$, $p = 0.753$.

In the present study, the combination of both methods (DARTs method and experimental method) was found to be more effective and resulted in better learning of the salt topic (i.e., confirmatory test for cation), compared to the DARTs method alone and experimental method alone. It seemed that each of the methods complemented one another. Past studies have reported on the benefits of the experimental method for learning chemistry—it exposed the learners to the practical experience of learning science processing skills (Omiko, 2015), increased learners' understanding of concepts (Ibrahim, Surif, Khew, & Yaakub, 2013), made learning more enjoyable (Hofstein, 2004) and encouraged inquiry among learners (Cavinato, 2017). However, it is important to note that these previous studies did not specifically examine the qualitative analysis topic. Therefore, their claims on the benefits of the experimental method may not completely account for the learning of the qualitative analysis of salt in the present study. As documented in past studies, there were several issues pertaining to learning the qualitative analysis topic in chemistry using the laboratory experimental method, such as the following: students' difficulty in understanding procedures and the reactions involved (Lay & Osman, 2015), learning the topic involved a lot of memory work (Tan et al., 2001), this in turn, could lead to cognitive overloading (Tan, 2005), and all these difficult challenges had resulted in a lack of motivation in students to learn qualitative analysis in chemistry (Tan, 2005). A recent study reported that the experimental method only emphasized rote memorization of procedures rather than providing opportunities for learners to discover ideas, concepts and procedures meaningfully (Lay & Osman, 2018). A longer instructional period will generally produce more durable learning (Rohrer, 2015). Nevertheless, in the context of learning the qualitative analysis topic in chemistry, which has been demanding in nature (Tan et al., 2001), it was likely that the performance of the Combined group in the study reported here might have been facilitated by the DARTs method. The instructional method had scaffolded learners' understanding through the use of a variety of text interaction activities. The effectiveness of the DARTs method over the experimental method in learning the qualitative analysis topic was observed in further analysis using the t-test ($t(78) = -8.20, p<.001$). The test results seemed to support the argument for the possibility that DARTs activities might have enhanced the learning of the qualitative analysis topic in the Combined method. Thus, the present study believed that the benefits of the DARTs method observed in past studies on the English language subject (Hameed, 2017; Ni'mah, 2016) and science-related subjects (Grady, 2010; Pham & Hoang, 2016) could also be observed in the context of an important component of chemistry, more specifically learning the topic of the qualitative analysis of salt.

The DARTs method involved the concept of reading while interacting with the text to help learners gain a deeper understanding about the content of the text (Henderson & Wellington, 1998). In the present study, while participants were reading the text, they were asked to underline or highlight essential ideas and connections between them (see DARTs handouts 1 & 2). These DARTs activities encouraged learners to read the text carefully, became more focused and to continuously think about what they were reading (Hernández & Solano, 2017). Participants who performed DARTs activities did not only identify the relevant ideas, but also knew how the ideas were developed or connected in the text. In addition, through the three-tier text completion activities (see DARTs handouts 7, 8 & 9), the participants gradually built their understanding about the apparatus, materials and procedures for conducting the experiment, and the observations made. The activities started with participants filling in a few blanks with important single keywords. This was followed by the activity of completing a text with missing important phrases or sentences. Here the participants were able to guess the answers by looking at the clues given before or after the blanks. Lastly, participants were required to complete the whole procedure based on the given aim of the experiment. These three-tier text-completing activities allowed participants to actively engage with the text they had read, thus enhancing their comprehension about the experimental procedures on the salt topic (i.e., confirmatory test for cation). In addition to the text marking and text completion tasks, questioning activities (DARTs handouts 10 & 11) also encouraged deep processing and understanding of the content. The questioning activity encouraged participants to share their knowledge, ideas and perspectives with their partner. This activity would gradually help learners to extend their thinking skills and develop enquiring minds, which would be critical in understanding the content (Pearsall, 2018).

It was also observed in past studies that learners perceived qualitative analysis as a very difficult topic when they learned using the experimental method. A negative perception would eventually affect their motivation to learn more about the topic (Tan, 2005; Tan et al., 2001). In another DARTs activity (i.e., DARTs handout 6), participants were asked to arrange a jumbled up set of experimental procedures for the confirmatory test for cation, but they would be guided by the correct sequencing in a given diagram. It was generally difficult to complete the activity on writing the experimental procedures (Tan et al., 2001), but with the help of the diagram, participants managed to do well in this task. As a result, the scaffolded activity might have changed their perception of qualitative analysis from being a difficult topic to a learning goal within their reach, challenging materials which they were more motivated to learn about. The DARTs activities generally provided clues throughout the tasks and gradually increased the difficulty of the tasks in stages, hence avoiding learners from feeling frustrated, instead encouraging learners to continue interacting with the text (Ulfianda, 2019).

The results from the study revealed that the DARTS method also helped with the issue regarding the massive memory work required in learning qualitative analysis (Tan, 2005; Tan et al., 2001). The findings in the study reported here clearly showed that through the DARTs activities, participants learned to construct a simple yet meaningful table or diagram that connected all the important components of qualitative analysis in chemistry (i.e., DARTs handout 3). They also learned to reorganize their new knowledge by completing a given table complete with given columns and headings (i.e., DARTs handout 4) to help them memorize the facts more systematically, and later learned to recall the formulae of cations and the chemical equations that were a representation of the reaction between cations and the sodium hydroxide solution or ammonia solution (i.e., DARTS handout 5). These DARTs activities seemed to have helped in reducing the amount of memory work the participants had to deal with in learning the qualitative analysis of salt (i.e., confirmatory test for cation) and allowed the participants to organize and construct the learning materials on their own, This pedagogical scaffolding had led to a steep learning curve which in turn, helped the participants of the study to perform well in the test later. The present finding is consistent with that in Hernández and Solano (2017), where it was found that learners gain the benefits of DARTs, such as developing the ability to memorize facts systematically during reading comprehension activities, and to convert and represent large blocks of text into a table, flow chart or diagram based on their own individual way of organizing their understanding of the topic at hand.

It has been argued that learning qualitative analysis using a laboratory experimental method resulted in a cognitive overload (Tan, 2005; Tan et al., 2001). In the present study, the DARTs method was found to have addressed this issue of cognitive overload, which eventually facilitated better understanding of the learned materials. In particular, DARTS activities (i.e., diagram construction and labelling) allowed participants to visualize how they could better handle the reagents and apparatus; that is, regarding the amount of reagent to use, and the apparatus involved in the experiment. For example, in the present study, completing diagrams based on procedures (i.e., DARTs handout 9) stimulated participants' imagination to draw the apparatus and labelled the reactants involved, as well as how the reactants were added or mixed. By reflecting on the experiments they have conducted, the participants experienced an enhanced understanding of the procedures and reactions involved in the qualitative analysis of salt.

The findings in the present study also indicated that there were no significant differences between genders in their achievements in learning about qualitative analysis of salt in chemistry. This seemed to a different outcome compared to that in the other findings that found male students having a higher achievement in chemistry (Amunga et al., 2011; Obrentz, 2012; Veloo et al., 2015). Nevertheless, it is important to note that the past studies which had found that males outperformed females in chemistry were referring to general chemistry, and not specifically to the qualitative analysis topics. In the present study, regardless of instructional methods, both female and male participants performed equally well, and this could be due to the nature of the topic on qualitative analysis which was more complex and abstract (Lay & Osman, 2018). In addition, the qualitative analysis of salt topic itself was ranked as the most difficult among other qualitative analysis topics (Lay & Osman, 2015; Lee & Osman, 2014), thus posing a daunting challenge to both female and male participants in the present study.

Regarding the interaction between instructional method and gender, no significant effect was found. This indicated that the effect of instructional methods on chemistry learning was not different for female and male participants. This could have been due to the difficulty of the salt topic itself. Even though the interaction effect of the variables was not significant in the present study, the means seemed to show that female participants in the DARTs group (*M* = 21.75, *SD* = 4.327) seemed to benefit a bit more from the DARTs method than the male participants (*M* = 21.70, *SD* = 3.743), whereas male participants in the control group using the experimental method (*M* = 15.30, *SD* = 3.164) seemed to score slightly higher than the female participants (*M* = 14.95, *SD* = 3.220). This may have occurred due to the females' abilities to complete verbal tasks found in the DARTs activities, while males have a better visual-spatial memory and they benefit from experiments in the laboratory (Lowe et al., 2002; Merrill et al., 2016; Zulkiply et al., 2008).

CONCLUSION

The findings of the study reported here are of both theoretical and practical importance for learning qualitative analysis in chemistry. With respect to theoretical importance, it provides experimental evidence in support of the claim that the DARTs method has been beneficial as a pedagogical approach as it helps to enhance qualitative analysis learning in chemistry. The DARTs method has never been empirically tested in past studies concerned with qualitative analysis learning in chemistry. The present study however, has shown that the DARTs method facilitated better learning of the qualitative analysis component of chemistry when it was combined with the experimental method. Using the DARTs method only results in better learning of qualitative analysis component in chemistry, as compared with using the Experimental method only. From a practical perspective, the present study has provided significant insights into the benefits of DARTs activities, especially in scaffolding participants' learning of the qualitative analysis component of chemistry. The DARTs activities were beneficial because they seemed to have helped in addressing the previously mentioned difficult issues confronting students learning qualitative analysis using an experimental method; challenges such as difficulty in understanding, the requirement of a great amount of memory work, the potential for cognitive overload and the lack of student motivation. In learning qualitative analysis, the importance of doing the practical session in the laboratory (experimental method) is undeniable, as it gives the students invaluable experience in the practice of the relevant science process skills. Nevertheless, considering the empirical evidence on the benefits of DARTs for learning qualitative analysis topics as found in the present study, educators may want to consider using DARTs activities as well in teaching chemistry. In particular, DARTs activities can be incorporated in the classroom (during the non-practical session) to teach students about qualitative analysis.

One limitation of the present study would be the sample used; the participants were all from two local fully residential schools, which were schools for students with high academic performance. As was highlighted in the literature review, learning qualitative analysis using a laboratory experimental method resulted in the potential for cognitive overload among students (Tan, 2005; Tan et al., 2001). However, it was claimed in the findings of the present study that the DARTs method had addressed the issue of student cognitive overload to a certain extent, which eventually facilitated a better understanding of the learned materials in the Combined group and the DARTs group. Generally, high-achieving students have better cognitive abilities than low- achieving students. It would be interesting to find out if the current pattern of findings could be observed in the low- achieving students, and if the DARTs method could address the issue of cognitive overload in the low achievers as much as in the high achievers. Future research could further examine the effect of the DARTs method on students' achievement in chemistry by taking into consideration differences in students' academic backgrounds, and explore the interaction between instructional methods and gender. Furthermore, the effectiveness of DARTs can also be examined in other topics or branches of chemistry. Researchers should also not continue to a focus on the secondary school chemistry syllabus only, but also the teaching and learning of chemist at the institutions of higher learning in the country

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REFERENCES

Adesoji, F. A., Omilani, N. A., & Nyinebi, O. M. (2015). The effect of homogenous and heterogeneous gender pair cooperative learning strategies on students' achievement in chemistry. *Journal of Education, Society and Behavioural Science, 11*(3), 1-12. https://doi.org/10.9734/BJESBS/2015/19537

Afuwape, M. O. (2011). Students' self-concept and their achievement in basic science. *African Research Review*, *5*(4), 191-200. https://doi.org/10.4314/afrrev.v5i4.69276

Ajayi, V. O., & Ogbeba, J. (2017). Effect of gender on senior secondary chemistry students' achievement in stoichiometry using hands-on activities. *American Journal of Educational Research*, *5*(8), 839-842.

Amunga, J. K., Amadalo, M. M., & Musera, G. (2011). Disparities in chemistry and biology achievement in secondary schools: Implications for vision 2030. *International Journal of Humanities and Social Science, 1*(18), 226-236.

Andrade, J. (2001). The working memory model: Consensus, controversy, and future directions. In J. Andrade (Ed.), *Working Memory in Perspective.* Psychology Press.

Aniodoh, H. C. O., & Egbo, J. J. (2013). Effect of gender on students' achievement in chemistry using inquiry role instructional model. *Journal of Educational and Social Research*, *3*(6), 17. https://doi.org/10.5901/jesr.2013.v3n6p17

Bamiro, A. O. (2015). Effects of guided discovery and think-pair-share strategies on secondary school students' achievement in chemistry. *SAGE Open*, *5*(1), 1-7. https://doi.org/10.1177/2158244014564754

Banerjee, A. C., & Vidyapati, T. J. (1997). Effect of lecture and cooperative learning strategies on achievement in chemistry in undergraduate classes. *International Journal of Science Education*, *19*(8), 903-910. https://doi.org/10.1080/0950069970190804

Berger, S.G. (2015). *Investigating Student Perceptions of the Chemistry Laboratory and Their Approaches to Learning in the Laboratory* [Unpublished doctoral dissertation]. University of California, Berkeley.

BouJaoude, S., & Attieh, M. (2008). The effect of using concept maps as study tools on achievement in chemistry. *Eurasia Journal of Mathematics, Science & Technology Education*, *4*(3), 233-246. https://doi.org/10.12973/ejmste/75345

Broman, K., Ekborg, M., & Johnels, D. (2011). Chemistry in crisis? Perspectives on teaching and learning chemistry in Swedish upper secondary schools. *Nordic Studies in Science Education, 7*(1), 45-53. https://doi.org/10.5617/nordina.245

Cavinato A. G. (2017). Challenges and successes in implementing active learning laboratory experiments for an undergraduate analytical chemistry course. *Analytical and Bioanalytical Chemistry*, *409*(6), 1465-1470. https://doi.org/10.1007/s00216-016-0092-x

Chu, C. K., & Hong, K. Y. (2010, August). *Misconceptions in the teaching of chemistry in secondary schools in Singapore & Malaysia* [Paper presentation]. Innovative Thoughts, Invigorating Teaching: Proceedings of the Sunway Academic Conference (The 1st Pre-University Conference), Selangor, Malaysia.

Darby-White, T., Wicker, S., & Diack, M. (2019). Evaluating the effectiveness of virtual chemistry laboratory (VCL) in enhancing conceptual understanding: Using VCL as pre-laboratory assignment. *Journal of Computers in Mathematics and Science Teaching*, *38*(1), 31-48.

Gabriel, I. A., Osuafor, A. M., Cornelius, N. A., Obinna, P. P., & Francis, E. (2018). Improving students' achievement in chemistry through cooperative learning and individualized instruction. *Journal of Education, Society and Behavioural Science*, *26*(2), 1-11. https://doi.org/10.9734/JESBS/2018/42873

Gebrehiwot, H. (2017). Evaluation and intervention of students' laboratory performance in chemistry graduating classes; Wachemo University, Ethiopia. *International Journal of Scientific Reports, 3*(7), 203-213. https://doi.org/10.18203/issn.2454-2156.IntJSciRep20173092

Goh, N. K., Toh, K. A., & Chia, L. S. (1987). *The effect of modified laboratory instruction on students' achievement in chemistry practicals*. Institute of Education.

Grady, M. K. J. (2010). *Development of scientific literacy by incorporating directed activities related to text in a college-level conceptual chemistry course*. California State University.

Groome, D. (1999). *An introduction to cognitive psychology: Processes and disorders*. Psychology Press.

Gunstone, R. F. (1991). Reconstructing theory from practical experience. In B. Woolnough (Ed.), *Practical Science* (pp. 67–77). Open University Press.

Hameed, S. (2017). Effect of Intervention of Directed Activities Related to Text (DARTs) on Undergraduates' Writing Skill. *Pakistan Journal of Educational Research and Evaluation, 2*(1), 77-103.

Haryanti, E. H. W., Ulfah, M., & Rahayu, P. (2013). The study of invertebrate zoology based DARTs through lesson study as an effort in building the biology studens' critical thinking. *BIOMA Jurnal Ilmiah Biologi*, *2,* 101-113. https://doi.org/10.26877/bioma.v2i1,%20April.406

Henderson, J., & Wellington, J. (1998). Lowering the language barrier in learning and teaching science. *School Science Review*, *79*(288), 35-46.

Hernández, L. M. B., & Solano, T. H. (2017). *Teaching reading comprehension strategies through a genre oriented reading course* [Unpublished Master's Thesis]. Universidad del Norte, Barranquilla.

Hikmah, N., Yamtinah, S., & Indriyanti, N. Y. (2018). Chemistry teachers' understanding of science process skills in relation of science process skills assessment in chemistry learning. *Journal of Physics: Conference Series*, *1022*, 1-7. https://doi.org/10.1088/1742-6596/1022/1/012038

Hodges, G. W., Wang, L., Lee, J., Cohen, A., & Jang, Y. (2018). An exploratory study of blending the virtual world and the laboratory experience in secondary chemistry classrooms. *Computers Education*, *122*, 179-193. https://doi.org/10.1016/j.compedu.2018.03.003

Hodson, D. (1993). Re-thinking old ways: Towards a more critical approach to practical work in school science. *Studies in Science Education, 22*, 85–142. https://doi.org/10.1080/03057269308560022

Hofstein, A. (2004). The laboratory in chemistry education: Thirty years of experience with developments, implementation, and research. *Chemistry education research and practice*, *5*(3), 247-264. https://doi.org/10.1039/B4RP90027H

Ibrahim, N. H., Surif, J., Hui, K. P., & Yaakub, S. (2013). "Typical" teaching method applied in chemistry experiment. *Procedia - Social and Behavioral Sciences, 116,* 4946–4954. https://doi.org/10.1016/j.sbspro.2014.01.1054

Ichwan, Z., Susilawati, S. M. E., & Bintari, S. H. (2015). The development of workbook DARTs-based to increase students' critical thinking skill on the contaminated environment. In Sutikno, A. Widiyatmoko, Masturi & A. Purwinako (Eds.), *International Conference on Mathematics, Science and Education 2015* (pp. 40-44). Semarang State University.

Imaduddin, M., & Haryani, S. (2019). Lembar kerja Directed Activities Related to Texts (DARTs) bermuatan multipel level representasi untuk meningkatkan kemampuan berpikir kritis calon guru kimia. *Jurnal Inovasi Pendidikan Kimia*, *13*(1), 2254-2267.

Johnstone, A. H. (1999). The nature of Chemistry. *Education in Chemistry, 36*(2), 45-48.

Kim, T. L. S., & Wai, M. C. (2007). Language development strategies for the teaching of science in English. *Learning Science and Mathematics Journal*, *2*, 47-60.

Lay, A.-N., & Osman, K. (2018). Developing 21st century chemistry learning through designing digital games. *Journal of Education in Science, Environment and Health (JESEH), 4*(1), 81-92. https://doi.org/10.21891/jeseh.387499

Lay, A.-N., & Osman, K. (2015). Framework for 21st century chemistry instruction: A guide to teaching and learning of Qualitative Analysis. *Technics Technologies Education Management*, *10*(2), 216–230.

Lee, T. T., & Osman, K. (2014). Development of Interactive Multimedia Module with Pedagogical Agent (IMMPA) in the learning of electrochemistry: Needs assessment. *Research Journal of Applied Sciences, Engineering and Technology, 7*(18), 3725–3732. https://doi.org/10.19026/rjaset.7.727

Lowe, P. A., Mayfield, J. W., & Reynolds, C. R. (2002). Gender differences in memory test performance among children and adolescents. *Archives of Clinical Neuropsychology, 18*(8), 865-878. https://doi.org/10.1093/arclin/18.8.865

Lunzer, E., & Gardner, K. (1979). *The effective use of reading*. Heinemann Educational Books for The Schools Council.

Merrill, E. C., Yang, Y., Roskos, B., & Steele, S. (2016). Sex differences in using spatial and verbal abilities influence route learning performance in a virtual environment: A comparison of 6 to 12-year old boys and girls. *Frontiers in Psychology*, *7*, 1-17. https://doi.org/10.3389/fpsyg.2016.00258

Nakhleh, M. B., & Krajcik, J. S. (1994). Influence of levels of information as presented by different technologies on students' understanding of acid, base, and pH concepts. *Journal of Research in Science Teaching*, *31*(10), 1077-1096. https://doi.org/10.1002/tea.3660311004

Ni'mah, H. (2016). *The Effectiveness of Directed Activities Related to Text (Darts) on students reading comprehension in narrative text of the eight grade at MTs Baitul Arqom Balung in The 2015/2016 Academic Year* [Doctoral dissertation]. Universitas Muhammadiyah Jember, Indonesia.

Obrentz, S. (2012). Predictors of science success: *The impact of motivation and learning strategies on college chemistry performance* [Unpublished dissertation]. George Washington University, Washington, DC.

Okereke, C., & Ugwuegbulam, C. N. (2014). Effects of competitive learning strategy on secondary school students learning outcomes: Implications for counselling. *International Journal of Academic Research in Progressive Education and Development*, *3*(2), 137-143.

Olatoye, R. A., & Adekoya, Y. M. (2010). Effect of project-based, demonstration and lecture teaching strategies on senior secondary students' achievement in an aspect of Agricultural Science. *International Journal of Educational Research and Technology*, *1*(1), 19-29.

Oludipe, D. I. (2012). Gender difference in Nigerian junior secondary students' academic achievement in basic science. *Journal of Educational and Social Research*, *2*(1), 93-99. https://doi.org/10.5901/jesr.2012.02.01.93

Omiko, A. (2015). Laboratory teaching: Implication on students' achievement in chemistry in secondary schools in Ebonyi State of Nigeria. *Journal of Education and Practice*, *6*(30), 206-213.

Osman, K., & Sukor, N. S. (2013). Conceptual understanding in secondary school chemistry: A discussion of the difficulties experienced by students. *American Journal of Applied Sciences*, *10*(5), 433-441. https://doi.org/10.3844/ajassp.2013.433.441

Pamelasari, S. D., & Khusniati, M. (2013, June). *The effectiveness of Directed Activities Related to Texts (DARTs) to improve reading comprehension for science students* [Paper presentation]. Foreign Language Learning and Teaching International Conference, Pathum Tani, Thailand.

Pearsal, G. (2018). *Fast and effective assessment: How to reduce your workload and improve students learning*. ASCD.

Pham, P. A., & Hoang, M. P. (2016, May). *Texts in teaching-learning science and directed activities related to texts-viewpoint from child rights* [Paper presentation]. First International Conference on Child - Friendly Education, Surakata, Indonesia.

Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, *63*(2), 167-199. https://doi.org/10.3102/00346543063002167

Reif, F., & Larkin, J. H. (1991). Cognition in scientific and everyday domains: Comparison and learning implications. *Journal of Research in Science Teaching*, *28*(9), 733-760. https://doi.org/10.1002/tea.3660280904

Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. *The Journal of the Learning Sciences*, *13*(3), 273-304. https://doi.org/10.1207/s15327809jls1303_2

Safadi, E., & Rabab'ah, G. (2012). The effect of scaffolding instruction on reading comprehension skills. *International Journal of Language Studies*, *6*(2), 1-38.

Tan, K. C. D. (2005). Pre-service teachers' conceptions of basic inorganic qualitative analysis. *Canadian Journal of Math, Science & Technology Education*, *5*(1), 7-20. https://doi.org/10.1080/14926150509556641

Tan, K. C. D., Goh, N. K., Chia, L. S., & Treagust, D. F. (2001). Secondary students' perceptions about learning qualitative analysis in inorganic chemistry. *Research in Science & Technological Education*, *19*(2), 223–234. https://doi.org/10.1080/02635140120087740

Tasker, R., & Freyberg, P. (1985). Facing the mismatches in the classroom. In R. Osborne & P. Freyberg (Eds.), *Learning in Science* (pp. 66-80). Heinemann.

Tsoi, M. F. (1994). *Effects of different instructional methods on interpretation skills in chemical qualitative analysis* [Unpublished Master's Thesis]. National University of Singapore.

Ulfianda, F. (2019). *The effect of Directed Activity Related to Text (DART) method in improving students' reading comprehension* [Unpublished Master's Thesis]. University of Muhammadiyah Sumatera Utara.

Veloo, A., Lee, H. H., & Seung, C. L. (2015). Gender and ethnicity differences manifested in chemistry achievement and self-regulated learning. *International Education Studies*, *8*(8), 1-12. https://doi.org/10.5539/ies.v8n8p1

Wachanga, S. W., & Mwangi, J. G. (2004). Effects of the cooperative class experiment teaching method on secondary school students' chemistry achievement in Kenya's Nakuru District. *International Education Journal*, *5*(1), 26-36.

Walqui, A. (2006). Scaffolding instruction for English language learners: A conceptual framework. *International Journal of Bilingual Education and Bilingualism*, *9*(2), 159-180. https://doi.org/10.1080/13670050608668639

Wellington, J., & Osborne, J. (2001). *Language and literacy in science education*. McGraw-Hill Education.

White, R. T. (1990). Episodes and the purpose and conduct of practical work. In B. E. Woolnough (Ed.), *Practical Science: The Role and Reality of Practical Work in School Science*. Open University Press.

Woldeamanuel, M. M., Atagana, H., & Engida, T. (2014). What makes chemistry difficult? *African Journal of Chemical Education*, *4*(2), 31-43.

Yunus, F. W., & Ali, Z. M. (2013). Attitude towards learning chemistry among secondary school students in Malaysia. *Journal of Asian Behavioural Studies, 3*(11), 1-11.

Zainab, K. (2012, November). *Innovative approaches in teaching Science at secondary level: Focus on reading and writing in Science classrooms* [Paper presentation]. Search of Relevance and Sustainability of Educational Change: An International Conference, at Aga Khan University Institute for Educational Development, Karachi, Pakistan.

Zulkiply, N., Adruce, Z., Ahmad, S., Ghani, K. A., & Chen, P. L. (2008). Gender and educational stream differences in memory retention for verbal and non-verbal tasks. *International Journal of Learning, 15*(3), 11-21.