

**LEARNING STYLES AND PERFORMANCE ON CHEMISTRY PROBLEM
SOLVING OF FORM FOUR STUDENTS**

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DEDICATION

This work is dedicated to my parents, my brother, my sister and my grand parents

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ABSTRACT

Learning styles involves the concept that individuals differ in regards to what mode of instruction or study is most effective for them. Thus, students learn best within their own learning styles. Therefore, the aims of this study are (i) to ascertain the dominant type of Kolb's learning styles amongst Form Four Chemistry students (ii) to determine performance on algorithmic and conceptual problem solving across learning styles (iii) to determine if there any significant differences in performance on algorithmic and conceptual problem solving across learning styles (iv) to find out students' difficulties when solving the algorithmic and conceptual questions. The findings of this study show that the dominant learning style of Form 4 chemistry students was assimilation. It was found the convergers were the best problem solvers in terms of algorithmic and conceptual questions. One-way ANOVA showed that there were significant differences in the performances on algorithmic and conceptual questions associated with differences in learning style preferences. The findings also showed poor deductive reasoning, poor mathematical skills and unfamiliarity with the symbols used in mathematical expression were the factors which posed difficulties to students in solving algorithmic questions, whereas a poor grasp of concepts at the microscopic level was the factor which impeded students' problem solving in conceptual questions.

ABSTRAK

Gaya pembelajaran mempunyai konsep bahawa setiap individu berbeza dari segi mod pengajaran yang paling berkesan kepada mereka. Oleh itu, seseorang belajar terbaik dengan gaya pembelajarannya. Maka, tujuan dalam kajian ini ialah (i) menentukan gaya pembelajaran yang dominan bagi pelajar-pelajar kimia Tingkatan 4 dengan menggunakan model gaya pembelajaran Kolb (ii) mengkaji jenis gaya pembelajaran Kolb ke atas pencapaian dalam soalan algorithm dan soalan konsep berkaitan kimia (iii) mengkaji kesan gaya pembelajaran atas pencapaian dalam penyelesaian soalan algorithm dan soalan konseptual (iv) menentukan masalah kesukaran pelajar dalam konsep persamaan kimia dan molariti. Hasil kajian menunjukkan gaya pembelajaran dominan pelajar kimia ialah asimilasi. Didapati gaya pembelajaran jenis *converger* merupakan penyelesai masalah yang terbaik dalam penyelesaian soalan algorithm dan soalan konseptual. Analisis ANOVA menunjukkan gaya pembelajaran mempunyai kesan yang signifikan atas pencapaian dalam penyelesaian soalan algorithm dan soalan konseptual. Kajian juga menunjukkan bahawa kekurangan keupayaan deduktif, penggunaan teknik matematik dan tidak biasa dengan simbol dan ekspresi matematik adalah penyebab pelajar tidak dapat menyelesaikan soalan jenis algorithm dan kelemahan memahami konsep pada aras mikroskopik adalah faktor yang menghalang pelajar menyelesaikan soalan konseptual.

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LIST OF ABBREVIATIONS

AC	Abstract Conceptualization
AE	Active Experimentation
ANOVA	Analysis of Variance
BPPDP	Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
CE	Concrete Experience
dfb	Degrees of Freedom for Treatment
dfw	Degrees of Freedom for Error
ELM	Experiential Learning Style Model
EPRD	Educational Program Research and Development
ILP	Inventory of Learning Process
JPNJ	Jabatan Pelajaran Negeri Johor
KPM	Kementerian Pendidikan Malaysia
LSI	Learning Style Inventory
LSQ	Learning Styles Questionnaire
PPD	Pejabat Pelajaran Daerah
RO	Reflective Observation
SMK	Sekolah Menengah Kebangsaan
SPSS	Statistical Packages for Social Science
SPQ	Study Process Questionnaire
UTM	Universiti Teknologi Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Chemistry is an elective science subject offered at upper secondary level to provide students with knowledge and skills in chemistry. Chemistry enables learners to understand what happens around them and therefore it is considered the most important branches of science (Sirhan, 2007). Chemistry curriculum incorporates many abstract concepts. The introduced concepts form the basis of further concepts which are difficult to grasp. Hence, students sometimes repel themselves from continuing their chemistry studies (Sirhan, 2007).

Learning style refers to the distinctive and habitual manner of acquiring knowledge, skills or attitudes through study or experience (Smith and Dalton, 2005). It has been often conceived as the manner to approach a learning situation. Thus learning style is believed to have an impact on learning performance (Cassidy, 2004). To facilitate students' learning, their learning styles and the related topics are studied. Research into learning styles has been fairly comprehensive, but incomplete. Most studies identify students' learning styles (Lee Ming Foong, 2001; Baykan and Nacar, 2007); the relation of learning styles with academic performance (Lynch et al., 1998; Yeung et al., 2005) or are related to cognitive skills (Zoller, 1997). Still, the weaknesses of students possessing specific learning styles in problem solving are unclear.

There exists a lot of research (Chiu, 2001; Boujaoude and Barakat, 2003; Toth and Sebestyen, 2009) which shows that students' performance on algorithmic problem solving and conceptual understanding in chemistry are different. They report that students perform better on algorithmic questions than conceptual questions. Findings have indicated that algorithmic and conceptual questions present students with different types of problems. In light of this information, there is a need to ascertain students' chemistry performance by assessing their performance on these types of questions (algorithmic and conceptual questions) separately. By doing so, teachers may gain a better understanding of how their students learn and at the same time, spot the students' difficulty in chemistry.

The (Chiu, 2001; Boujaoude and Barakat, 2003; Toth and Sebestyen, 2009) literature proves the learning styles can affect students' approach to learning and academic performance. Nonetheless, no published research has been found on students' learning styles and academic performance based on types of these problems: algorithmic and conceptual problems. Thus, this study is ultimately concerned with the effect of learning styles on performance in solving algorithmic and conceptual understanding questions in chemistry. This study is also interested in determining the performance of types of learners solving the chemistry questions. In addition, the dominant type of student learning style and student difficulties in solving algorithmic and conceptual questions are also discussed in this report.

1.2 Background of the Research Problem

The study aims to investigate students' learning styles and their performance in solving chemistry algorithmic and chemistry conceptual questions. Kolb's Learning

Style Inventory was used to determine the learning styles of Form Four chemistry students. In this section, some previous studies related to this researched topic are described. From the background information of previous studies has come the rationale to conduct this present research.

1.2.1 Learning Styles and its Importance

Learning style is the typical way an individual likes to go about learning (Smith and Dalton, 2005). To determine learning styles, many learning style models have been made available for this purpose. Regardless of a wide variety of models to choose from, the outcome of these models describes how a learner responds to a wide range of intellectual and perceptual stimuli to approach new material. For example, some students may prefer a learning experience which involves discussion, while others prefer to study alone (Chamillard and Sward, 2005).

One of the learning style models which focus more on students' preferences for the learning environment is Grasha & Reichmann's Student Learning Styles Scales (Logan & Thomas, 2002). This model proposes six different learning styles to determine how people interact with a learning environment. The six learning styles are competitive, collaborative, avoidant, participant, dependent, and independent. Among these learning styles, researches regarding collaboration in students learning are found. Cooper et al. (2008), for example probed the effectiveness of using small groups to improve problem solving.

In Cooper et al. (2008) study, the participants were 713 students enrolled in the first semester of a general chemistry course for science and engineering majors. To

investigate the effectiveness of a collaborative group, the participants were paired up and asked to answer five questions. They were then asked to answer five more questions individually. The findings indicated that individual performance improved after grouping. The findings of Cooper et al. also report that learning styles can affect student effectiveness in chemistry problem solving. Undoubtedly, a collaborative environment provides students with a learning experience in their learning process. Cooper et al. (2008) described that such learning experiences are important in chemistry performance. Kolb's learning style model emphasizes the important role that experience plays in learning (Kolb, 1976). However, no published research has been found which uses Kolb's model to study learners' performance on chemistry problem solving, especially performance in solving chemistry questions in algorithm-form and concept-form. Thus there is a need to study this current topic.

Jegade (2007) conducted research to identify the factors that cause student anxiety towards learning chemistry. The study was conducted by using questionnaire. In the study, Jegede found that 82% of students agreed that their teacher's teaching caused them great anxiety when learning chemistry. The findings suggest that accommodating students' learning styles in teaching can create a comfortable or harmonious environment which will serve to enhance students' understanding towards abstract concepts. If not, students may simply have a phobia about chemistry. Some questions arise from the findings: "If learning styles affect students' learning, what about the relationship between learning style and problem solving ability?" "Will a specific type of learners show better performance in solving problems?" These questions need to be empirically tested in order to have any credence.

1.2.2 Learning Styles, Academic Performance and Learning Styles Inventory

A number of researchers have investigated the effect of learning styles on students' chemistry performance. For example, Yeung et al. (2005) used the Paragon of Learning Styles Inventory (PLSI) on first year chemistry students and found that most of the Introverts outperformed Extroverts and Thinkers outperformed Feelers. While most of us agree on the impact of learning styles, some refute that claim. Nor Hafidatulhusna (2009) has determined Form Four students' learning style using Honey and Mumford (1992) LSQ. Her findings indicated that learning styles were not related to academic performance and students were generally good in problem solving. Yeung et al. (2005) and Nor Hafidatulhusna (2009) used different learning style models in their study. Thus, it makes the readers wonder if the psychometric properties of the model used cause the contradiction between the results of Yeung et al. (2005) and Nor Hafidatulhusna (2009). Honey and Mumford's Learning Style Questionnaire (LSQ) has been proposed by Duff & Duffy (2002) as an alternative to Kolb's Experiential Learning Style Model (ELM) Penger et al. (2008). If so, will the findings using Kolb's ELM show the same results as LSQ (2009)?

A paucity of research uses Kolb's ELM to determine the chemistry students' learning styles. At the same time, little is known about Malaysian students' learning styles, especially in the field of chemistry education. Thus, research about this topic should be conducted to provide more information to the educational field.

1.2.3 Problem Solving in Chemistry

Problem solving can be defined as systematically finding the right solutions in unfamiliar or challenging situations, or in the face of unanticipated difficulties. Johnstone (1993) categorized the problems into 8 types (cited in Reid (2002) (refer to Table 2.4). In this classification, the aspects to be considered are data, methods, and goals or outcomes. Data problems are concerned with the completeness of the data; that is the data given is either complete or incomplete. The methods relate to the familiarity of students to the problems – familiar or unfamiliar. Goals or outcomes refer to the clarity of the goal, that is, the goal is given or open. Among the types of problems, type 1 has been focused on the most in schools and universities (Reid, 2002; Bennett, 2008).

Type 1 problems are algorithmic in nature. In these types of problems, the data and goal are given, and the students are familiar with the methods to solve the problems. The skill bonus acquired by the students in solving this type of problem is the recalling of algorithms. The emphasis on this skill and algorithmic problems concerns readers and lead them to wonder if it is the best predictor for students' problem solving ability. Research (Aziz and Hasnah, 1990; Chiu, 2001; BouJaoude and Barakat, 2003; Schmidt and Jigneus, 2003) has shown that students who could solve algorithmic questions were not necessarily good problem solvers. The researches also found that students who did not know the relevant concept resorted mostly to algorithmic problem solving to get the correct answer, and when in answering more conceptual problems, students used algorithms blindly or showed messy solving strategies. The researches finding suggests that algorithms are not the only nature of chemistry and that chemistry is also abstract in nature. Hence algorithmic questions should not be the only questions used to test a student's chemistry performance.

Previous studies (Aziz and Hasnah, 1990; Chiu, 2001; BouJaoude and Barakat, 2003; Schmidt and Jigneus, 2003) have found that student performances on algorithmic problem solving and conceptual understanding were different. The results showed that most of the students performed better in algorithmic questions than conceptual understanding questions. On the other hand, Stamovlasis et al. (2005) reported that students did well only in simple algorithmic, but when algorithmic questions became complex, students' performed worse than they did on conceptual questions. The mentioned researches have suggested the ability to solve algorithmic and conceptual questions are different. Thus if these abilities are not evaluated separately, the evaluation of students' performance in chemistry is not effective enough to know their level in this subject.

Benett (2008) stated that chemistry problems are not merely the exercise or the application of the algorithm, but the totality of the problem. As a result, teachers should attach greater important to students' conceptual understanding as well so that they can become good problem solvers.

1.2.4 Learning Styles, Algorithm and Chemistry Conceptual Understanding Problem

Previous researchers (Yeung et al., 2005; Nor Hafidatulhusna, 2009) have studied the effect of learning style on students' chemistry performance. However their conclusions were not as one on this topic. Yeung et al. (2005) concluded that learning styles affected students' performance, whereas Nor Hafidatulhusna (2009) disagreed. There is very little information available on this topic, especially in the field of

chemistry education. Thus it is hard to build a general conclusion about the effect of learning styles on chemistry performance with the limited information available.

Studies (Aziz and Hasnah, 1990; Chiu, 2001; BouJaoude and Barakat, 2003) have discovered that students' performances in algorithmic problem solving and conceptual understanding of chemistry are different. The findings of the studies showed that students performed better in algorithmic questions than conceptual questions. These findings support and align with abundant studies which reported that secondary students held misconceptions about concepts in chemistry (Aziz and Hasnah, 1990; Lin et al., 2002; Tee, 2002; Onwu and Randall, 2006; Yau, 2007; Lee, 2009). The findings indicate that the ability to solve algorithmic problems is not equivalent to the ability of solve conceptual problem. Hence, it brings into the question the validity of tests used to measure academic performance in chemistry. If problems in chemistry are focused mostly on algorithms, can chemistry be said to teach the nature of science? Can the result represent the conceptual understanding of students? Also, will the test show bias to students who favor algorithmic questions?

Learning styles model that stresses the process of learning can be a cognitive information processing model to explain assimilation of information (Duff, 2004). The suggested model is Kolb's ELM (1976) (Duff, 2004). Assimilating information is important in problem solving. Lee et al. (2001) reported that linkage skill (effect of assimilating) was a cognitive variable which significantly affected problem solving performance. The findings reveals that learning style and problem solving involve cognitive and the assimilation of information. From these similarities, it can be said that learning styles and problem solving are related.

To study the effect of learning styles on problem solving, an appropriate learning styles model to determine students' learning styles and type of problems to test the

students' performance has to be considered. From the results of previous researches (Yeung et al., 2005; Nor Hafidatulhusna, 2009), it seems that in choosing an inappropriate learning style model, the test questions may not measure the students' real problem solving abilities and therefore, the effect of learning styles on their problem solving abilities. Instead of thinking and searching for the right model or facing unexpected factors which might affect the result, is it not better just to compare the performance on problem solving within the learning styles? Riechmann-Hruska (1989) suggested that a successful teaching has to consider at least two learning styles. Comparing learners' performance in two types of chemistry questions (algorithmic and conceptual questions) is thus more meaningful as it suggests two learning styles in teaching chemistry.

To simplify this study and to eliminate unwanted factors which might affect the result, the interest of this present study lies mainly in comparison among students' learning styles and their performance in solving algorithmic and conceptual questions of chemistry.

1.3 Statement of Problem

Learning styles leverage the way we acquire knowledge (Smith and Dalton, 2005), but previous researches showed a contradictory relation between learning styles and academic performance (Yeung et al., 2005; Nor Hafidatulhusna, 2009). Studies have reported an inequality of algorithm and conceptual understanding problem solving (Aziz and Hasnah, 1990; Chiu, 2001; BouJaoude and Barakat, 2003). Therefore the finding suggests type of problems should be varied to measure the real chemistry performance of students.

Duff (2004) described the model that stressed that learning process can be used to explain ways to assimilate information. One of the learning style models suggested by Duff (2004) is Kolb's ELM (1976). The importance of assimilation is reported by Lee et al. (2001). They reported that linkage skill (effect of assimilating) was a cognitive variable which significantly affected problem solving performance. The result implies that problem solving strategies depend on the effects of assimilation. In other words, problem solving also depends on learning styles to assimilate information in solving problems.

Riechmann-Hruska (1989) suggested that a successful teacher has to consider at least two learning styles. Thus, comparing learners' performance in two types of chemistry questions (algorithmic and conceptual) will be more meaningful as it suggests two learning styles in teaching chemistry. In addition, psychometric properties of learning styles and unstudied type of problems (e.g. hands-on problem) may ruin the study. Therefore, this present study concentrates on the comparison between students' learning styles and their performance in solving algorithmic and conceptual chemistry questions.

1.4 Objective of the Study

This research concentrates on the learning styles of chemistry students and their performance in algorithmic and conceptual problem solving, as well as the objectives arising there from. The objectives of the study are:

1. To ascertain the dominant type of Kolb's learning styles amongst Form Four Chemistry students

2. To determine performance on algorithmic and conceptual problem solving across learning styles
3. To determine any significant differences in performance on algorithmic and conceptual problem solving across learning styles
4. To find out students' difficulties when solving algorithmic and conceptual questions

1.5 Research Questions

This study provides answers to the following questions:

1. What is the dominant type of Kolb's learning styles amongst Form Four Chemistry students?
- 2) How is the performance of algorithmic and conceptual problem solving across learning styles?
- (3) Is there any significant difference in performance between algorithmic and conceptual problem solving across learning styles?
- (4) What are the difficulties students face when solving algorithmic and conceptual questions?

1.6 Significance of the Study

This study is important for three primary reasons. One is the notion of determining students' learning style to develop teaching strategies to enhance students' learning. The second is the knowledge of strengths and weaknesses of type of learners that help in improving the performance of students solving chemistry problems. The third is to provide better insight into the effect of learning styles on problem solving in chemistry.

1.7 The Limit of Study

This research does not study the background and gender of the students. 347 students from 6 SMK secondary schools in Pontian are involved in this study. The selected schools are:

1. SMK Dato' Ali Haji Ahmad
2. SMK Sri Tanjung
3. SMK Dato' Mohd. Yunos Sulaiman
4. SMK Sri Perhentian
5. SMK Pekan Nanas
6. SMK Dato Penggawa Barat

1.8 Conceptual Framework

There are 4 objectives in this study. The objectives are indicated in Figure 1.1 below.

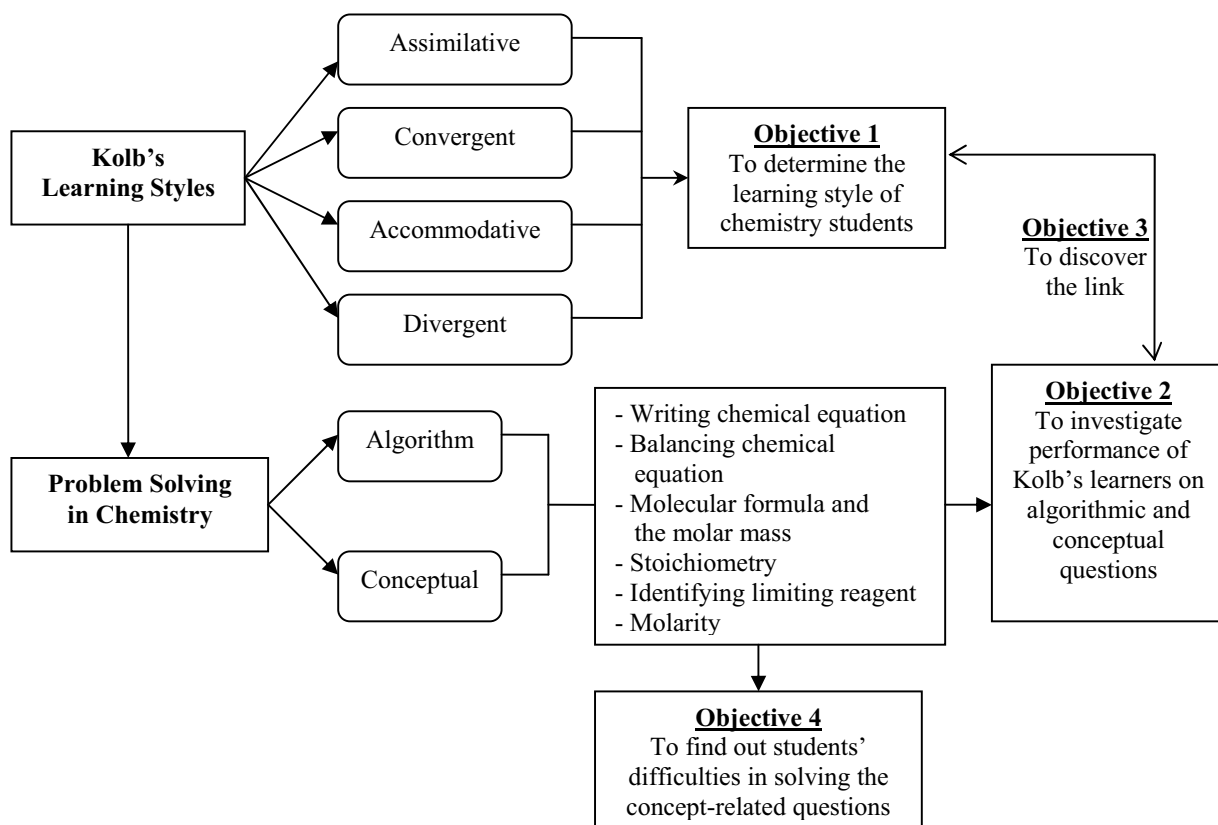


Figure 1.1: Conceptual Framework

There are many learning style models to explain the way that students prefer to learn. One of the models is Kolb's model. In this model, Kolb identifies 4 types of

learning styles. These are: 1) Assimilative learning style 2) Convergent learning style 3) Accommodative learning style 4) Divergent learning style. Kolb (1981) demonstrated that undergraduates majoring in chemistry tended to favor an assimilative learning style. Kolb believed that undergraduate education was a major factor in shaping one's learning style. If so, how about the preferred learning styles of chemistry students in secondary education? Thus, one of the purposes of this study is to determine their preferred learning style.

The concept behind Learning Style is that learners differ in regards to what mode of instruction is most effective for them. It emphasizes that learners should learn with their own learning style to help them learn best in a learning situation. Theoretically, learning style is an important determinant of academic performance. However there is research that is not in agreement. For example, Nor Hafidatulhusna (2009) concluded that there was no relationship between learning styles and chemistry performance.

It is generally agreed that academic performance depends on the ability to solve problems. In chemistry, academic performance depends on the ability to solve conceptual and algorithmic questions. In Nor Hafidatulhusna (2009) study, she did not categorize the types of problems when examining the effect of leaning styles on academic performance. Thus, it might be the reason she failed to study the effect of learning style.

Different disciplines have different learning content and different types of problems. In Chemistry, conceptual and algorithmic questions make up the problems, whereas other disciplines are not involved. Therefore, it is believed that not every learning style favors different disciplines and one's learning style may not dovetail in every learning situation.

Reviewing the previous researches, most of them studied the link between learning styles and academic performance in Chemistry, but none of them classified problems into conceptual and algorithmic problems before studying the link. Many researchers have reported that students show different abilities in solving conceptual and algorithmic questions, which may be one of the reasons why previous researches showed inconsistent findings of the link between learning styles and academic performance in Chemistry.

It is suspected that a thorough understanding of the link between learning styles and academic performance points to the need to explore links between learning styles and performance in solving chemistry problems. As a result, this study investigates learning style groups and their performance on algorithmic and conceptual questions. Only then can the effect of learning styles on the performance in solving algorithmic and conceptual questions be open to discovery. In order to provide initial insight into the problems students have in solving algorithmic and conceptual questions, their difficulties in solving these types of questions are studied.

1.9 Definition

Some terminologies have been used in this research. The following terms are required for the purpose of this study:

a. Kolb's Learning Style Model

This model is based on experiential learning to define learners' learning styles (Kolb, 1984). The four learning styles in this model are:

- (i) Divergence learning style (divergers)
- (ii) Assimilation learning style (assimilators)
- (iii) Convergence learning style (convergers)
- (iv) Accommodation learning style (accommodators)

b. Kolb's Learning Style Inventory

Kolb's is an instrument built to measure preference of four learning styles: divergence, assimilation, convergence, and accommodation.

c. Conceptual Understanding Problem

According to Bowen and Bunce (1997), conceptual questions tap into the "why" aspect of a response that indicates understanding of chemical ideas associated with the question. To achieve an understanding in chemistry, an ability to represent and translate chemical problems using three forms of representation (macroscopic, microscopic, and symbolic) must be possessed. Conceptual problems in this study are the problems that have to be solved by translating one form of representation to another.

d. Algorithmic Problem

According to Bowen and Bunce (1997), algorithmic questions are problems that can be answered by applying a set of procedures to generate a response. Thus the algorithmic problems in this study will be the problems that can be solved by applying a set of steps or procedures to obtain answers without probing or using the three forms of representation (macroscopic, microscopic, and symbolic).

1.10 Summary

This chapter has presented an overview of the background and rationale for this study. In summary, this study uses Kolb's model to determine chemistry students' learning styles. The performances within learning style groups in solving algorithmic and conceptual questions have been studied. Then, the effect of learning styles on students problem solving was analyzed. Finally, the difficulties that students faced in solving algorithmic and conceptual questions are discussed.

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