# CHAPTER 1

# THE STATEMENT OF PROBLEM

## 1.0 Introduction

As Malaysia prepares to join the ranks of developed nations by 2020, it has placed on its national agenda in the creation of a scientific and progressive society that is innovative, forward looking and one that is not only consumer of technology, but also a contributor to the scientific and technological civilizations of the future. According to Poisson, M. and Nacereddine,F.(cited by Sharifah Maimunah, 2000), mastery of science and technology among the young is crucial, as this will provide the necessary pool of technocrats who have the capabilities and creativity to take the lead in the various technology related activities.

The National Philosophy of Science Education states that 'In consonance with the National Education Philosophy, science education in Malaysia nurtures a science and technology culture by focusing on the development of individuals who are competitive, dynamic, robust and resilient and able to master scientific knowledge and technological competency.'

With this philosophy, science education, therefore is aimed at developing the potentials of individuals in an overall and intergrated manner so as to produce Malaysian citizens who are scientifically and technologically literate, competent in scientific skills, practice good moral values, capable of coping with the changes of scientific and technological advances and be able to manage nature with wisdom and responsibility for the betterment of mankind.

Given the emphasis to science education in the Vision 2020 policy document, it is appropriate to look into the main problems encountered in the teaching of science and technology. One of the problems faced in the teaching of science and technology is teaching of abstract topics. There are certain topics that are abstract in nature which students find difficult to learn. Two concepts that students find difficult to understand in the Malaysian Form Four Biology Syllabus are diffusion and osmosis.

These two concepts are often considered by many students to be difficult to understand and students often encounter problems in the learning of these two concepts. Students are often not able to fully understand these two abstract concepts in biology and are not able to apply these concepts in the explanation of how biological systems function.

The purpose of this study is to assess students understanding of these two concepts that is diffusion and osmosis in biology and to ascertain the kind of problems faced by the students in the learning of these two concepts. Included in this chapter are the background of this study, biology education in Malaysian Secondary Schools and the research questions asked. The significance of this study is also included.

### 1.1 Background of the Study

Diffusion and Osmosis are two concepts that are fundamental to a study of biology at both a secondary and tertiary level. Both these concepts are abstract in nature and students have demonstrated alternative conceptions which have been identified in numerous documents in the research literature (Okeke & Wood-Robinson, 1980; Westbrook, 1987; Odom, 1992; Zuckerman, 1993).

It is important for students to develop a strong understanding of the concepts of diffusion and osmosis in order to build their knowledge base for other science concepts within the cellular system. Various reasons have been identified to be the sources for students' difficulties in the learning of diffusion and osmosis. Christianson and Fisher (1999) reported that there were certain reasons for students difficulties in the learning of diffusion and osmosis. The causes of students' difficulties were related to three reasons.

Firstly , diffusion and osmosis are two important processes required in the understanding of how biological systems function. Secondly, these two topics are difficult to understand and formal reasoning ability skills are required to understand them. A third reason for studying these topics is the availability of a tool designed specifically to assess conceptual understanding of diffusion and osmosis, the Odom and Barrow Diffusion and Osmosis Diagnostic Test (DODT).

Johnstone and Mahmoud (1980) surveyed high school biology students on their perceived difficulty of isolated biology topics and reported that osmosis and water potential were regarded by students and teachers as being among the most difficult biological concepts to understand. Misconceptions pertaining to diffusion and osmosis processes are common in high school and college level students. These misconceptions or alternative views by students have been described as "mistakes, errors, misunderstandings, misleading ideas and misinterpretation of facts and as preconceptions, private concepts, alternative frameworks and naïve theories" (Odom and Barrow, 1995).

Odom (1995) administered the Diffusion and Osmosis Diagnostic Test (DODT) to 116 secondary biology students, 123 college non-biology majors and 117 biology majors. Misconceptions were detected in five of the seven areas measured by the test that

is the particulate and random nature of matter, concentration and tonicity, the influences of life forces on diffusion and osmosis, the process of diffusion and the process of osmosis.

Marek and Cavallo (1994) reported that students have many erroneous thoughts on diffusion and osmosis processes. They further explored the idea that concrete learners acquired misconceptions about diffusion and osmosis easier than formal learners. From the study it was apparent that many of the principles of diffusion and osmosis were being taught at the formal operational level to predominantly concrete operational students.

Subject matter should be introduced to students in a manner that permits them to gain an accurate and working understanding of the finite principles of diffusion and osmosis. In the Piagetian model, disequilibrium occurs when the details the student has gathered conflicts with existing mental structures. Disequilibrium is the driving force in the learning process and demands a choice on the part of the learner to ignore the new data or resolve the conflict (Westbrook and Marek, 1992).

When students discover connections between related topics for themselves, they experience an ownership of the new idea. When they have this experience, they may release old ideas and replace them with newly modified ideas. Students should be z (Marek, Cowan and Cavallo, 1994).Unfortunately some students will persist in holding on to their alternative idea and make the new information fit into their mental framework making future learning even more difficult.

If concrete operation students are being taught formal operation ideas through lecture only, most high school students will only memorize the facts and provide them on the test without understanding in order to make an acceptable grade. Memorization of

isolated pieces of information that students do not understand logically leads to misconceptions (Westbrook and Marek, 1992).

According to Piaget's four stages of cognitive development (Inhelder & Piaget, 1958), students at the age of 12 to 15 years should be able to perform the formal operational thinking, i.e. perform mental operations in a hypothetical-deductive manner as well as understand abstract concepts. However, a number research studies (Lawson, 1983; Lew, 1987; Renner, Abraham, Grzybowski & Marek, 1990) have reported that a majority of secondary school students failed to reach the level of formal thought and were still operating at the concrete operational or transitional formal stage.

Concrete operational students have not developed the mental structures necessary to assimilate and accommodate new knowledge without the benefit of exploration and laboratory activities (Westbrook & Marek, 1992). Because many secondary students are concrete or preformal learners, Odum suggested that specific instructional strategies should be developed to counter students' misconceptions when teaching diffusion and osmosis in secondary science classrooms.

According to Lawson and Thompson (1988) in order to overcome misconceptions students must become aware of the scientific conceptions, the evidence that bears on the validity of their misconceptions and the scientific conceptions, and they must be able to generate logical relationships among the evidence and alternative conceptions. Because formal operational reasoning patterns are necessary to generate these logical relationships, it is predicted that following instruction, formal operational students would hold significantly fewer misconceptions than their concrete operational classmates.

In Malaysia, as far as the researcher can determine, only one study on the conception of a biology concept was carried out. The study was carried out by Lew (1994) on the conceptions of photosynthesis among students across different grade levels. There had been no studies pertaining to the understanding of diffusion and osmosis and its relationship with formal reasoning ability. Thus, it was appropriate for the researcher to conduct a study on the Understanding of Diffusion and Osmosis, and to establish whether there were significant relationships between understanding of diffusion and osmosis and the variables of formal reasoning ability as well as gender.

## 1.2 Biology Education in Malaysian Secondary Schools

Biology is a field in science that investigates about life, environment, interaction between life and environment and related phenomenons. The form four Biology syllabus consist of four themes that are:

(i) Introduction to Biology,

(ii) Investigating Cell as a Basic Unit of Life,

(iii) Investigating Physiology, and

(iv) Investigating the interrelationship of life and it's environment.

Biology is one of the three science subjects offered to all Malaysian Form Four and Form Five students who enroll in the science stream at the upper secondary school level.Table 1.1 below shows that there are altogether sixteen main topics to be covered in the Malaysian Biology KBSM syllabus.

**Table 1.1**

**Main topics in the Malaysian Biology KBSM syllabus**

| Topics for Form Four | Topics for Form Five |
|---|---|
| 1. Introduction to Biology | 11. Transportation System |
| 2. Cell Structure and Function of Cell parts | 12. Movement and Support |
| 3. Movement of material across plasma membrane | 13. Coordination and Response |
| 4. Chemical Composition in a cell | 14. Reproduction and Growth |
| 5. Cell Division | 15. Inheritance |
| 6. Cell Organization | 16. Variation |
| 7. Nutrition | |
| 8. Respiration | |
| 9. Dynamic ecosystem | |
| 10. Threatened ecosystem | |

For the purpose of this study, the researcher has decided to focus on the second theme in the Form Four Biology syllabus that is investigating cell as a basic unit of life. The reason is because there are certain topics abstract in nature and involve concepts that students find difficult to learn such as diffusion and osmosis. Students often hold numerous alternative conceptions in the understanding of these two concepts. This could be due to the fact that to understand difficult concepts like diffusion and osmosis, students are required to reach the formal operational stage.

## 1.3 Purpose of the Study

Diffusion and Osmosis are the key to understanding many important life processes. Diffusion is the primary method of short-distance transport in a cell and cellular system. On the other hand, an understanding of osmosis is the key to understanding water intake by plants, water balance in land and aquatic creatures, turgor

pressure in plants and transport in living organisms. In addition, diffusion and osmosis are closely related to key concepts in physics and chemistry such as permeability, solutions and the particulate nature of matter (Friedler, Amir & Tamir, 1987).

This study aimed to investigate the understanding of diffusion and osmosis by Form Four biology students in a secondary school in Wilayah Persekutuan. Particular attention was given to the alternative conceptions held by the students. The study also aimed to investigate whether there was a relationship between students' understanding of diffusion and osmosis and their formal reasoning ability as well as their gender.

The students' understanding of diffusion and osmosis was assessed by their test scores obtained on a two-tier multiple-choice test on diffusion and osmosis. The test was adopted from Odom and Barrow,1995 a two-tier diagnostic test known as Diffusion and Osmosis Diagnostic Test (DODT).

## 1.4 Research Questions

The study was carried out on a group of form four biology students in a secondary school in Wilayah Persekutuan. This study was aimed at answering the following research questions:

1. What were the form four science students common alternative conceptions of diffusion and osmosis?
2. What were the form four science students recurring alternative conceptions of diffusion and osmosis?

3. What was the distribution of formal reasoning ability of Form Four science students as measured by the Test of Logical Thinking?
4. Is there any significant difference among students' of different formal reasoning ability and understanding of diffusion and osmosis as measured by test scores in the DODT?
5. Is there any significant difference between male and female students in their understanding of diffusion and osmosis as measured by test scores in the DODT?

## 1.5 Conceptual Framework of the Study

The conceptual framework for this study was shown in Figure 1.1. The independent variables in this study were the formal reasoning ability and gender and the dependent variable was the conception and alternative conception of diffusion and osmosis. This study wished to ascertain whether both the independent variables had any relationship with the conception and alternative conception of diffusion and osmosis for the following concepts:

(i) The process of osmosis

(ii) The particulate and random nature of matter

(iii) The process of diffusion

(iv) Concentration and tonicity

(v) Influence of life forces on diffusion and osmosis

(vi) Membranes

(vii) Kinetic energy of matter

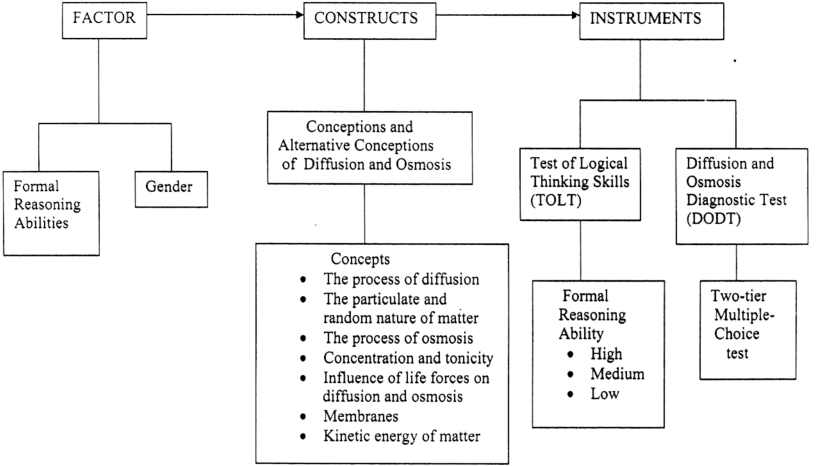


Figure 1.1 Conceptual Framework of the study

## 1.6 Significance of the Study

Many research studies have been carried out in other parts of the world in investigating problems and difficulties faced by students in the understanding of diffusion and osmosis. A considerable number of studies have also been carried out in probing students' understanding of these two concepts in biology.

In Malaysia, research studies related to conception of biology concepts at secondary school levels are very few. Except for a study by Lew(1994) on conception of photosynthesis among students across grade levels, studies pertaining to understanding of diffusion and osmosis are very rare.

Hence, this study can be considered to be one of the very few attempts conducted locally to investigate the following:

(i) students' conceptions and alternative conceptions of diffusion and osmosis

(ii) students' common and recurring alternative conceptions of diffusion and osmosis

(iii) relationship of formal reasoning ability and gender with understanding of diffusion and osmosis.

The seven concepts analysed in diffusion and osmosis were as follows:

(i) The process of diffusion

(ii) The particulate and random nature of matter

(iii) The process of osmosis

(iv) Concentration and tonicity

(v) Influence of life forces on diffusion and osmosis

(vi) Kinetic energy of matter

If students were found to possess alternative conceptions of these seven concepts, then teachers can take necessary steps to device appropriate teaching resources and

instructional strategies to overcome their alternative conceptions. Hopefully, this will result in the students achieving a better understanding of the concepts.

## 1.8 Definition of Terms

Throughout this study, certain terms were used. Their definitions for this particular study are as follows:

(1) Understanding

This is defined as the ability to select the correct of best responses from those in multiple-choice test items.

(2) Concept

This is defined as a summary of essential characteristics of a group of ideas or facts that epitomize important common features of factors from a large number of ideas (Pella, 1996). This definition includes concepts learnt as principles or laws in physical sciences.

(3) Alternative conception

Alternative conception is defined as knowledge spontaneously derived from extensive personal experience that is incompatible with established scientific theory (Lawson & Thompson, 1988). Alternative conceptions are considered the wrong conceptions held by the students in contract with correct scientific conceptions.

(4) Common alternative conceptions

Common alternative conceptions are the conceptions misconceived by at least 25% or more of the students. These are identified from students' responses in all test items.

(5) Recurring Alternative Conceptions

Recurring alternative conceptions are students alternative conceptions identified from their responses in more than one of the DODT items. It should be noted that these recurring alternative conceptions refer to the alternative conceptions that appear in the different items and not referring to the same students having the alternative conception.

(6) Formal Reasoning Ability

It is defined as the capability of dealing with formal reasoning operations, such as proportional reasoning, control of variables, correlational reasoning, probabilistic reasoning and combinational reasoning (Lawson, 1985). In this study the formal reasoning ability is measured by the subject's total score on the Test of Logical Thinking (TOLT), an instrument developed by Tobin and Capie (1981).

## 1.8 Limitations of the Study

There are two foreseeable significant limitations to this study. Firstly, this study will only be confined to a secondary school in Wilayah Persekutuan. Thus, the subjects of the study may not be representative of the entire population of secondary students in Malaysia.

Secondly, the items used in the DODT and TOLT are in the form of a multiple-choice response. As such there could be a tendency for some students to guess the answers by simply marking one of the options of the items. The result, may then not potray the true picture of the students' understanding and alternative conceptions of the concepts investigated.

Therefore, the findings of this study cannot be used to make any generalizations on the relationship between students' understanding of diffusion and osmosis and their formal reasoning ability as well as their gender and students' common alternative conceptions in diffusion and osmosis, to the entire population of secondary students in Malaysia.