Chapter I

STATEMENT OF THE PROBLEM

1.0 Introduction

As a high performing East Asian Economies, Malaysia aims to establish a scientifically and technologically advanced industrial society by the year 2020. As the country strives towards industrialization, one of the major concerns is to develop skilled human manpower that are scientifically and technologically literate in order to meet the growing demands of the fast expanding economy. Like any other developing countries such as Brazil and Mexico, Malaysia also has invested extensively in educational development especially in science, medicine, engineering and technical-related fields. Efforts have been undertaken to increase science and technical enrolment at the degree, diploma and certificate levels beyond the secondary education. In the Seventh Malaysian Plan (1996-2000), the government attempts to improve the enrolment and output in science and technical courses from 42 per cent in the Sixth Malaysian Plan to 50 per cent in the Seventh Malaysian Plan (Malaysia, 1996).

However, even though the government had attempted to boost the study of science over the last 15 years, the present Deputy Minister of Education, Dr. Fong reiterated that only 20 per cent of students entered science and technical streams in the upper secondary schools ("Move to boost", 1997). According to him, this figure was low when compared to the government's target of 60:40 ratio for the science and arts streams. To a larger extent, the percentage of science and technical students in upper secondary schools determines the rate of enrolment and output at the tertiary level.

Studies that attempt to investigate students' difficulty in understanding science concepts could shed some light on the problems faced by the students. Studies conducted by Lee et al. (1995) claim that one of the reasons of low enrolment in Malaysian upper secondary school science is that the students have no confidence in their ability to do science. Champagne, Klopfer and Anderson (1980), Clement (1982) and Griffith (1985) stated that among some of the sources of students' difficulties in physics learning were their mathematical skills, levels of cognitive development and prior conceptions before instruction. Helms (1980) found that if the intellectual development of the students did not match the demands of the contents of the physics course, the students were unable to grasp the complexities of some of the abstract concepts in physics.

According to Piaget's 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. Students at the formal operational stage would be able to perform mental operations in a hypothetical-deductive manner without any concrete objects and be able to understand abstract concepts. Physics is commonly considered as a difficult subject (Clement, 1982; Jones & Mooney, 1981) and students consider many of the physics concepts as abstract concepts (Lawson & Renner, 1975). The understanding of physics concepts requires students to be operating at the formal operational stage (Pandey, 1990; Lawson & Renner, 1975). However, a considerable number of research studies (Chiappetta, 1976; 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. Instead, they were found to be still at the concrete operational or transitional formal stage. Consequently, a mismatch between students' levels of cognitive development and the demands of the physics content makes it difficult for the students to understand some of the abstract concepts.

Moreover, a review of research studies on students' conceptions of force and motion (circular motion is one of the examples) summarizes some of the students' alternative frameworks of force and motion (Gilbert & Watts, 1983; Gunstone & Watts, 1985) as follows:

(1) If a body is moving, there is a force acting on it in the direction of motion.

(2) Constant motion requires a constant force.

(3) If a body is not moving, there is no force acting on it.

These conceptions of force and motion are at variance with the Newtonian scientific views. This will give rise to difficulties in the teaching and learning involving circular motion. Efforts should be made by teachers, educators or curriculum planners to remedy these variations in conceptions. However, before such remediations can take place, students' conceptions in circular motion must first be identified.

This study attempted to identify students' conceptions in circular motion. The relationships of students' understanding of concepts in circular motion and their gender and formal reasoning ability would also be explored.

1.1 An Overview of Sixth Form Physics Education in Malaysian Schools

Form six programme is a two-year upper secondary educational course that prepares students for tertiary education. Only students who have done well in Malaysian Certificate of Education Examination are selected to enter the form six course. Sixth form students need to perform well in Malaysian Higher School Certificate Examination (*Sijil Tinggi Pelajaran Malaysia*, with the acronym of STPM in Malay Language) as the results are used as criteria for selection of entry into Malaysian public universities.

Besides chemistry and biology, physics is one of the fundamental fields of science and is therefore offered as one of the science subjects to form six science students.

The present sixth form physics syllabus was introduced in March 1995. This new syllabus for all science subjects was introduced to ensure continuity with the New Curriculum for Secondary School (KBSM) and to suit the needs of the nation. The previous one was prepared by the University of Cambridge Local Examination Syndicate. It was adopted and used for the past 25 years until March 1995 ("new syllabus", 1995). The contents of the new physics syllabus comprise a combination of innovative ideas from local teachers of government and private schools, lecturers from local publics universities, personnel from Curriculum Development Center, Malaysian Examination Council, and Inspectorate of the Ministry of Education of Malaysia. The new syllabus defines every topic clearly and accurately to prevent teachers from covering irrelevant topics. Attention was paid to several dimensions when formulating the new syllabus. Among these dimensions were the introduction of new technology in physics, expansion of new knowledge, combination of classic and modern knowledge, development of the cognitive and manipulative skills and new approach to assessment. The first year physics syllabus at local public universities was also taken into consideration in devising the syllabus to prevent unnecessary overlapping (Malaysian Examination Council, 1995).

The sixth form physics programme is generally aimed at increasing the students' physics knowledge in order to enable them to pursue studies in higher education institutions or to prepare them for careers in related fields. In addition, it seeks to cultivate an awareness of the role of physics knowledge in the world around them. According to Malaysian Examination Council (1995), the specific aims or objectives of the sixth form physics programme are shown in Table 1.1.

Table 1.1

Specific Aims or Objectives of Sixth Form Physics

(a) To know, understand, and use physical models, laws, principles, concepts and theories;

(b) To understand, interpret, and use scientific information presented in different forms;

(c) To solve problem in different situations;

(d) To analyze, synthesize, and evaluate the information in a logical and critical way;

(e) To design and perform experiments scientifically;

(f) To acquire the technique of handling equipment and ensuring safety in using scientific equipment;

(g) To promote right attitude and values towards the study and nature of science.

The STPM physics syllabus consists of nine major sections. As can be seen from Table 1.2, circular motion is one of the topics in the mechanics section. The major concepts dealt in the topic of circular motion include uniform circular motion, centripetal acceleration and centripetal force.

Table 1.2

Major Sections in STPM Physics Syllabus

Section		Topics
1. Mechanics	(i)	Physical quantities and units
	(ii)	Kinetics and dynamics
	(iii)	Work, energy and power
	(iv)	Circular motion
	(v)	Rotation of rigid body
	(vi)	Static
	(vii)	Gravitation
	(viii)	Simple harmonic motion
	(ix)	Oscillations
2. Waves		
3. Properties of matter		
4. Thermodynamics		
5. Electricity and magnetism		
6. Optics		
7. Quantum physics		
8. Atomic physics		
9. Nuclear physics		

Specifically, according to the sixth form physics syllabus (Malaysian Examination Council, 1995), the behavioral outcomes expected from instruction in circular motion are shown in Table 1.3.

Table 1.3

Students' Behavioral Outcomes Expected from Instruction in Circular Motion

The students are expected to be able:
(a) to use angular displacement, speed, angular velocity and period of motion to describe the circular motion.
(b) to understand that the acceleration of uniform circular motion is due to the change of direction of velocity.
(c) to understand that there exists a resultant force acting towards the centre of the circle for an object in circular motion.
(d) to use the following formulae : $v = r\omega$ $\omega = 2\pi/T$ $a = v^2/r$ $a = r\omega^2$, and
(e) to analyze examples of circular motion.

1.2 Research Questions

This study aimed at assessing upper six physics students' understanding of concepts in circular motion as well as their misconceptions. It also sought to establish the relationships between students' understanding of concepts in circular motion and their gender and formal reasoning ability. The students, with ages ranging from 19 to 20 years old and of both gender, were the subjects of this study. This study sought to answer the following questions:

(1) Were there any significant differences between students of different formal reasoning ability in their understanding of the concepts in circular motion?

(2) Were there any significant differences between the male and female students in their understanding of the concepts in circular motion?

(3) Regardless of gender and formal reasoning ability, what were students' recurring misconceptions in circular motion?

(4) Regardless of gender and formal reasoning ability, what were students' common misconceptions in circular motion?

1.3 Definition of Terms

The following terms are operationally defined in this study:

(1) Understanding

This is defined as the ability to select the correct or best responses from those given in multiple-choice test items. It also refers to the ability to give correct workings, computation or explanations for the open-ended items.

(2) Concepts

They are defined as a summary of essential characteristic of a group of ideas and/or facts that epitomize important common features or factors from a large number of ideas (Pella, 1966). This definition includes concepts learnt as principles or laws in physical sciences.

(3) Misconceptions

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

(4) 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 combinatorial reasoning. (Lawson, 1985). In this study the formal reasoning ability was measured by the subject's total score on the Test of Logical Thinking (TOLT), an instrument developed by Tobin and Capie (1981).

(5) Form Six Education

This is one of the post-secondary education whereby students will attend two years of education prior to entering university. These two years of education are named the lower and upper six levels.

(6) Recurring Misconceptions

Recurring misconceptions in circular motion were students' misconceptions identified from their responses in more than one of UCCMT items. It should be noted that these recurring misconceptions refer to the misconceptions that appear in the different items and not referring to the same students having the misconceptions.

(7) Common Misconceptions

Common misconceptions in circular motion were the conceptions misconceived by some 20% or more of the students. These misconceptions were identified from students' responses in all UCCMT items.

(8) Items or Questions Used in the UCCMT

The term 'Item' used in the text refers to the term 'Question' as used in the UCCMT shown in Appendices A and B. Both terms were used interchangeably in this study.

1.4 Significance of the Study

Although there have been much research done in other parts of the world to probe students' understanding of basic physics concepts, only a few studies have been done in Malaysia (Wee, 1971; Lew, 1987; Ng, 1991; Giam, 1992; Tan, 1999; Man, 1999). Apart from Man's (1999) study, most of the subjects of the study were at the form four and form five levels. Hence, the students' level of understanding of basic physics concepts at form six level could be explored so that the teachers could use this research to better design learning resources.

Research into students' conceptions has established three main factors concerning their effects on understanding (Clement, 1982; McDermott, 1984). First, it is clear that the misconceptions were not simply misunderstanding. Second, they were strongly held by students and finally, they were barriers to meaningful understanding of physical phenomena. Increased awareness of such students' misconceptions would allow the development of new instructional strategies that take students' beliefs into account and hence would help to foster a better understanding of the concepts in circular motion.

Results of students' conceptions in circular motion would also enable curriculum planner to sequence the easier and less abstract concepts first in the syllabus as compared to the more difficult abstract concepts.

It was the intention of this study to probe students' understanding of concepts in circular motion and its relationships with their formal reasoning ability and gender. The knowledge of cognitive developmental levels of their students would enable the teachers to present or plan the teaching materials appropriate to the cognitive level of the students. Moreover, if there were any significant differences between the different formal reasoning ability groups or between the male and female students, in relation to understanding of the concepts in circular motion, teachers could take appropriate actions in order to facilitate students' learning in circular motion.

1.5 Limitation of the Study

This study was confined to the upper six physics students in two schools in Kuching, Sarawak. The sample might not be representative of the population of upper six physics students in Malaysia. Thus, the findings could not allow generalization to be made on students' understanding of the concepts in circular motion, their misconceptions and its relationships with their gender and formal reasoning ability to the whole population of upper six physics students of Malaysia.