Chapter V

SUMMARY OF THE FINDINGS, IMPLICATIONS AND SUGGESTIONS FOR FURTURE RESEARCH

5.0 Introduction

The purpose of this study was to examine upper six physics students' understanding of concepts in circular motion and their misconceptions. The study also sought to establish the relationships between students' understanding of concepts in circular motion and their gender and formal reasoning ability.

A total of 89 students participated in this study. The students, comprising 39 males and 50 females, were selected from two secondary schools in Kuching, Sarawak.

Two data gathering instruments, the TOLT and the UCCMT were used. The TOLT was used to categorize the formal reasoning ability of the students. On the other hand, the UCCMT was used to assess the students' understanding of the concepts in circular motion. Besides assessing their understanding of the concepts in circular motion, the UCCMT was also used to probe their recurring and common misconceptions.

Statistical analyses involving descriptive statistics and *t*-tests were used to analyze the data collected for this study.

5.1 Summary of the Findings

The findings of this study can be summarized as follows:

(1) There was a significant difference between the students of different formal reasoning ability in the understanding of the concepts in circular motion. The high formal reasoning ability students were found to perform significantly better than the medium formal reasoning ability students in their understanding of concepts in circular motion.

(2) There was a significant gender difference in the understanding of concepts in circular motion. The male students were found to perform significantly better in their understanding of concepts of circular motion when compared to the female students.

(3) The six recurring misconceptions in circular motion (the percentage of students having these misconceptions were shown in parenthesis) were:

 (i) Perceived an object would continue to travel in curvilinear path in the absence of centripetal force (29.2% in Item 2 and 9.0% in Item 3).

 (ii) Misinterpreted diagrams in horizontal plane as vertically placed (25.8% in Item 2 and 14.6% in Item 3).

 (iii) Regarded centripetal force and resultant force (e.g. gravitational force) as two different forces acting on an object (22.5% in Item 6, 7.9 % in Item 10 and 18.0 % in Item 13).

 (iv) Perceived a motive force acting on a body in motion (4.5% in Item 6, 28.1% in Item 10 and 13.5% in Item 13).

 (v) Perceived an outward force acting on a body in motion (10.1% in Item 6, 9.0% in Item 10 and 1.1% in Item 13).

(vi) Did not regard the object as a point mass by drawing multiple forces acting on the object (5.6% in Item 13 and 3.4 % in Item 14).

(4) The students' common misconceptions in circular motion were:

(i) In Item 1, a total of 24.7 % of the students wrongly perceived that the direction of acceleration of the ball at the lowest point of a circular track was tangential to the circular track or in the direction of velocity. Another 21.3% of the students wrongly perceived that the direction of acceleration of the ball at the lowest point of a circular track followed the shape of curvature or direction of motion.

(ii) In Item 2, a total of 29.2 % of the students wrongly perceived that the balls will continue to move in curvilinear paths after leaving the double C-shaped tubes while 25.8 % of the students wrongly perceived that the double C-shaped tubes were placed in vertical plane.

(iii) In Item 6, a total of 22.5% of the students regarded the centripetal force and the resultant force as two different forces acting on the bob.

(iv) In Item 8, a total of 32.6% of the students resolved wrongly the forces acting on a bob or used wrong equations for computing the tension of the string.

(v) In Item 9, a total of 25.8 % of the students wrongly perceived that for a bob swinging in a horizontal plane, at the instant the bob was cut suddenly, it would drop down vertically under the influence of gravitational force.

(vi) In Item 10, a total of 28.1 % of the students wrongly perceived a motive force acting on the Moon of Jupiter.

(vii) In Item 11, a total of 42.7% of the students wrongly perceived that the force acting on the Moon was not zero and in the direction of the motion while 21.3 % of the students wrongly perceived that the force acting on the Moon was zero.

(viii) In Item 15, a total of 28.1% of the students wrongly perceived the ratio of the angular speeds between two cars travelling in circular tracks as $r_1 : r_2$ while 21.3% of the students wrongly perceived the ratio of the angular speeds between two cars travelling in circular tracks as $r_2 : r_1$.

(ix) In Item 18, a total of 20.2% of the students wrongly perceived the ratio of the centripetal forces acting on the two cars travelling in circular tracks as $m_1 r_2 : m_2 r_1$.

5.2 Implications of the Findings

There are several implications that can be drawn from the findings of this study.

The students' formal reasoning ability or their ability to think in abstract manner would enhance their understanding of physics concepts in circular motion. This has implications for learning which requires the students to deal with abstract physical concepts and principles. Teachers need to be aware that undeveloped cognitive abilities will inhibit physics achievement for many form six students. If teaching occurs beyond the students' level of formal reasoning ability, the physics content may not be properly assimilated into their cognitive structure. Measures should therefore be taken to ensure that the content of learning matches the formal reasoning ability of the students. According to Kaplus (1977), the learning cycle would help to facilitate acquisition of formal and abstract concepts. The learning cycle consists of three instructional phases, namely, *exploration, concept introduction and concept application.* During exploration, the students explore new materials and new ideas with minimal guidance from their teachers. This new experience should raise questions that they can not resolve with their accustomed patterns of reasoning. As a result, mental disequilibrium will occur and the students will be ready for self-regulation.

The second phase, which is concept introduction, starts with the definition of a new concept or principle that helps the students to apply a new pattern of reasoning to their experience. The teacher, a textbook, a film or another medium may introduce the concept and this will aid self-regulation.

In the last phase of the learning cycle, which is concept application, familiarization takes place as students apply the new concept and/or reasoning pattern to other situations. This phase provides additional time and experiences for self-regulation. The concept application activities also will aid those students whose conceptual reorganization takes place more slowly in dealing with the learning tasks.

Sixth form teachers should explore the use of learning cycle in the teaching of the topic of circular motion in order to enhance physics achievement.

The male students were found to have a better understanding of concepts in circular motion than the female students. Measures should be taken to ensure that the classroom environment facilitate females to learn as well as the males. Female students should be encouraged to participate in hand-on experiments and laboratory activities which will facilitate better visualization and understanding of the physics concepts.

This study also revealed that, regardless of gender and formal reasoning ability, the students held several common and recurring misconceptions in circular motion despite receiving formal instructions from their teachers. This finding might suggest that the students could not understand or assimilate their teachers' instruction or that the preconceptions of the students were quite resistant to change even after formal instruction. Hence identifying students' preconceptions is essential for the teachers to devise appropriate instructional strategies to bring about the desired conceptual change. There should be more opportunities for practical activities and discussions so that the students could clarify their views. This will help them to resolve any preconceptions that are not consistent with their observations of the ideas or phenomena discussed in the classroom.

Some of the students' conceptions in circular motion were indeed the wrong conceptions such as the Aristotelian motive force and the Impetus theory of motion which were also held by the scientists in the past ages. Thus the topic of history of science should be included in the teacher-training programme for physics teachers so that the trainees will have the knowledge of how the past scientists altered their wrong reasoning with the passage of time. The trainees could also compare and contrast the students' and historical misconceptions with the correct scientific conceptions. The teachers could also use the wrong reasoning of the past in convincing their students to discard any misconceptions and to acquire the accepted scientific conceptions.

The findings of this study indicated that some students had a poor understanding of Newton's First and Second Laws of motion. Newton's First Law implies that if a body changes its state of motion, there is a force acting on it. Newton's Second Law states that if a body experiences an acceleration, there is a force acting on it, or conversely, if there is a force acting on a body, it will accelerate. Findings in this study showed that some students could not apply Newton's First and Second Laws in the cases of motion provided. They did not have a profound understanding of the fundamental concepts of acceleration, velocity, and force. These students did not grasp the fact that acceleration could be either due to any change of speed or any change of direction of motion. Thus, with any change of speed or change of direction of speed, a body will definitely experience a force acting on it. Teachers should provide sufficient concrete examples of different situations of motion for the students to engage in peer-group or teacher-student discussions so that the students could firmly grasp the essence of the two laws of motion. This is important, as understanding of these two laws will affect mastery of other concepts related to mechanics.

In circular motion instruction, it is important for teachers to first identify the physical nature of the force acting on an object in circular motion, rather than just stating the term 'centripetal force' that enables the object to travel in circular motion. Teaching circular motion in a well-conceptualized qualitative approach without using numbers in the early part of a lesson will prevent unnecessary rote learning of formulae. This will encourage the students to understand the concepts presented.

Moreover, writers of physics textbooks should give some historical presentation of the concepts or principles currently taught, so that the students could be exposed to the misconceptions of the past. This might help the students to correct their misconceptions in circular motion.

5.3 Suggestions for Future Research

As the research findings were obtained from a sample of form six physics students in Kuching, hence the findings could not be generalized and applied to all form six students and other groups of pre-university students such as the matriculation classes of the Malaysian public universities. It would be worthwhile to carry out research to see whether other form six or matriculation students have the same understanding and common misconceptions in circular motion for the benefits of all physics teachers and students.

This study showed that form six students still held a number of common misconceptions in circular motion even after undergoing formal instruction by their teachers. Research could be done to determine whether these misconceptions were from students' existing preconceptions arising from their own experiences or were due the unclear and incorrect instructions by their teachers. Data could be collected at two stages, that is, before and after instruction of the topic in circular motion.