

CHAPTER III

RESEARCH METHODOLOGY

3.0 Introduction

This study aimed at examining upper six physics students' conceptions in circular motion. The study also attempted to determine whether the students of different gender and formal reasoning ability differed significantly in their understanding of the concepts in circular motion. The survey approach was employed for data collection. Included in this chapter were the subjects of this study, instrumentation and the procedure for data collection.

3.1 The Subjects of the Study

The subjects of the study comprised 89 students from four intact upper six physics classes in two secondary schools in Kuching, Sarawak. The students' ages ranged from 19 to 20 years old. The schools selected were two among the four schools that offered form six physics to their students. All the classes were coeducational.

3.2 Instrumentation

Two instruments were used in the study. The first instrument, entitled the Understanding of Concepts in Circular Motion Test (UCCMT) was used to assess students' understanding of concepts in circular motion and their misconceptions. The second instrument, the Test of Logical Thinking (TOLT), was used to measure the

formal reasoning ability of the students. Both the instruments were of paper and pencil tests.

3.2.1 The Understanding of Concepts in Circular Motion Test (UCCMT)

This instrument was constructed specifically to assess the students’ understanding of concepts in circular motion. It comprised 18 items. The items in the UCCMT were of two formats, the multiple-choice and the open-ended. In addition to choosing the correct alternative from the list of choices provided, most of the multiple-choice items had short open-ended questions sequenced after their respective alternatives. This type of questions was used to provide opportunities for students to give reasons or explanations for their responses to the items. This way of formatting the items enabled the researcher to assess students’ understanding of concepts and their misconceptions. Other open-ended items would allow the students to show their drawings and steps of working leading to their answers and explanations.

The items constructed were based on a review of literatures from science education journals and physics textbooks. Items constructed were within the content area of the topic of circular motion as stated in the STPM physics syllabus (Malaysian Examination Council, 1995).

The items were first categorized into a broad scope according to their respective concepts in circular motion and then into more specific aspects within their respective categories. The composition and the sources of UCCMT items were shown in Table 3.1.

Table 3.1

Concepts Tested in the UCCMT

Item No.	Concept/Aspect Tested	Source
Speed or angular speed of object in circular motion		
5	Speed of object after absence of centripetal force and under the influence of gravity	Adopted from Halloun and Hestenes' (1985a) study
12	Angular speed of object moving in synchrony with another object	Adopted from Lim's (1976) study
15	Ratio of angular speeds	Adopted from Lim's (1976) study
16	Ratio of speeds	Adopted from Lim's (1976) study
14	Computation of speed in terms of forces acting on an object	Constructed by the researcher
Path of motion immediately after absence of centripetal force		
2	Path of motion immediately after the absence of centripetal force	Adapted from McCloskey et al.'s (1980) study
3	Path of motion immediately after the absence of centripetal force	Adapted from McCloskey et al.'s (1980) study
9	Straight line motion with velocity equal to velocity at the instant of the absence of centripetal force	Adopted from Lim's (1976) study
4	Path of motion after the absence of centripetal force and in the presence of gravitational force	Adopted from Halloun and Hestenes' (1985a) study

Table 3.1 continued

Item No.	Concept/Aspect Tested	Source
Acceleration of object and/or forces acting on object in circular motion		
6(i)	Identification of all the forces acting on a body	Constructed by the researcher
10	Identification of all the forces acting on a body	Adapted from Gunstone's (1984) study
13(i)	Identification of all the forces acting on a body	Adapted from Duncan (1994)
6 (ii)	Identification of the resultant force acting on a body	Constructed by the researcher
11	Identification of the resultant force acting on a body and its direction.	Adapted from Gunstone's (1984) study
13(ii)	Identification of the resultant force acting on a body.	Constructed by the researcher
1	Direction of acceleration, of an object travelling in a track, based on the direction of resultant force.	Adapted from Peters' (1982) study
7	Direction of centripetal acceleration based on the direction of centripetal force	Adapted from Lim's (1976) study
17	Ratio of centripetal accelerations	Adopted from Lim's (1976) study
18	Ratio of centripetal forces	Adopted from Lim's (1976) study
8	Computation of the tension of the string due to an object in circular motion	Constructed by the researcher

Since the items in the UCCMT were selected from sources that were either written in English or Bahasa Malaysia, there was a need to translate the items from English to Bahasa Malaysia and vice-versa. Thus two versions of the UCCMT were produced. They were then presented to an experienced physics educator who was proficient in both languages to check the accuracy of the translation. Based on the suggestions given by the educator, the items were further improved. The edited versions of the UCCMT were then presented to three other experienced physics teachers who were proficient in both Bahasa Malaysia and English. They were requested to further check the accuracy of the physics terminologies used in the Bahasa Malaysia version of the test.

3.2.2 Content Validation of UCCMT

The content validity of the UCCMT was established by submitting the test to the same three qualified physics teachers who had at least five years experience in teaching physics. They were asked to judge whether the test items were within the content of circular motion as specified in the STPM syllabus. They were also requested to judge the content validity of the test. They all agreed that the items in Table 3.1 were relevant for the STPM physics syllabus. Thus the content validity of the test was established with the help of their verifications and comments.

3.2.3 Reliability of UCCMT

The reliability of the UCCMT was estimated by using Cronbach's α formula. Using a sample of 89 students, the reliability coefficient was found to be 0.72. The

result was moderately high, implying that the UCCMT items were moderately homogenous for measuring the students' understanding of concepts in circular motion.

3.2.4 Test of Logical Thinking (TOLT)

The Test of Logical Thinking (TOLT) was used to measure the formal reasoning ability of the students. It was developed by Tobin and Capie (1981). The test comprised ten items and was used to measure five modes of reasoning: proportional reasoning, controlling variables, probabilistic reasoning, combinatorial reasoning and correlational reasoning. There were two items for each mode of thinking. Each of the ten items required the respondents to select a correct response and justification from a list of alternatives given.

Siow (1993) in his study of the achievement of students in selected aspects of logical reasoning in mathematics used the TOLT to measure the formal reasoning ability of the students. He took vigorous procedures to translate this test from English to Bahasa Malaysia. Siow had tried to adhere closely to the original instrument of the test. However, minor modifications were made in the translated version of the test. These were done to suit the local situations and made the versions in English and Bahasa Malaysia to be equivalent.

3.2.5 Validity and Reliability of TOLT

Evidence of the criterion-related validity of the TOLT was obtained using a sample of 88 students from grade 10 to college (Tobin & Capie, 1981). The TOLT

was administered to the students followed by a battery of five clinical interviews selected from those described in Inhelder and Piaget (1958) to provide a measure of each of the formal modes of reasoning assessed by the TOLT. On each task the students were given a score of one if they demonstrated formal thought in solving a problem in the item. However, a score of zero was given if they did not. The scores for all the tasks were summed up to provide a measure of performance on the clinical interview. The correlation between the performance on the interviews and the score in the TOLT was 0.80.

Regarding the reliability of the TOLT, Tobin and Capie (1981) found that the Cronbach coefficient was 0.85 by using a group of 682 students from grade six through college. The internal consistency estimate of each of the two-item subtests ranged from 0.56 to 0.82. Moreover, using a sample of 299 preservice teachers enrolled in the second year of a teacher education course in Australia, Garnett and Tobin (1984) reported that the internal consistency of the TOLT was 0.85. When administered to a total of 34 student in his pilot study, Siow (1993) computed the reliability of the TOLT by using the Kuder-Richardson 20 formula. The value of KR-20 coefficient was found to be 0.62. On the other hand, Lam (1994) in her study, used Siow's translated version of TOLT to a sample of 181 form four technical school students and reported a KR-20 value of 0.51. In this study, using 89 students, the KR-20 coefficient was found to have a value of 0.35, which was low as compared to the studies carried out by Tobin and Capie (1981), Garnett and Tobin (1984), Siow (1993) and Lam (1994).

3.3 Pilot Study for the Instruments

Both the UCCMT and the TOLT were constructed in English and Bahasa Malaysia. However, only the Bahasa Malaysia version of the two instruments was administered to the subjects of the study as it was the medium of instruction in the schools.

The UCCMT was constructed specifically by the researcher to assess students' conceptions in circular motion. It needed to be pilot-tested:

- (a) to ascertain the understanding of items, be its wording or language used,
- (b) to determine the time required to complete the test, and
- (c) to provide useful information on any unexpected problem that may arise in the actual study.

The test was administered to a group of three students in a school not selected to participate in the actual study. During the pilot study, the students were free to ask the researcher if they found any difficulty in understanding any item in the test. It was found that the students did not encounter any difficulty in understanding the test.

The TOLT was the instrument used to determine the formal reasoning ability of the students. As this instrument was adopted entirely from Siow's (1993) study, it was not subjected to any further pilot study, since Siow had rigorously taken care of this test to make it suitable for use in the Malaysian context, which included a well-planned pilot study of the test.

3.4 Data Collection

As soon as this research synopsis was approved by the Faculty of Education, University of Malaya, an application form was sent to the Educational Planning and Research Division (EPRD) of the Education Ministry of Malaysia to obtain approval to conduct this study. Together with the approval letter obtained from the EPRD, a letter was sent to the Education Department of Sarawak (JPS) to obtain further permission to carry out this study in the schools. Data collection was carried out after permission from the EPRD and JPS had been granted.

Data collection for the entire study was carried out by the researcher. Permission from the headmasters or headmistresses of schools involved in the pilot and actual studies were sought before administering the instruments to the students. The tests were administered in early April 1999. This was the time when the physics teachers in the school would have taught the topic of circular motion and there were no major examinations during this time.

Two sessions of testing were conducted in each school as two instruments were to be administered. The survey was carried out after school hours. Both testing sessions were conducted on the same day. The total time taken for the two sessions was about 100 minutes. The administration of the UCCMT and the TOLT took about 60 and 40 minutes respectively. There was a break of 30 minutes between the sessions to minimize students' fatigue that might arise if they were to sit for a long session of tests.