CHAPTER 3

METHODOLOGY

3.0 Introduction

This study was designed to investigate science graduate teacher trainees’ understanding of the nature of science. The study also sought to examine the relationships between the trainees’ understanding of the nature of science and their formal reasoning ability, academic background as well as their gender. In order to achieve these objectives, a questionnaire was administered through the survey approach to collect the data. In the questionnaire, the trainees’ understanding of the nature of science was measured by the POTSS, a 24-item Likert scale instrument. The questionnaire was also employed to collect their demographic information. In addition to the questionnaire, a paper and pencil test was used to measure teacher trainees’ formal reasoning ability. This chapter describes, in detail, the subjects, instruments, and research procedures of the study.

3.1 The Subjects of the Study

The subjects of this study comprised of 80 science graduate teacher trainees drawn from four selected teacher training colleges in the west coast of Peninsular Malaysia. The subjects were enrolled in a one-year Post Graduate Teaching Course
(KPLI, the acronym for ‘Kursus Perguruan Lepas Ijazah’ as it is known in Bahasa Melayu) conducted by the Teacher Training Division of the Ministry of Education, Malaysia. In this KPLI science programme, Malaysian graduates, who were from both the local and foreign universities, were enrolled in the science teaching methodology course. Arising from this science teaching methodology, they were expected to teach “Kurikulum Bersepadu Sekolah Menengah” (KBSM) science as well as KBSM Chemistry, Physics, and Biology.

The subjects were selected as intact groups in each of the colleges. The four teacher training colleges selected were among eight colleges in Peninsular Malaysia which offered the KPLI science programme to graduate teacher trainees for the January 2000 academic session.

The subjects were heterogeneous with respect to gender and science major type. Thirty-five male and forty-five female trainees participated in this study. Of these trainees, 29 were pure science majors and 51 were applied science majors. Their mean age, at the point of data collection, was 26 years 5 months.

3.2 The Instruments

Since this study involved 80 KPLI trainees from four different teacher training colleges, a questionnaire and a paper-and-pencil test were considered to be the most suitable instruments for collecting data.
3.2.1 The Nature of Science Questionnaire

The questionnaire was divided into two main sections. Section A aimed to solicit background information about the respondents with regard to the independent variables of the study. Section B consisted of items to assess their understanding of the nature of science.

3.2.1.1 Respondents' Particulars

Section A of the questionnaire consisted of six questions. These questions pertained to the trainees' background information such as gender and academic background.

3.2.1.2 Process Orientation Toward Science Scale (POTSS)

Section B of the questionnaire consisted of items adopted from the POTSS. The universality of the conception of the nature of science ensured that the POTSS was applicable in the Malaysian context. In this study, the POTSS, developed by Scharmann et al. (1986), was used for the collection of data. The original POTSS was a five-point Likert scale instrument consisting of twenty-five items (see Appendix A). A respondent was required to react to individual statements by either strongly agreeing, agreeing, feeling uncertain, disagreeing, or strongly disagreeing with the statements. The responses were scored 5, 4, 3, 2, or 1 respectively. However, for statements which were inconsistent with the concept of the nature of science, scores were reversed in which the responses to "strongly agree", "agree", 
"uncertain", "disagree", and "strongly disagree" were scored 1, 2, 3, 4, and 5 respectively.

In this study, one item (Item 9) from the original POTSS was excluded because it did not measure the aspects of the nature of science as used in the study. Item 9 was purported to directly assess the respondent's attitudes toward science as inquiry. In addition, the 5-point Likert scaling employed in the original POTSS was modified to suit the present study. From the review of literature, it was noted that responses to statements pertaining to the concept of the nature of science could be regarded as right or wrong as evident from instruments developed by other researchers to measure the understanding of the nature of science such as the TOUS and the TUNS. These instruments employed the multiple choice format whereby the responses to items in the tests were considered as either right or wrong. Hence in this study, the researcher took the stand that the teacher trainees' responses to the POTSS items could be regarded as the right conception or the wrong conception of the nature of science. As such, their response to each item was scored by awarding one point for each response in agreement with the correct conception of the nature of science. No point was given for each response not in agreement with the correct conception of the nature of science. The "uncertain" response was considered as a wrong conception of the nature of science. Therefore, no point was given for the response "uncertain". Consequently, the modified POTSS used in this study consisted of 24 items with a three-point Likert scale which employed the dichotomous scoring as explained above.
The English version of the POTSS was translated into Bahasa Melayu by the researcher to fit the purpose of this study. The accuracy of the translated version of the POTSS was checked by a panel of three bilingual Malay-English experts. All of them have a bachelor degree in science and a postgraduate degree in Master of Education. The panel of experts was asked to judge the accuracy of the translation and to recommend changes that would improve the accuracy of the translation. Comments and suggestions from the panel of experts were found to be constructive and were used to further improve the POTSS. The refined Bahasa Melayu version of the POTSS is shown in Appendix B.

3.2.1.3 Reliability of the POTSS

In this study, since the POTSS employed the dichotomous scoring, the reliability of the POTSS was estimated by computing the K-R 20 coefficient based on the POTSS scores of 80 teacher trainees. The reliability coefficient was found to be .54. The obtained reliability value could be considered quite satisfactory since the items in the POTSS measured the various aspects of the nature of science and were therefore, not expected to be highly homogeneous.

3.2.2 Test of Logical Thinking (TOLT)

The TOLT, developed by Tobin and Capie (1981), was used to measure the trainees' formal reasoning ability. The test comprises of groups of two items selected to measure each of the five modes of formal reasoning: proportional
reasoning, controlling variables, probabilistic reasoning, combinatorial reasoning, and correlational reasoning. The ten-item TOLT consists of two responses for each item; both an answer as well as a reason for having selected that answer. Each of the ten items requires a respondent to correctly select a reason consistent with his or her answer in order to be awarded 1 point.

Since the subjects of the study were proficient in the Malay language, a Malay translated version of the TOLT that had been used in a previous study by Siow (1993) was utilized for the purpose of this study. Siow had taken rigorous procedures to translate the TOLT from English to Bahasa Melayu. He made no attempt to change the nature of the test during the translation. However, minor modifications were made on a few items to suit the Malaysian settings as well as to make the English and Bahasa Melayu versions to be equivalent. Some of the sample items of TOLT in Bahasa Melayu are shown in Appendix C.

3.2.2.1 Validity and Reliability of the TOLT

Criterion-related validity of the TOLT was established by correlating its items with performance on tasks presented using traditional Piagetian interviews with 25 college students and 63 high school students from grades 10 through 12 (Tобin & Capie, 1981). A coefficient of .80 was obtained for the correlation between performance on the interviews and scores on the TOLT. This result, along with the high predictive validity obtained in other studies (Tобin & Capie, 1981), lent credence to the TOLT as being a valid measure of formal reasoning ability.
Regarding the reliability of the instrument, Tobin and Capie (1981) assessed the internal consistency of the TOLT by computing the Cronbach’s alpha based on the scores of 682 students from grades 6 through college. A Cronbach coefficient of .85 was obtained for the whole test. The internal consistency estimate of each of the two-item subtests was found to range from .56 to .82. Moreover, in a study 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 .85.

The reliability of the Bahasa Melayu version of the TOLT was estimated by Siow (1993) using the K-R 20 formula on the test scores of 34 form five students. The K-R 20 coefficient computed was .62. Siow’s translated TOLT was then used by Lam (1994) to a sample of 181 form four technical students. She reported a K-R 20 value of .51. On the other hand, Mah (1999) in her study, administered Siow’s translated TOLT to a sample of 89 upper six physics students and reported a K-R 20 value of .35. In this study, the computation of the test scores from 80 teacher trainees gave a K-R 20 coefficient of .59 which was comparable to that obtained by Siow (1993). However, this K-R 20 value was high when compared to those obtained by Lam (1994) and Mah (1999).

3.3 Pilot Study of the Instruments

The Bahasa Melayu version of the POTSS and the TOLT were pilot tested with a sample of 18 KPLI trainees from one of the teacher training colleges in Kuala
Lumpur. The POTSS was pilot-tested to:

1. ensure the clarity of the wording of each POTSS item so that subjects in the study would not encounter any difficulty in answering the questionnaire. The respondents were encouraged to raise whatever doubts they might have with regard to the items in the questionnaire.

2. estimate the time required for the subjects to complete the questionnaire.

3. serve as a trial run and to provide useful information on any unexpected problems that might arise in the actual study.

In the course of the administration of the questionnaire, none of the teacher trainees indicated that they had any difficulty in understanding the items in the questionnaire. Not one of the trainees needed more than 15 minutes to complete the questionnaire. The results of the pilot testing implied that the questionnaire had been well prepared in terms of comprehensibility and clarity of the items and instructions. Hence, no further changes were made to the items in the questionnaire. Thus, the original translated version of the questionnaire was retained to be used in the subsequent actual study.

The Bahasa Melayu version of the TOLT was adopted from Siow's (1993) study. Siow had test-piloted the translated version of the TOLT with a sample of 34 form five students. He reported that the students did not encounter any difficulty in understanding the wording of all the items in the test. In this study, the Bahasa Melayu version of the TOLT was pilot-tested with a sample of 18 KPLI trainees.
It was found that these trainees did not have any difficulty in comprehending the test. The result of the pilot testing implied that the Bahasa Melayu version of the TOLT could be used for testing without further changes to the test items.

3.4 Data Collection

Data collection for the study began after permission was obtained from the relevant authorities, namely the Educational Planning and Research Division (EPRD) of the Malaysian Ministry of Education, the Teacher Training Division of the Ministry of Education of Malaysia, and the principals of the teacher training colleges concerned.

In addition to the college selected for the pilot study, three other teacher training colleges in Peninsular Malaysia were further selected in the actual study. The survey began in late March 2000 and was completed in mid April 2000. The duration taken to collect all the data was four weeks. The entire data collection for the study was carried out by the researcher.

The administration of the questionnaire and the TOLT to the respondents from the other three colleges followed the same procedures and under similar conditions as in the pilot study. The questionnaire and the TOLT were administered by the researcher to the subjects of the study, under a standardized whole class setting. Both the instruments were administered on the same day, the questionnaire was administered first, then followed by the TOLT. No prior notification of testing was given to the trainees. At the beginning of the testing session, the purpose of the
test was explained to them. The trainees were told that no time limit was set for the completion of both the questionnaire and the test. As soon as a trainee completed the questionnaire, his or her paper was collected and the trainee was then given the test. The trainees took no more than 15 minutes to respond to the questionnaire while the time taken to complete the test ranged from 25 minutes to 40 minutes.

In view of the similar conditions and procedures of the administration of the same instruments to the subjects in the pilot study as well as in the other three colleges, the researcher took the decision to include the subjects of the pilot study in the actual study. Thus, the subjects for this study comprised 80 teacher trainees from the four selected teacher training colleges. The inclusion of the subjects of the pilot study in the actual study was carried out to further increase the size of the subjects in this study in order to allow a better statistical analysis of the data without jeopardising the objectives of the study. It should be noted that there were no known differences in terms of the instruments used and the administration conditions and procedures between the pilot study and the other three colleges.

3.5 Data Analysis

All data collected were processed and analysed using the Statistical Package for the Social Sciences, SPSS (Norusis, 1997). The demographic data and the POTSS scores were analysed using descriptive statistics. Statistical techniques of t-test and Pearson product moment correlation were carried out to determine if there were significant relationships between teacher trainees' understanding of the nature
of science and their (a) formal reasoning ability, (b) academic background, and (c) gender.