CHAPTER THREE

METHODOLOGY

Introduction

This chapter discusses about the methodology of the study. The discussion comprises nine main sections: research design, selection of subjects, data collection, administration of the interview, instrumentation, pilot study, data analysis, content validity, and reliability.

Research Design

Yin (2003) noted that "a research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of study. Every empirical study has an implicit, if not explicit, research design" (p. 19). Merriam (1998) identified four of the common types of qualitative research in education as: (a) ethnography, (b) phenomenology, (c) grounded theory, and (d) case study. Table 3.1 summarizes the characteristics of the four common types of qualitative research in education.

Table 3.1

Characteristics of the Four Common Types of Qualitative Research in Education

Type	Characteristics
Ethnography	1. Focus on society and culture 2. Uncovers and describe beliefs, values, and attitudes that structure behavior of a group
Phenomenology	1. Is concerned with essence or basic structure of a phenomenon 2. Uses data that are the participant's and the investigator's firsthand experience of the phenomenon
Grounded theory	1. Is designed to inductively build a substantive theory regarding some aspect of practice 2. Is "grounded" in the real world
Case study	1. Is intensive, holistic description and analysis of a single unit or bounded system 2. Can be combined with any of the above types

Note. Adapted from "Table 1.2 Common Types of Qualitative Research in Education," by S. B. Merriam, 1998, *Qualitative Research and Case Study Applications in Education*, p. 12.

In this study, the researcher employed case study research design to examine, in-depth, preservice secondary school mathematics teachers' subject matter knowledge (SMK) of perimeter and area. "A case study design is used to gain an in-depth understanding of the situation and meaning for those involved" (Merriam, 1998, p. 19). Several researchers (e.g., Aida Suraya, 1996; Chew, 2007; Lim, 2007; Rokiah, 1998; Seow, 1989; Sharifah Norul Akmar, 1997; Sutriyono, 1997) employed case study research design to study Malaysian students, preservice teachers, and lecturers.

Merriam (1998) noted that "all research design can be discussed in terms of their relative strengths and limitations. The merits of a particular design are inherently related to the rationale for selecting it as the most appropriate plan for addressing the research problem" (pp. 40-41). In the present study, case study research design was employed to examine, in-depth, preservice secondary school mathematics teachers' subject matter knowledge (SMK) of perimeter and area because of the nature of the research problem and the research questions being asked. Case study is considered the appropriate research design for answering the research questions in this study as its strengths far outweigh its limitations.

As Merriam (1998) observes:

The case study results in a rich and holistic account of a phenomenon. It offers insights and illuminates meanings that expand its readers' experiences. These insights can be construed as tentative hypotheses that help structure future research; hence, case study plays an important role in advancing a field's knowledge base. Because of its strengths, case study is a particularly appealing design for applied fields of study such as education. (p. 41)

According to Merriam (1998), case study research has three main features: (a) "particularistic – focus on a particular situation, event, program, or phenomenon; (b) descriptive – the end product is a rich, 'thick' description of the phenomenon under study; and (c) heuristic – illuminate the reader's understanding of the phenomenon under study" (pp. 29 – 30).

The present study: (a) focuses on the way the eight PSSMTs confront each of the eight categories of tasks related to perimeter and area during the clinical interviews (i.e., particularistic); (b) provides a rich, 'thick' description of the PSSMTs' five basic types of knowledge of perimeter and area, namely conceptual knowledge, procedural knowledge, linguistic knowledge, strategic knowledge, and ethical knowledge (i.e., descriptive); and (c) enhances the reader's understanding of the nature and levels of SMK of perimeter and area that the PSSMTs exhibit (i.e., heuristic). Thus, case study research design was appropriate for the present study in comparison with other common types of qualitative research design in education, namely ethnography, phenomenology, and grounded theory.

Selection of Subjects

There are two basic types of sampling, namely probability (random) sampling and nonprobability (nonrandom) sampling. Generalization is not a goal of qualitative research. Thus, "nonprobability sampling is the method of choice for most qualitative research" (Merriam, 1998, p. 61). Purposeful (purposive) sampling is the most common form of nonprobability sampling. According to Merriam (1998), "purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight and therefore must select a sample from which the most can be learned" (p. 61).

Generalization of results of the study from the sample to the population from which it was drawn was not the goal of the present study. The purpose of this study was to examine, in-depth, preservice secondary school mathematics teachers' subject matter knowledge (SMK) of perimeter and area. Thus, the researcher employed purposeful sampling to select the subjects (sample) for this study. To begin purposeful sampling, the researcher must first determine the essential selection criteria in choosing the subjects (sample) to be studied (Merriam, 1998). The criteria for selecting the subjects (sample) for the present study were: (a) preservice secondary school

teachers enrolled in a public university who majored or minored in mathematics, (b) they enrolled for a one-semester mathematics teaching methods course during the data collection, (c) they agreed to serve as case study participants, (d) they agreed to be audiotaped and videotaped throughout the clinical interview sessions, and (e) they agreed to complete the four clinical interview sessions. Nevertheless, the subjects (sample) were given the freedom of withdrawals from the study at any stage at their own will.

The selection of subjects (sample) began when the researcher sought permission from the mathematics teaching methods course coordinator to conduct the study. The researcher had explained the purpose and the nature of this study to the course coordinator. The course coordinator granted the permission and allowed the researcher to enter her class to collect background information data from the PSSMTs.

The researcher explained the purpose and the nature of this study to all the PSSMTs before distributed the Background Information Form to them. They were assured that all their responses in the Background Information Form and clinical interview would be treated as confidential and would only be used for the purpose of this study. They were also assured that all their responses in the Background Information Form and clinical interview would not affect the nature of their grades in the mathematics teaching methods course. The Background Information Form sought to collect demographic information included PSSMTs' gender, age, national examinations mathematics results, teacher education programs, major and minor, university content courses taken and grades attained, cumulative grade point average (CGPA) secured, and teaching experience (if any) (see Appendix F).

Based on the above selection criteria, eight subjects (sample) were selected for the purpose of this study. They were PSSMTs from a public university in Peninsula Malaysia enrolled in a 4-year Bachelor of Science with Education (B.Sc.Ed.) program, majored or minored in mathematics. These subjects enrolled for a one-semester mathematics teaching methods course

during the data collection of this study. The mathematics teaching methods course was offered to B.Sc.Ed. program students who intended to major or minor in mathematics. The researcher had selected four B.Sc.Ed. program students who majored in mathematics, and four B.Sc.Ed. program students who minored in mathematics for the purpose of this study.

The results of the analysis on the total of 180 copies of the Background Information Form collected showed that 94 (52.2%) and 86 (47.8%) of the PSSMTs majored and minored in mathematics, respectively. For those who majored in mathematics, about 25%, 50%, and 25% of them minored in biology, chemistry, and physics, respectively. Similarly, for those who minored in mathematics, about 25%, 50%, and 25% of them majored in biology, chemistry, and physics, respectively. Thus, two PSSMTs were selected from those who majored in mathematics and minored in chemistry, and from those who majored in chemistry and minored in mathematics, respectively. One PSSMT was selected from each of the other combinations of majors and minors, respectively.

PSSMTs who have selected mathematics as their major in the B.Sc.Ed. program were required to take 44 units of mathematics content courses. These courses were nine compulsory mathematics content courses (36 units) and any two (8 units) out of seven mathematics content courses from the optional component courses throughout the four year B.Sc.Ed. program (see Table C1 in Appendix C). For those who have selected mathematics as their minor in the B.Sc.Ed. program, they were required to take 20 units of mathematics content courses. Specifically, they were required to take any five out of ten mathematics content courses throughout the four year B.Sc.Ed. program (see Table C2 in Appendix C). Each PSSMT was given a pseudonym, namely Beng, Liana, Mazlan, Patrick, Roslina, Suhana, Tan, and Usha, in order to protect the anonymity of all interviewees. The brief background information about the subjects is shown in Table 3.2.

Table 3.2

Subjects' Ethnicity, Gender, Age, Major, Minor, and CGPA

Subject	Ethnicity	Gender	Age	Major	Minor	CGPA
Usha	Indian	Female	(21, 9)	Mathematics	Biology	2.92
Mazlan	Malay	Male	(21, 8)	Mathematics	Chemistry	2.70
Patrick	Bidayuh	Male	(21, 7)	Mathematics	Chemistry	3.04
Beng	Chinese	Female	(22, 9)	Mathematics	Physics	3.82
Roslina	Malay	Female	(21, 8)	Biology	Mathematics	3.15
Liana	Malay	Female	(21, 5)	Chemistry	Mathematics	2.77
Tan	Chinese	Male	(22, 7)	Chemistry	Mathematics	3.69
Suhana	Malay	Female	(20, 10)	Physics	Mathematics	2.52

Data Collection

Data for this study was collected using clinical interview technique. Interviewing is a common means of data collection for qualitative studies in education (Merriam, 1998). It is noted to be the only source of data collection in numerous studies (e.g., Aida Suraya, 1996; Ball, 1988; Fatimah, 1997; Nik Azis, 1987; Lim, 2007; Rokiah, 1998; Sharifah Norul Akmar, 1997; Sutriyono, 1997). The term "clinical" means direct observation on student's behaviors in the context of one to one interaction. The term "direct observation" refers to researcher's observation that focused on student's behaviors when the latter solving problems. The researcher observes each of the student's behaviors carefully, be it verbal or nonverbal behaviors (Nik Azis, 1999).

Clinical interview is an interactive communication between a researcher or teacher (interviewer) and a student (interviewee) in which the interviewer seeks to elicit information from the interviewee about how the latter thinks and learns (Long & Ben-Hur, 1991). The question posed by the researcher is interrelated with response pattern or answer given by the student to the

earlier questions. In other words, the researcher use questioning and answering procedure that are flexible, open, intensive, elicit, explore, and required students to provide explanation about their actions to enable researcher to understand their thinking (Nik Azis, 1999). The communication is focused on a problem or task that allowed the student to display behavior from which mental process used in thinking about that problem or task can be inferred (Hunting & Doig, 1997). Central to clinical interview is the "recognition of the role of language and the importance of clarification of meaning as researchers ask questions and pose problems, and students talk about their mathematics and explain their actions" (Hunting, 1997, p. 2). It gives insights into students' experiences by allowing the researcher to understand the meanings that students find in mathematical problems or tasks. It also permits researcher to emphasize process over product, encourages communication about mathematics, and provide researchers and students instant feedback (Long & Ben-Hur, 1991).

In the present study, the researcher used the context of one to one interaction to make direct observation on the subject's behaviors when the latter solving problems. During the interview, the researcher also use questioning and assessment. In this case, the researcher was able to elicit preservice secondary school mathematics teachers' SMK of perimeter and area. Specifically, the clinical interviews techniques permitted the researcher to elicit PSSMTs' five basic types of knowledge of perimeter and area, namely conceptual knowledge, procedural knowledge, linguistic knowledge, strategic knowledge, and ethical knowledge. Subsequently, the researcher was able to determine PSSMTs' levels (low, medium, high) of SMK of perimeter and area.

In this study, the clinical interview was designed to incorporate the following features as suggested by Nik Azis (1987, 1996): (a) an interview plan that anticipates as many contingencies as possible as the preservice teachers solving a mathematical problem, (b) the mathematical problems were structured in such a way that allow the preservice teachers to use the most

sophisticated strategies available, (c) the settings of the mathematical problems were chosen carefully to increase motivation so that preservice teachers are interested to attempt each problem, and (d) the preservice teachers were given every opportunity to attempt each problem.

In the present study, materials collected for analysis consisted of audiotapes and videotapes of clinical interviews, subject's notes and drawings, and researcher's notes during the interviews. The audiotapes and videotapes were verbatim transcribed into written form and the transcriptions were the raw data for this study. The transcriptions include verbal and nonverbal interaction between researcher and subject.

Administration of the Interview

The clinical interview was conducted in the Mathematics Teaching Room at a public university in Peninsula Malaysia. Mathematics Teaching Room was selected because all PSSMTs were familiar with it. They used to attend mathematics teaching methods tutorials in the Mathematics Teaching Room on a weekly basis. They felt more relax and comfortable.

The physical setting for each interview consisted of a table with two chairs, a tape recorder, and a digital video camera. Each interview was recorded through the tape recorder and digital video camera positioned in front of the table. The camera was focused on the subject, the working area, and the researcher. Blank papers, grid papers, pencil, ruler, thread, compasses, and calculator were accessible to the PSSMTs throughout the interviews. The interview was conducted in January 2008. Each of the eight subjects was individually interviewed from 30 to 50 minutes on four separate occasions in a period of approximately four weeks. Each session involved three or four tasks or subtasks (see Appendix G).

The total time for each interview varied from subject to subject depending on the amount of time taken to complete the tasks. During the interview, the researcher started the session by posing a task to the subject. The subject responded to the task. Based on the subject's response to

this task, the researcher probed, presented the same task in different form or posed a new task. For instance, after posing Task 1.1 to the subject, the researcher probed with the following questions: "Why did you select this shape?", "Why didn't you select this shape?", "What do you mean by ____?", or "Could you tell me more about it?". The probes generated by the researcher were interrelated with the subject's response to the previous probe. Thus, each interview was different from one another as each subject is unique.

Instrumentation

Eight types of interview tasks were devised for this study (see Appendix G): (a) notion of perimeter and area, (b) notion of the units of area, (c) comparing perimeter and area, (d) Converting units of area, (e) relationship between perimeter and area, (f) calculating perimeter and area, (g) fencing problem, and (h) developing area formulae. The tasks were constructed based on Topic 11 (i.e., perimeter and area) (see Appendix D) from the Form One Mathematics Curriculum Specifications and literature review. Tasks 1 and 3 were adapted from Baturo and Nason (1996) while Tasks 5.1, 5.2, 5.3, and 7 were adapted from Wilson & Chavarria (1993), Billstein et al. (2006), Ball (1988), and Sgroi (2001), respectively (see Appendix G).

The tasks and standard probes for the clinical interview were given in Appendix G. Supplementary probes were generated in the course of the clinical interview whenever necessary so as to get a clearer picture about what the interviewee was thinking. In each case, effort was channeled at probing as deeply as possible the PSSMTs' SMK of perimeter and area. By asking PSSMTs to provide an explanation to justify their responses, it gave the researcher a view of their understanding of the SMK of perimeter and area in the respective tasks of the clinical interview. The description of the tasks was done in the following subsection.

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Description of the Tasks

Task 1: Notion of perimeter and area

Task 1.1: Notion of perimeter

In Task 1.1, subjects were asked to select the shapes (12 shapes) that have a perimeter. The objective of this task was to determine the subjects' conceptual knowledge about the notion of perimeter. According to Beaumont, Curtis, & Smart (1986), "the study of the concept of perimeter is unified by considering the simple closed curve" (p. 5). Thus, four simple closed curves (A, C, H, K), each of them has one interior, were used to ascertain whether the subjects understood the concept of perimeter. For all simple closed curves, the perimeter is the number of linear units it takes to surround it. Two simple but not closed curves (B, G) were included to investigate further the subjects' understanding of the concept of perimeter. Another two closed but not simple curves (D, I), each of which has more than one interior, were included to ascertain whether the subjects understood the concept of perimeter.

Two 1-dimensional shapes (E, L) were included to ascertain whether the subjects understood the concept of perimeter. Finally, two 3-dimensional shapes (F, J) were included because review of research literature has shown that some students and teachers encountered difficulty in distinguishing between the attributes of perimeter, area, and volume (Baturo & Nason, 1996; Beaumont, Curtis, & Smart, 1986; Ramakrishnan, 1998; Reinke, 1997).

Task 1.1 was also used to determine the subjects' linguistic knowledge of perimeter based on the language of mathematics (such as mathematical terms and symbols) that the subjects used to justify their selection of shapes that have a perimeter. There are some good behaviors that the subjects need to follow when dealing with perimeter and area. Knowledge and justification of knowledge is an important aspect in any discipline. Thus, this task was also used to determine the subjects' ethical knowledge of perimeter by ascertaining whether the subjects justify the selection of shapes that have a perimeter.

Task 1.2: Notion of area

In Task 1.2, subjects were asked to select the shapes (12 shapes) that have an area. The objective of this task was to determine the subjects' conceptual knowledge about the notion of area. Six 2-dimensional shapes (A, C, D, H, I, K) were used to ascertain whether the subjects understood area from a static perspective. Based on this perspective, "area can be considered as the amount of surface enclosed within a boundary" (Baturo & Nason, 1996, p. 245). Two open shapes (B, G) were included to investigate further the subjects' understanding of the notion of area from a static perspective.

Two 1-dimensional shapes (E, L) were included to ascertain whether the subjects understood area from a dynamic perspective. If a subject selected one or both of these shapes and explained that the shape(s) had an area of zero, then this response indicated that the subject is having a dynamic perspective of area (Baturo & Nason, 1996). Finally, two 3-dimensional shapes (F, J) were included because review of research literature has shown that some students and teachers encountered difficulty in distinguishing between the attributes of perimeter, area and volume (Baturo & Nason, 1996; Beaumont, Curtis, & Smart, 1986; Ramakrishnan, 1998; Reinke, 1997).

Task 1.2 was also used to determine the subjects' linguistic knowledge of area based on the language of mathematics (such as mathematical terms and symbols) that the subjects used to justify their selection of shapes that have an area. This task was also used to determine the subjects' ethical knowledge of area by ascertaining whether the subjects justify the selection of shapes that have an area.

Task 2: Units of area

In Task 2, subjects were asked to respond to a scenario where three students were discussing about the units of area. The objective of this task was to determine the subjects'

conceptual knowledge about the notion of the units of area. This task was used to determine whether the subjects knew that square as well as nonsquare (e.g., rectangle, and triangle) can be used as the units of area measurement. The subjects who responded that only square can be used as the unit of area indicated that they had a limited idea of unit of area. On the other hand, the subjects who responded that square as well as nonsquare (e.g., rectangle, and triangle) can be used as the units of area had an idea about the conceptual knowledge of the units of area. In fact, any plane figure that tessellates can be used as the units of area measurement.

Task 2 was also used to determine the subjects' linguistic knowledge of units of area based on the language of mathematics (such as mathematical terms and symbols) that the subjects used to justify their selection of shapes (square and nonsquare) that can be used as the units of area measurement. This task was also used to determine the subjects' ethical knowledge of units of area by ascertaining whether the subjects justify their selection of shapes (square and nonsquare) that can be used as the units of area measurement.

Task 3: Comparing perimeter and area

Task 3.1: Comparing perimeter (No dimension was given)

In Task 3.1, subjects were asked to determine whether the given pair of shapes (T-shape and a rectangle) had the same perimeter. The objective of this task was to determine the subjects' strategic knowledge of comparing perimeters of two different shapes. It also revealed whether the subjects know the availability of alternative methods not involving formula for measuring perimeter.

Task 3.2: Comparing area (No dimension was given)

In Task 3.2, subjects were asked to determine whether the given pair of shapes (L-shape and a square) had the same area. The objective of this task was to determine the subjects' strategic

knowledge of comparing areas of two different shapes. It also revealed whether the subjects know the availability of alternative methods not involving formula for measuring area.

Task 3.3: Comparing perimeter (Nonstandard and standard units)

In Task 3.3, subjects were asked to compare, from the measurements given, which shape in each set (Sets 1, 2, and 3) has the longer perimeter. In Set 1, perimeters of shapes A and B were given as the length of 25 paper clips and 12 sticks respectively. In Set 2, perimeters of shapes A and B were denoted as the length of 10 paper clips and 15 paper clips respectively. In Set 3, perimeters of shapes A and B were given as 16 cm and 13 cm respectively. The objective of this task was to determine the subjects' conceptual knowledge of comparing perimeter through nonstandard and standard units. This task was used to determine whether the subjects focused on the number of unit or the unit of measure when they were comparing perimeters with (a) nonstandard units, (b) common nonstandard units, and (c) common standard unit. This task was also used to determine whether the subjects knew that (a) nonstandard units (such as paper clip and stick) are not reliable for comparing perimeters, (b) common nonstandard units (such as paper clips) are not reliable for comparing perimeters, and (c) common standard unit (such as cm) is reliable for comparing perimeters.

Task 3.4: Comparing area (nonstandard and standard units)

In Task 3.4, subjects were asked to compare, from the measurements given, which shape in each set (Sets 1, 2, and 3) has the larger area. In Set 1, areas of shapes A and B were given as the area of 25 triangles and 12 squares respectively. In Set 2, areas of shapes A and B were denoted as the area of 10 squares and 15 squares respectively. In Set 3, areas of shapes A and B were given as 16 cm^2 and 13 cm^2 respectively. The objective of this task was to determine the subjects' conceptual knowledge of comparing area through nonstandard and standard units. This

task was used to determine whether the subjects focused on the number of unit or the unit of measure when they were comparing areas with (a) nonstandard units, (b) common nonstandard units, and (c) common standard unit. This task was also used to determine whether the subjects knew that (a) nonstandard units (such as triangle and square) are not reliable for comparing areas, (b) common nonstandard units (such as squares) are not reliable for comparing areas, and (c) common standard unit (such as cm^2) is reliable for comparing areas. Task 3.4 was also employed to determine the subjects' linguistic knowledge of conventions of writing and reading SI area measurement such as 16 cm^2 (16 square centimetres).

Task 4: Converting units of area

In Task 4, subjects were asked to respond to a scenario where several students encountered difficulty in converting units of area. The objective of this task was to determine the subjects' procedural knowledge of converting units of area measurement.

Task 4 was also used to determine the subjects' conceptual knowledge related to converting units of area. Specifically, this task was used to determine whether the subjects: (a) knew the relationships between the standard units of length measurement such as 1 cm = 10 mm, 1 m = 100 cm, and 1 km = 1000 m; (b) knew the relationships between the standard units of area measurement such as 1 cm^2 = 100 mm^2, 1 m^2 = 10 000 cm^2, and 1 k m^2 = 1 000 000 m^2; and (c) knew the relationship between area units and linear units of measurement: Area units are derived from linear units based on squaring.

Task 5: Relationship between perimeter and area
Task 5.1: Same perimeter, same area?

In Task 5.1, a Form One student claimed that he found a way to calculate the area of a leaf. The student placed a piece of thread around the boundary of the leaf. Then he rearranged the

thread to form a rectangle and got the area of the leaf as the area of a rectangle. Subjects were asked how they would respond to this student. The objective of this task was to determine the subjects' conceptual knowledge of the relationships between perimeter and area of an irregular figure. Task 5.1 was used to ascertain whether the subjects knew that there is no direct relationship between perimeter and area. Two shapes with the same perimeter can have different areas. Woodward (1982), and Woodward and Byrd (1983) found that some students thought that figure have the same perimeter also have the same area.

Task 5.1 was also used to determine the subjects' ethical knowledge of the relationship between perimeter and area. This task was used to ascertain whether the subjects (a) examine pattern within the domain of perimeter and area measurement, (b) formulate generalizations within the domain of perimeter and area measurement, and (c) test generalizations within the domain of perimeter and area measurement.

Task 5.2: Longer perimeter, larger area?

In Task 5.2, the subjects were asked to respond to a student, Mary, who claimed that she could determine whose garden has the larger area to plant flowers. She claimed that the garden with the longer perimeter has the larger area. The objective of this task was to determine the subjects' conceptual knowledge of the relationship between perimeter and area of irregular figures. Task 5.2 was used to ascertain whether the subjects knew that there is no direct relationship between perimeter and area. The garden with the longer perimeter can have a smaller area.

Task 5.2 was also used to determine the subjects' ethical knowledge of the relationship between perimeter and area of. This task was used to ascertain whether the subjects (a) examine pattern within the domain of perimeter and area measurement, (b) formulate generalizations

within the domain of perimeter and area measurement, and (c) test generalizations within the domain of perimeter and area measurement.

Task 5.3: Perimeter increases, area increases?

In Task 5.3, the subjects were asked how they would respond to a Form One student's claimed regarding the relationships between perimeter and area of a closed figure. The student claimed that as the perimeter of a closed figure increases, the area also increases. The objective of this task was to determine the subjects' conceptual knowledge of the relationship between perimeter and area of regular figures. This task was used to ascertain whether the subjects knew that there is no direct relationship between perimeter and area. When the perimeter of a figure increases, the area of the figure may increases, decreases, or remains the same. Ball (1988) found that some prospective elementary and secondary school mathematics teachers thought that the area of a figure increases as the perimeter of the figure increases, and vice versa.

Task 5.3 was also used to determine the subjects' ethical knowledge of the relationship between perimeter and area. This task was used to ascertain whether the subjects test generalizations within the domain of perimeter and area measurement.

Task 6: Calculating perimeter and area
Task 6.1: Rectangle and parallelogram/triangle

In Task 6.1, subjects were required to help his or her student to calculate the perimeter and area of the given diagram (Diagram 1) that involved composite figure, namely rectangle and parallelogram/triangle. The objective of this task was to determine the subjects' procedural knowledge for calculating perimeter and area for the composite figure. Task 6.1 was used to determine the subjects' linguistic knowledge of standard units of perimeter and area measurement

by determining whether the subject use the correct standard units of measurement for perimeter (cm) and area (cm^2) when they write the answers for these measurements.

Task 6.1 was also used to determine the subjects' strategic knowledge for checking the correctness of their answers for perimeter as well as area. Task 6.1 was used to determine the subjects' ethical knowledge by ascertaining whether the subjects write units of measurement upon completing a task. This task was also used to ascertain whether the subjects check the correctness of their answers.

Task 6.2: Square and trapezium/triangle

In Task 6.2, subjects were required to help his or her student to calculate the perimeter and area of the given diagram (Diagram 2) that involved composite figure, namely square and trapezium/triangle. The objective of this task was to determine the subjects' procedural knowledge for calculating perimeter and area for the composite figure. Task 6.2 was used to determine the subjects' linguistic knowledge of standard units of perimeter and area measurement by determining whether the subject use the correct standard units of measurement for perimeter (mm) and area (mm^2) when they write the answers for these measurements.

Task 6.2 was also used to determine the subjects' strategic knowledge for checking the correctness of their answers for perimeter as well as area. Task 6.2 was used to determine the subjects' ethical knowledge by ascertaining whether the subjects write units of measurement upon completing a task. This task was also used to ascertain whether the subjects check the correctness of their answers.

Task 7: Fencing problem

In Task 7, subjects were required to help his or her student to solve the fencing problem. The objective of this task was to determine the subjects' strategic knowledge for solving the

fencing problem. Task 7 was also used to ascertain what strategies the subjects have for checking the correctness of their answer. Task 7 was also used to determine the subjects' ethical knowledge by ascertaining whether the subjects write units of measurement upon completing a task. This task was also used to ascertain whether the subjects check the correctness of their answers.

Task 8: Developing area formulae

In Task 8, subjects were asked to show a Form One student the way to develop (derive) area formulae of a rectangle, parallelogram, triangle, and trapezium. The objective of this task was to determine the subjects' procedural knowledge of developing or deriving these area formulae. This task was also used to determine the subjects' conceptual knowledge of the relationship among area formulae.

Task 8 was also used to determine the subjects' linguistic knowledge based on the mathematical terms (such as half, length, width, base, height, sum of parallel sides) and symbols that they employed to develop and explain the meaning of the formulae. Task 8 was also used to determine the subjects' strategic knowledge of developing or deriving the area formulae as there was more than one way of doing that. This task was also used to determine the subjects' ethical knowledge by ascertaining whether the subjects had attempted or taken effort to develop the area formulae as 'doing' mathematics also involved the development of area formulae.

Table 3.3 summarizes the distribution of the five basic types of SMK in the 8 tasks used for the clinical interview. For the distribution of the components of each type of knowledge that were assessed during the clinical interview, see Appendix E.

Table 3.3

Distribution of SMK in the 8 Tasks

Interview	Task	Conceptual knowledge	Procedural knowledge	Linguistic knowledge	Strategic knowledge	Ethical knowledge
	1.1	x		x		x
1	1.2	x		x		x
	2	x		x		x
	3.1				x	
	3.2				x	
2	3.3	x				
	3.4	x		x		
	4	x	x			
	5.1	x				x
3	5.2	x				x
	5.3	x				x
	6.1		x	x	x	x
	6.2		x	x	x	x
4	7				x	x
	8	x	x	x	x	x

Pilot Study

Two pilot studies were conducted prior to the actual field of data collection in January 2008. The first pilot study was carried out in October 2006 prior to the vetting of the research proposal in March 2007. It involved two PSSMTs who had enrolled in a mathematics teaching methods course at a public university in Peninsula Malaysia. One of them majored in mathematics and the other one minored in mathematics.

The purpose of this pilot study was to familiarize the researcher with the procedures and techniques of conducting clinical interview, and to validate the written instruments in terms of task relevance, content coverage, and language appropriateness. The pilot study also allowed the researcher to estimate the needed time for each interview and examine the possible responses for each task of the interviews in order to provide additional probing questions. The tasks were revised and refined after the first pilot study.

Nevertheless, during the vetting of the research proposal in Mac 2007, the vetting committee members recommended several constructive amendments to further improve the tasks of the proposed study. Thus, the tasks were further revised and refined based on the recommendations from the vetting committee members. The tasks, description of the tasks, Form One Mathematics Curriculum Specifications, Task Relevance Judgment Form, and Content Coverage Judgment Form were then submitted to two university lecturers and a secondary school mathematics teacher to determine the content validity of the tasks (i.e., to determine whether the tasks were relevant to the topic of perimeter and area and covered the content of the topic of perimeter and area). They agreed that the tasks were appropriate for the purpose of this study and suggested that the tasks to be pilot tested.

The tasks were pilot tested in the second pilot study which was conducted in August 2007. The second pilot study also involved two PSSMTs who had enrolled in a mathematics

teaching methods course at the same public university in Peninsula Malaysia. One of them majored in mathematics and the other one minored in mathematics. Based on the responses of these two subjects, the researcher found that the tasks were appropriate in terms of content and language. These tasks were used in the actual field of data collection in January 2008 (see Appendix G).

Data Analysis

For the analysis of data in this study, demographic information was drawn from the data collected from the Background Information Form. The analysis and interpretations of the preservice secondary school mathematics teachers' SMK of perimeter and area were made using audiotapes and videotapes of the clinical interview. All interviews data were verbatim transcribed, coded, categorized, and analyzed.

The data analysis process encompassed four levels. At level one, the audio and video recording of the clinical interview were verbatim transcribed into written form. The transcription included the interaction between the researcher and the subject during the interviews as well as the subject's nonverbal behaviors. At level two, raw data in the forms of transcription were coded, categorized, and analyzed according to specific themes to produce protocol related to the description of subjects' SMK of perimeter and area. Specifically, to answer research question one, the nature of the subjects' SMK of perimeter and area were coded, categorized, and analyzed based on the respective components of its five basic types of knowledge of perimeter and area, namely conceptual knowledge, procedural knowledge, linguistic knowledge, strategic knowledge, and ethical knowledge. Table 3.4 summarizes the five basic types of knowledge of perimeter and area and its respective components. Coding rubrics for determining the subjects'

SMK of perimeter and area was devised to facilitate the coding, categorization, and analysis processes of each subject's SMK of perimeter and area (see Appendix J).

Table 3.4

Summary of the Five Basic Types of Knowledge of Perimeter and Area and its Respective Components

Type of knowledge	Its components
Conceptual knowledge	1. Notion of perimeter 2. Notion of area 3. Notion of the unit of area 4. Number of units and unit of measure 5. Inverse relationship between number of units and unit of measure 6. Relationship between standard units of length (linear units) 7. Relationship between standard units of area (square units) 8. Relationship between area units and linear units 9. Relationship between perimeter and area 10. Relationship among area formulae
Precedural knowledge	1. Converting standard units of area measurement 2. Calculating perimeter of composite figures 3. Calculating area of composite figures 4. Developing area formulae
Linguistic knowledge	1. Mathematical symbols 2. Mathematical terms 3. Standard unit of length measurement (linear units) 4. Standard unit of area measurement (square units) 5. Conventions of writing and reading SI area measurement
Strategic knowledge	1. Strategies for comparing perimeter 2. Strategies for comparing area 3. Strategies for checking answer for perimeter 4. Strategies for checking answer for area 5. Strategies for solving the fencing problem 6. Strategies for checking answer for the fencing problem 7. Strategies for developing area formulae
Ethical knowledge	1. Justifies one's mathematical ideas 2. Examines pattern within the domain of perimeter and area measurement 3. Formulates generalization within the domain of perimeter and area measurement 4. Tests generalization within the domain of perimeter and area measurement 5. Develops area formulae 6. Writes units of measurement upon completed a task 7. Checks the correctness of their solutions or answers

To answer research question two, each subject' levels (low, medium, high) of SMK of perimeter and area was analyzed in terms of its level of each of the five basic types of knowledge, namely levels of conceptual knowledge, procedural knowledge, linguistic knowledge, strategic knowledge, and ethical knowledge as well as the overall level of SMK that were identified from the clinical interview. Procedure for determining the overall level of each subject's SMK of perimeter and area was devised using coding rubrics adapted from the Learning Mathematics for Teaching (LMT) (2006) project which consists of four principal investigators, namely Hill, Ball,

Bass, and Schilling, from the School of Education, University of Michigan. For the detail of the description of the procedure, see Appendix K. Based on this procedure, coding rubrics for determining overall level of each subject's SMK was constructed (see Appendix L).

At level three, case study for each subject was constructed based on information from the written protocol (see Appendix N). At this level, analysis was carried out to describe each subject's behaviors in solving every tasks or problems. At level four, cross-case analysis was conducted (see Chapter 4). The analysis aimed to identify pattern of responses of SMK of perimeter and area held by the subjects. Based on this pattern of responses, preservice secondary school mathematics teachers' SMK of perimeter and area were summarized.

Content Validity

In general, content validity demonstrates the degree to which the sample of questions or tasks on a test or instrument is representative of some defined universe or domain of content (Hogan, 2007; McMillan, 2001; Popham, 2000). Usually, a panel of experts can be asked to review the instrument, questions by questions, to see if all the questions satisfactorily represent the domain of content involved. The judgmental procedures can be gathered systematically. A panel of knowledgeable individuals can be asked to decide: (a) whether each question represents the designated assessment domain or topic, and (b) the extent to which the assessment domain's important components have been measured by the questions (Popham, 2000).

The panel of experts in the present study consisted of two university lecturers and a secondary school mathematics teacher. The university lecturers specialized in mathematics education, and measurement and evaluation in education, respectively. The mathematics teacher has more than twenty years of experience in teaching secondary school mathematics. The clinical interview tasks, description of the tasks, Form One Mathematics Curriculum Specifications, Task

Relevance Judgment Form, and Content Coverage Judgment Form were given to each of the panel of experts to determine the content validity of the tasks (i.e., to determine whether the tasks were relevant to the topic of perimeter and area and covered the content of the topic of perimeter and area). The Task Relevance Judgment Form was used to examine the tasks in terms of its relevance to the topic of perimeter and area while the Content Coverage Judgment Form was used to examine the content coverage of the tasks to the topic of perimeter and area.

Table 3.5 shows the result of the judgment of task relevance by each panel of expert and the mean value of the judgment on each task. It was apparent that all the values of judgment assigned by the three panels of expert were at least 4 and the mean value of the judgment on each task were more than 4. Thus, it can be concluded that all the tasks were very relevant to the topic of perimeter and area.

Table 3.6 depicts the mean value of judgment assigned by the three panels of expert regarding the content coverage of the task. It was obvious that all the mean values of judgment were more than 4. Thus, it can be concluded that all the tasks covered the topic of perimeter and area very comprehensively. As a conclusion, the result of the task relevance and content coverage judgment by the panel of experts demonstrates that the interview tasks in this study contained a high degree of content validity.

Table 3.5

The Judgment of Task Relevance

Task	Judge 1	Judge 2	Judge 3	Mean
1.1	5	5	5	5
1.2	5	5	5	5
2	4	5	4	4.33
3.1	5	5	5	5
3.2	5	5	5	5
3.3 (a)	5	5	5	5
3.3 (b)	5	5	5	5
3.3 (c)	5	5	5	5
3.4 (a)	5	4	5	4.67
3.4 (b)	5	4	5	4.67
3.4 (c)	5	4	5	4.67
4	5	5	5	5
5.1	5	5	5	5
5.2	5	5	5	5
5.3	5	5	5	5
6.1	5	5	5	5
6.2	5	5	5	5
7	5	4	5	4.67
8	5	5	5	5

Judgment scale:
5 – most relevant
4 – quite relevant
3 – relevant
2 – less relevant
1 – not relevant

Table 3.6

The Judgment of Content Coverage

Judge	Mean
Judge 1	5
Judge 2	4.73
Judge 3	5

Judgment scale:
5 – most comprehensive
4 – quite comprehensive
3 – comprehensive
2 – less comprehensive
1 – not comprehensive

Reliability

In general, reliability refers to the extent to which the process of the study or research findings is consistent or can be replicated (Merriam, 1998; Miles and Huberman, 1994). One of the aspects to determine the reliability of the study is checking the coding of the data to ascertain whether the coding showed the adequate agreement (Miles and Huberman, 1994).

A stratified random sample of two of the eight verbatim transcriptions of the clinical interviews, coding rubrics for determining SMK of perimeter and area, sample of coding rubrics for determining overall level of a subject's SMK, coding rubrics for determining overall level of a subject's SMK of the two selected samples, and procedure for determining the overall level of preservice secondary school mathematics teachers' SMK of perimeter and area were submitted to the same university mathematics education lecturer to determine the reliability of coding procedure employed in the present study. The random sample were stratified by the subjects' major or minor – that is, one from the four subjects who majored in mathematics and one from

the four subjects who minored in mathematics so as to acquired an equal representation of responses from each category of subject (Gay & Airasian, 2003).

The reliability is necessary for the coding procedure. The mathematics education lecturer provided his professional assistance in checking the researcher's coding work. "In this situation, it was considered to be the closest approach to encode as objectively as possible" (Lee, 2002, p. 91). In general, the mathematics education lecturer strongly agreed with the coding work which was done on the verbatim transcriptions of the clinical interviews.