Developing and Validating a Measure of Self-Efficacy in Teaching using Science Inquiry Skills

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Abstract

From 2011 teacher education curricula in Malaysia have been required to emphasise the teaching of science using science inquiry skills. However, the performance of science pre-service teachers using these skills is an under-researched area. It is acknowledged in the teacher development literature that personal beliefs mediate the knowledge and practice of pre-service teachers in their classroom. This study explores how the self-efficacy beliefs of science pre-service teachers in Malaysia relate to teaching performance using science inquiry skills.

This thesis presents the development and validation of a measure of teacher's self-efficacy: Self-efficacy in Teaching using Science Inquiry Skills (SETSIS). The conceptual framework used in this study consists of three factors: knowledge efficacy (KE), personal teaching efficacy (PTE) and outcomes belief expectancy (OBE). Using a multi-methods research approach the study developed the SETSIS instrument comprising 72 items using a five-point rating scale. The SETSIS instrument was piloted using a cross-sectional survey of 325 pre-service teachers at 13 Institutes of Teacher Education across Malaysia. Factor analysis confirmed the contribution of the three factors with high reliabilities ($\alpha>0.9$). The SETSIS also met the Rasch rating scale model requirement in terms of reliability, dimensionality, difficulty and item discrimination but, needs to include more difficult to affirm items to distinguish the high self-efficacy level. A concurrent validation using a separate knowledge test and teaching practice assessment confirms weak associations but were able to establish the models to infer knowledge and teaching practice performance among the samples.

Overall, the findings confirm new conceptualisations of teacher self-efficacy among pre-service teachers using the three factors proposed in the SETSIS. The empirical evidence supports the utilisation of the factors of the SETSIS in assessing the belief component of pre-service teachers in teacher education. However, the study suggests different utilisation of the factors to infer pre-service teachers' performance in content knowledge and teaching practice.

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List of Abbreviations

ANOVA - Analysis of variance
BoTP- Bachelor of Teacher Programme
EFA - exploratory factor analysis
EFA - Exploratory Factor Analysis
FDM - Fuzzy Delphi Method
GTE - General teaching efficacy
ITE - Institute of Teacher Education
KE - Knowledge efficacy
MOE - Malaysia Ministry of Education
OBE - Outcomes Belief Efficacy
PCAR - Principle Component Analysis Residual
PCK - pedagogical content knowledge
PTE - Personal Teaching Efficacy
PST - Pre-service teacher

RSM - Rating Scale Model
SD - Standard deviation
SETSIS- Self-efficacy in Teaching using Science Inquiry Skills
TCC -Test characteristic curve
TISP - Test of Integrated Science Process Skills
TSE - Teacher self-efficacy

TSI - Teaching Science as Inquiry measure

Chapter 1 Introduction

1.1 Introduction

This thesis presents a study in the development and validation of an instrument to measure self-efficacy in teaching using science inquiry skills called the SETSIS. The development of the SETSIS to measure belief was inspired by the transformation in education policy in Malaysia. The new policy of the Malaysian Ministry of Education (MOE) aspires to increase the participation of students in the science classroom through a skills-based approach. The introduction of a new primary science curriculum to include the process of science instead of only science content outcomes through learning requires a significant shift in classroom teaching approach and practices. The study of the development of the SETSIS aims to measure belief development in implementing the practice changes focusing on pre-service teachers (PSTs). This chapter introduces the background context towards this study, its rationale and its objectives.

1.2 The study background

1.2.1 Science curriculum reform in Malaysia

The current science curriculum in Malaysia is largely shaped by a combination of internal and external global factors (Turiman et al. 2012). Compared to other subjects in the curriculum, changes in the science curriculum generally occur at a much faster pace due to the significant impact created by science and technology advancement in human civilisation (Adey 2001;Smith et al. 2012). The new Malaysian primary science curriculum has emphasised the acquisition of scientific skills (process and manipulative skills) and thinking skills as well as understanding the basic principles of science with scientific attitudes and values., According to policy-makers and researchers, there is an urgent sense today that a science skill-based approach is more important than acquiring content for science literacy at school (Malaysia Blue Print 2013; Wicht 2016).

In 2011, a new curriculum for primary schools, the standards-based Primary School Standard Curriculum (KSSR), was launched to restructure the old integrated curriculum, Integrated Curriculum for Primary School (KBSR). The transformation into KSSR aims to upgrade scientific literacy in school children for better development of scientific understanding. The new primary science curriculum asks teachers to change their instruction-oriented approach to be more process-oriented. Teachers are asked to facilitate student understanding of the concept by using science inquiry skills rather than via a concept explanation by the teacher. To date, science inquiry skills have become an important component in the new science curriculum and have become one of the new approaches to teaching science in a more effective and meaningful way (Malaysia Ministry of Education 2014).

The new curriculum (i.e. KSSR) has been designed using a modular curriculum that stresses content and learning standards, rather than merely outcomes as in the old curriculum (i.e. KBSR). With the implementation of KSSR, science teachers must be well equipped with the necessary knowledge and skills so that what is outlined in the curriculum is being realised in the classroom. Although teachers are expected to stress the process of science rather than the science concepts as outcomes in science classrooms, there is no explicitly stated expectation for teachers to meet these standards. This issue creates a challenge for teacher educators and PSTs to make changes in practice, appropriate to this newly reformed curriculum.

There has been lots of research that defines the work in teacher knowledge within the science content-based approach. In Malaysia, the primary curriculum has emphasised the acquisition of scientific skills (process and manipulative skills) and thinking skills as well as understanding the basic principles of science with scientific attitudes and values.

1.2.2 Defining science inquiry skills in the classroom

This study defined science inquiry skills as collective of science process skills by these skills are implemented during inquiry for the instructional setting in science classrooms. The transferability of the science process skills in the classroom depends on the learning context. In a science inquiry instructional setting, science process skills are the skills that always specifically frame what students should learn in the particular context of a science pedagogical setting (Millar & Driver 1987).

Science inquiry skills are the courses of action science researchers use in scientific explorations, the mental mode of acquiring science concepts, and the didactic processes in lecture rooms (Millar, 1987). They are also known as science process skills, a set of broadly transferable abilities, applicable to many scientific disciplines and reflective of the works of scientists (AAAS, 1967). In the new Malaysian primary science curriculum context, science process skills are defined as skills that enable students to become involved in science learning more effectively. These skills are assessed by the standards based on the ability of students to perform the skills during science activities. The definitions of science process skills in the Malaysian primary science curriculum are given in Table 1 (Malaysia Ministry of Education 2003).

Table 1 Definition of Science Process Skills (Malaysia Ministry of Education 2003)

No	SPS	Definition
1	Observing	Using the sense of hearing, touch, smell, taste and sight to collect information about an object or a phenomenon.
2	Classifying	Using observations to group objects or events according to similarities or differences.
3	Measuring and using numbers	Making quantitative observations using numbers and tools with standardised units. Measuring makes observation more accurate.
4	Inferring	Using past experiences or previously collected data to draw conclusions and explain events.
5	Predicting	Stating the outcome of a future event based on prior knowledge gained through experiences or collected data.
6	Communicating	Using words or graphic symbols such as tables, graphs, figures or models to describe an action, object or event.
7	Using space-time relationship	Describing changes in parameter with time. Examples of parameters are location, direction, shape, size, volume, weight and mass.
8	Interpreting data	Giving rational explanations about an object, event or pattern derived from collected data.
9	Defining operationally	Defining concepts by describing what must be done and what should be observed.
10	Controlling variables	Identifying the fixed variables, manipulated variable, and responding variable in an investigation. The manipulated variable is changed to observe its relationship with the responding variable. At the same time, the fixed variables are kept constant.
11	Hypothesising	Making a general statement about the relationship between a manipulated variable and a responding variable in order to explain an event or observation. This statement can be tested to determine its validity.
12	Experimenting	Planning and conducting activities to test a certain hypothesis. These activities include collecting, analysing and interpreting data and making conclusions.

Osman (2012) in her view of the early science curriculum in Malaysia, states that the current science curriculum reform efforts have re-focused on the necessity of teaching students to make use of scientific knowledge to solve problems. Science teachers are challenged to use inquiry skills as their pedagogical approach to facilitate the development of cognitive development in the context of science learning. Therefore, the generic components of these skills are defined by science process skills and teachers can implement the skills in their inquiry teaching instruction for organising a more systematic approach to science in the primary level.

Implementing a skill-based approach to science instruction need to emphasise what children are able to do. Science process skills are defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behaviour of scientists. These skills are grouped into two types: basic and integrated. The basic process skills are observing, inferring, measuring and using numbers, communicating, classifying, predicting and using the space/time relationship, while the integrated process skills are controlling variables, defining operationally, hypothesis and interpreting data. The basic (simpler) process skills provide a foundation for learning the integrated (more complex) skills.

In the empirical evidence presented in Smith et al. (2012), science teachers in a primary school in America agreed that scientific literacy in classroom practice can be viewed through how children learn to '*taking apart issues; analysing; sorting; reconstructing; defining; explaining; redefining ideas; …….; categorizing; using deeper thinking strategies; and making connections'* (Smith et al. 2012, p.145). The compilation of all these skills is what we call science process skills, which are always associated with science inquiry (Chiapetta and Koballa 2006). Thus, in the context of primary science classrooms in Malaysia, science process skills listed in Table 1 are used to frame the features of science inquiry skills of this study.

1.2.3 The role of science inquiry skills in promoting scientific literacy in learning

Scientific literacy means being able to make informed and balanced judgements about how science impacts on students' lives and how to use scientific knowledge to solve problems (American Association for Advancement of Science, 1993). The major goal of science curricula is to promote scientific literacy to enable people to understand reports and discussion about science in the media (Millar and Osborne, 1998; DeBoer, 2000). Further, it is believed that the fundamental sense of scientific literacy is more than the ability to read and write about science, thus suggesting that the science curriculum should focus on the skills and applications that flow from science (Shortland, 1988).

In his systematic review, Ryder (2001) shows that, besides subject matter knowledge, individuals need knowledge about science to critically engage with everyday scientific issues. Further, Ryder indicates the significance of learning scientific skills including assessing the quality of data, interpreting data and the validity of scientific interpretation. These arguments suggest that the development of process skills in science education are important because of their role in the development and pursuit of scientific knowledge and not just because they are valuable skills in their own right. Supporting this view, Huppert, Lomask, and Lazarowitz (2002) argue that learning scientific skills, known as science process skills, is a major goal of science education, since those skills are not only needed by scientists but by every citizen in order to become a scientifically literate person who can function in a global society.

In the empirical study to investigate how the cognitive domain is affected by scientific skills among primary students in Turkey, Özgelen (2012) found that scientific skills are related to cognitive development in providing support in students' thinking, reasoning, inquiry, evaluation and problem-solving skills, as well as their creative thinking. This finding supports Adey's research (2001) which found that teaching scientific skills are necessary in the primary school because of the important role of the scientific method in accelerating the cognitive development to a higher level of science learning.

The section pointed to the role of science inquiry skills in reforming science literacy, especially in the science curriculum in Malaysia. It seems that teacher education has a major role in providing PSTs with essential training in order to support curriculum reform. The next section will look into the context of teacher education in Malaysia.

1.3 Teacher education curriculum in Malaysia

One of the MOE policies detailed in the Malaysia Education Blueprint (2013-2025) is to enhance the teaching profession by improving the quality of teachers. The Institute of Teacher Education Malaysia (ITE) has been given the responsibility to conduct the Bachelor of Teaching Programme (BoTP). Through this programme, the MOE wishes to reform the teaching profession in Malaysia as this programme was raised in status from a diploma to a bachelor degree qualification for primary teachers. The aim of this programme is to produce high quality primary school teachers with the knowledge, skills, and competencies to become effective teachers (Faridah et al. 2012).

The programme was started in 2007 as a four-year teacher education degree programme with one year of the foundation specialised in various primary subject areas (e.g. primary science education, primary mathematics education, primary English language education, primary special education). The programme is run by ITE throughout 27 campuses all over Malaysia. The aim of the BoTP is mainly to produce quality primary teachers that have specialised in their subjects together with the knowledge of general teachers. The curriculum design in BoTP is parallel with the concept of teacher knowledge (Shulman 1986, 1987) that is widely used in the teacher education area (Grossman, 1990; Ben-Peretz, 2011). Details on the concept of teacher knowledge can be viewed in Chapter 2.

The BoTP curriculum is structured into three components which are core courses (65 percent of the total 133 credits), elective courses (18 percent) and compulsory courses (17 percent). The curriculum design for core courses includes professional studies, professional practice and major subject courses, which are the essential teacher knowledge to be used and developed by the PSTs in their professional teaching practice (Moore, 2014). Table 2 below shows the components in core courses for BoTP specialising in primary science education.

PSTs are required to complete all the core courses within eight semesters of study. Professional studies provide exposure in basic teacher knowledge (i.e. general instructional and pedagogical knowledge) with a total of 27 credits. Major courses are offered to provide students with science content knowledge up to degree level and pedagogical content knowledge (PCK) in the context of teaching science in primary school. The major courses allocate a total of 45 credits, with one course named Thinking and Working Scientifically offering the module specifically on implementing science process skills.

The professional practice provides the '*in-site exposure*' for PSTs to turn the knowledge analysis into action in real school situations based on the professional teaching standards. Professional practice provides 14 credits, in which students are required to undergo a 32-week of professional practice which is implemented through three forms: namely,

- School-based Experience (PBS) is carried out for four weeks (4W) without credit through courses in professional, major and elective studies.
- Teaching Practical at school (Practicum) is carried out for 24 weeks, distributed in three phases.
- The internship is carried out for four weeks in the eighth semester.

Table 2 The components in core courses for BoTP specialising in primary science education

Courses	Module	Credits	Semester
Professional Studies	Philosophy and education in Malaysia	3	1
	Child development	3	1
	Learning and the learner	3	2
	Behaviour and classroom management	3	3
	Technology in Teaching and Learning	3	4
	Culture and learning	3	5
	Guidance and counselling for children	3	7
	Leadership and professional development	3	8
	Teacher and current challenges	3	8
Professional Practice	School Based Experience-Professional studies		1
	School Based Experience-Majoring studies		2
	School Based Experience-Elective 1 studies		3
	School Based Experience-Elective 2 studies		4
	Practicum I	2 (4 weeks)	5
	Practicum II	4 (8 weeks)	6
	Practicum III	6 (12 weeks)	7
	Internship	2 (4 weeks)	8
Major Course	Life and life processes	3	1
	Children learning science	3	1
	Explore the material	3	2
	Pedagogy and curriculum for primary science	3	2
	Physics context base	3	3
	Thinking and working scientifically	3	3
	Ecosystem and biodiversity	3	4
	Lesson plan for primary science	3	4
	Energetic chemistry	3	5
	Earth and space	3	5
	Assessment in teaching science	3	6
	Source and science lab management	3	6
	Action research I	3	7
	Science, technology and community	3	8
	Action research II	3	8

The BoTP curriculum has been designed to give the opportunities for teacher candidates to practice the theoretical grounded tools systematically (Grossman, Smagorinsky and Valencia, 1999). These experiences are educative and productive for PSTs to analyse, apply and reflect on the connection of subject matter and teaching outcomes, so that they will learn to be flexible and meet the specific teaching contexts (Ball and Bass 2000). However, Hairah and Keong (2011) found that PSTs on BoTP were not doing well in application and reflection in their teaching outcomes, especially in the context of teaching SPS during their professional practice. Although the teacher training programme may inspire teaching practices, there are other factors beyond the cognitive performance that influence the practice of PSTs.

1.3.1 Science inquiry skills in teacher education

New pre-service science teachers came into the first semester of BoTP training with various perceptions of their potential ability in the specific tasks of teaching using science inquiry skills. They came with perceived expectations in science teaching approaches observed during their school experiences. Considering the nature of changes in the national science primary curriculum from KBSR to KSSR, preparing PSTs for the shift from content-based learning into skill-based teaching is important to teacher education.

Tan (1996) has reviewed the level of achievement in integrated science process skills among science trainees at two teaching colleges in Penang. He reported that the achievement of integrated science process skills among trainees is low compared with the achievements of students in similar studies conducted in the United States using the same testing instrument (Burns, Okey and Wise, 1985). This may be true, as analysis by Hairiah and Chin (2011) shows that trainees recorded the science process skills in the teaching plan but did not execute this plan in the classroom. Surprisingly, their reflection notes never mention this problem because they had not given attention to the importance of process skills, even though the need of the skills was stressed during teacher training.

In summary, it can be argued that a common approach to science teacher education offers a mix of content, pedagogy and contexts but without explicitly stating what knowledge novices are supposed to construct or how to utilise this knowledge. With attention to the BoTP for primary science major courses, the courses offered certainly emphasised the content and pedagogical knowledge of teaching using science inquiry skills in the curriculum, but the PSTs are poorly utilising the skills in their classroom practices or worse not even noticing it during classroom teaching practices. Perhaps, with the identification of PSTs' personal belief in using the skills during classroom teaching practices, teacher educators can offer strategies with an explicit mechanism to affirm the teaching using science inquiry skills.

1.4 Problem statement

The latest primary science curriculum in Malaysia has emphasised the acquisition of scientific process skills as well as the understanding of basic principles of scientific concepts. This transformation attempts to upgrade the scientific literacy in schools to enable students to develop better scientific inquiry skills (Norris and Phillips 2003; Osman 2012). This reform explicitly asks teachers to change their teaching strategies by shifting from direct instruction to facilitating learning through inquiry instructions.

However, these changes have not yet been sufficiently reflected in the teacher education curriculum. PSTs have not reflected sufficient knowledge to surface their teaching using science inquiry skills explicitly during their practice (Balfakih, 2010; Mbewe, Chabalengula and Mumba, 2010; Chabalengula, Mumba and Mbewe, 2012). Whilst they were unable to provide a correct definition, conceptually, of the skills, they exhibited relatively good performance involving the skills in novel situations. It seems that the contexts exhibited within teaching and learning situations help teachers and PSTs to show better competency in science inquiry skills.

Competency of PSTs in the specific application of science inquiry skills but not in the content of conceptual knowledge can partially be explained by their teacher knowledge. Teacher knowledge describes teachers' professional knowledge derived from teaching practice as well as from schooling activities. Pre –service teachers translate their conceptual knowledge of science inquiry skills into the performance of science inquiry skills through their personal experience, which is highly contextualised and influenced by teaching interactions and experiences (Van Driel, De Jong and Verloop, 2002). How PSTs think and translate their knowledge to use in classroom teaching practices seems to be a consequence of the way they develop their belief in the possessed teacher knowledge.

Many researchers agree that successful teachers draw on specialised knowledge in their instructional work (i.e. teacher knowledge) with students, but specifying and measuring this knowledge has proven elusive in the teacher education programme (Pajares 1992; Abd-el-khalick et al. 1997;Cochran-Smith 2004; Ravindran et al. 2005). Although it is important to have the intellectual ability and capability to analyse their experiences in classrooms during teacher training, it shows that there are other factors that influence the transformation of the cognitive performances (i.e.

knowledge of teaching received in training) into action (i.e. practice of teaching). It seems that, the practice experiences for PSTs that obtained from the theoretical training (e.g. teaching courses, micro teaching, teaching courses' presentation and teaching courses' assignments) are not reflected in practice of teaching in classrooms within the real school environment (Hairiah and Keong 2011; Rauf et al. 2013) .

Previously, studies show that multi-perspective experiences and belief (i.e. school experiences, epistemological belief and teaching experiences) have an effect in PSTs' practice (Hutner and Markman 2016; Lebak 2015; Duit and Treagust 2003; Kane et al. 2002; Van Driel et al. 2001). Thus, this current study explores self-belief factors that influence the transformation of theory learned into practice in the context of teaching using science inquiry skills. This study was conducted among the pre-service science teachers in the Institute of Teacher Education (ITE) in Malaysia.

1.5 Focus of the study

In teacher education, development of PSTs is assessed using two main components of teacher knowledge. The first component is the cognitive test, where PSTs are tested using their knowledge attainment, and the second component is teaching practice performances (Park, 2011; Veal, 2012). However, it suggests that when PSTs are expected to depend on and be accountable for their own learning process during teaching practice, their belief plays a major role in the decision about curriculum and teaching tasks (Pajares, 1992).

This study intends to assess the beliefs of PSTs in implementing a skill-based approach in primary science instruction. Using the concept of self-efficacy, the study explores three elements of teacher development through the application of educational measurement techniques. The aims of this study are to

i) Develop and validate a self-efficacy instrument that includes knowledge efficacy, practice efficacy and belief in the context of teaching SPS among prospective science teachers in Malaysia

ii) Identify and understand whether self-efficacy traits (i.e. self-efficacy in knowledge, self-efficacy in personal practice and outcome expectancy) can infer teacher knowledge development in the component of knowledge and practice in PST education.

The study of development in the SETSIS reflects the model of teacher's self-efficacy in the specific task of teaching using science inquiry skills. As Germann (1994) claims, through inquiry experiences, teachers help students not only to learn about science but also to think logically, ask reasonable questions, seek appropriate answers, and solve daily problems. The measure from the instrument is assumed to indicate the characteristics for successful implementation of teaching with science inquiry instruction in classroom for prospective science teachers as intended in the reformed primary science curriculum of Malaysia.

Teacher education may provide sufficient knowledge and opportunities for pre-service teachers to practice teaching according to KSSR needs. However, to what extent these PSTs will persistently continue practicing the policy in future science classroom depend on their perceived beliefs in their own capability of teaching. The SETSIS is able to provide individual information about the perceived beliefs of teaching using science inquiry skills. The information can help teacher educators to identify the beliefs of individual PSTs in the implementation of the reform policy. This information can provide early intervention to strengthen PSTs' perceive beliefs in the capability of teaching using science inquiry skills. The beliefs can play a major role in affecting personal persistence in teaching using science inquiry skills in the science classroom in Malaysia, as expected in the reform policy of KSSR. The next chapter describes the importance of self-efficacy in teaching using science inquiry skills in the existing literature.

Chapter 2 Literature Review

2.1 Introduction

In this chapter I present a review of the literature to explore the argument that the underlying construct, self-efficacy in teaching using science inquiry skills has a role in improving science teaching practice in PST education. This chapter begins with a review of the prominent theory of self-efficacy, followed by tracing the teachers' self-efficacy (TSE) measure development and empirical evidence to provide the significant influence of TSE measures in student and teacher performance. Next, I trace the development of the teachers' efficacy assessment concept from its emergence up to the present to clarify its conceptualisation with the critiques on the existing factors of TSE belief, in which I also suggest current developments in the TSE measure concept literature. Then I conceptualise my study framework based on prior teacher efficacy definitions, conceptualisations and theorisation, incorporating the elements of best practices in teacher efficacy assessment for PSTs. Finally, I define the framework within self-efficacy in teaching using science inquiry skills and present justification for the need to develop a new self-efficacy tool aligned to the principle of teacher education development.

2.2 Theoretical and empirical review of teacher's self-efficacy (TSE)

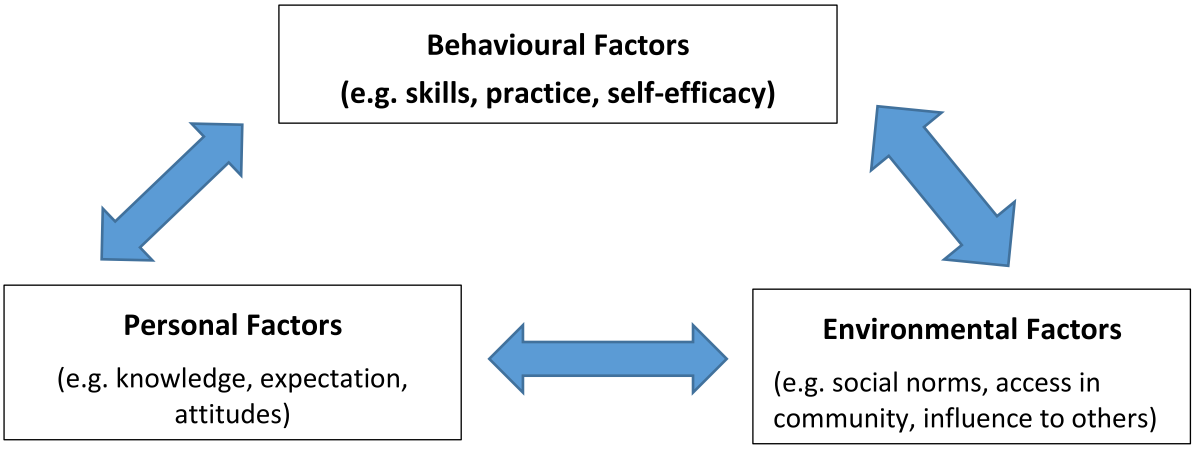
A role of self-efficacy in a teacher's teaching practice needs to be theoretically and empirically reviewed to provide strong evidence of contributions to teachers' self-efficacy, especially in quality of the PSTs' teaching practice. The strength of the theories of self-efficacy that align with the empirical evidence will be discussed later.

2.2.1 Bandura's Self-efficacy Theory

Self-efficacy defines as '*a person's belief that they can be successful when carrying out the particular task'* (dictionary.cambridge.org). A perceived self-efficacy refers to people's beliefs about their capability to exercise control over their own activities. Albert Bandura defines self-efficacy as personal judgement of 'one's capabilities to organize and execute the courses of action required to manage prospective situations' (Bandura 1997, p.2). He conceptualise the role of self-efficacy to infer future behaviour in general.

Bandura's definition is rooted in the social cognitive theory view on human agency, which suggests that individuals are responsibly engaged with their own development, within reciprocal causation relationships between environment, behaviour and personal factors. The driven action that can make things happen from the cognitive interaction of the three factors (Bandura 1986) was clarified in a model of triadic reciprocal determinism. The model used in Woods and Bandura (1989) is adapted into Figure 1 to explains the cognitive interaction between the three elements in determining human behaviours or performance in certain task.

Figure 1 Social cognitive theory emphasising reciprocal influences of behavioural, environment and personal factors in cognitive judgement

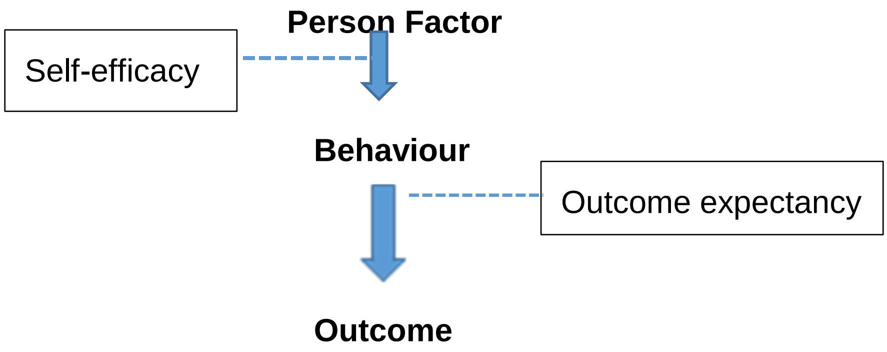


The model in Figure 1 shows the possibility to determine human behaviours through cognitive judgement of the three factors. Strategies for increasing performance in a task can be aimed at improving the three factors indicated. For example, in order to improve the practice of teaching among teachers, the trainer can work to improve teachers' self-efficacy in teaching (behavioural factors), improve their knowledge and attitudes towards teaching (personal factors) and/ or improve the expectation of the social community (environmental factor). This triadic reciprocal model interaction creates cognitive judgement for changes in behaviour.

Bandura has advanced the concept in self-efficacy theory. Self-efficacy, which is a component of social cognitive theory refers to people's belief about their capabilities to execute a specific task within a given context. The cognitive judgement contributed to the predictive power of certain levels of behaviour, which arose from personal factors and environment factors (i.e. outcome expectancy) (Bandura 1977, 1998). The relationship of Bandura's self-efficacy theory is portrayed in Figure 2.

In Figure 2, while self-efficacy is a cognitive judgement about one's capability of doing a task based on personal factors (i.e. self-reflection of personal competency) within the environmental sources, it also holds on to the relationship with outcome expectancy as a basis in predicting the capability of a person to perform a certain level of behaviour in future.

Figure 2 Relation between self-efficacy and outcome expectancy (Bandura, 1998). Self-efficacy may vary in terms level, strength and generality while outcomes expectancy may become positive or negative incentives.



Outcome expectancy is distinguished from self-efficacy because self-efficacy indicates the perceived intensity in the ability to do a behaviour in completing a task, while outcome expectancy is a judgement about the likelihood of outcomes from the behaviour. Given an example of self-efficacy '*I believe that I can cheer up the class by telling jokes',* self-efficacy is about perceived belief of the capability of telling jokes (i.e. to do a behaviour) in order to cheer the class (i.e a task). The likelihood of outcomes expectancy is about the belief that the behaviour (i.e. telling jokes) can be lead to positive or negative outcomes in physical, social or self-evaluative incentives (e.g. I believe that students do not like their teachers to tell jokes during lesson).

According to Bandura's theory, self-efficacy causally influences outcome expectancy, but not vice versa: "*People's judgement about how well they will perform largely determine what outcomes they expect their action to produce"* (Bandura 1998, p.53). This belief judgement is based on the perceived capability to coordinate and orchestrate the skills and capabilities in the context of competing for specific demands and impediments. People's perceptions of whether they are capable of successfully performing certain behaviours through the expectancy distinguish self-efficacy from general self-belief. Perseverance can produce the desired results, and this success then increases self-efficacy judgements.

The relation between self-efficacy and outcome expectancy explains self-efficacy as a belief that is goal-directed for specific tasks and domains, distinguishes it from general self-belief that only involves the willingness to carry out certain behaviour (Bandura 1997). With the expectancy on the outcome factors, people with high self-efficacy are more likely to believe they can overcome the challenges, recover from setbacks and disappointments, and do well in prospective tasks. While people with low self-efficacy tend to have low belief in doing well in the prospective challenges, which leads to avoiding the tasks.

This theorised relationship, in Figure 2, has been widely accepted in the area of self-efficacy measures (Maddux, Norton and Stoltenberg 1986; Tschannen-Moran and Hoy 2001; Siwatu 2007). However, numbers of empirical studies have demonstrated that outcome expectancy influences self-efficacy ratings, then called into the question of validity of the self-efficacy theory (Kirsch 1982, 1985, 1986, 1995; Teasdale 1978; Wolpe 1978 in Williams 2010). Bandura countered this critique with evidence involving correlational studies showing that self-efficacy is predictive of behaviour even when the effects of outcome expectancy were statistically controlled (Bandura 1984 in Williams 2010). He asserted that self-efficacy judgements are valid but can still be influenced by outcome expectations.

Development in self-efficacy judgement contributed from four sources that postulated self-efficacy and outcome expectancy factors (Bandura 1997). Mastery experiences, vicarious experiences, verbal persuasion and physiological arousal were stated as the main sources of the expectation. The mastery experiences develop a strong sense of efficacy through previous success in dealing with a particular challenge. The experiences of repeated success performance can build a resilient sense of efficacy from similar situations and contribute to a powerful sense of self-efficacy. Contradictory to success experiences that contribute to an increase in self-efficacy, failure in past experiences can contribute to decreased levels of self-efficacy.

On the other hand, people with little previous experiences develop a sense of efficacy with the observation of successful behaviour of model performance or vicarious experiences. Vicarious experiences encourage the belief that people are able to imitate the success of the model performance, especially when there is a similarity to the model. Observation of behaviour on certain tasks can affect levels of self-efficacy, in which seeing success or failure of the model in the tasks can contribute to the level of self-efficacy.

Moreover, verbal persuasion can have a built-in sense of efficacy when people are told about their capability to handle certain situations. Social persuasion received from other persons can manifest positive or negative encouragement. 'People who are persuaded verbally that they possess the capability to master given tasks are likely to mobilise greater effort and sustain it…' (Bandura 1997, p. 101). In the context of teacher practice, social persuasion usually comes from social interaction, especially from teacher trainers and peers.

Lastly, physiological arousal can lead to the development of self-efficacy. People's perception with their physical function can influence their belief. Lack of physiology perception (e.g. having speech problem or excessive body mass), which might be interpreted as inability by a person can feed negative responses reflected in low levels of self-efficacy rather than the normal perception of physiology that feeds perfectly positive responses for high levels of self-efficacy. In teacher training, these sources interacted within teachers' professional knowledge, which then can be seen in teachers' behaviour in classroom teaching. The model of self-efficacy that explains reciprocal interaction of cognitive judgement between the personal and environmental factors can be used to preliminarily assess competency in the teaching profession. The following is discussed as to how Bandura's self-efficacy theory has connected in self-efficacy concept measures for teachers.

2.2.2 Conceptual perspectives on the underpinning teacher self-efficacy (TSE) measure development

Teacher self-efficacy (TSE) belief was first introduced by Research ANd Development (RAND) Corporation. RAND's researchers introduced two items that measure the internal factors and external factors influencing a teacher's ability to teach (Armor et al. 1976). It was conceptualised using an internal-external scale inspired by Rotter's theory of social learning (1966). The internal scale in RAND's project indicates teacher's belief in accomplishing teaching activities in difficult contexts within classroom teaching. The external scale measures a teacher's belief in the environmental factors that overshadow teaching ability and inhibit learning. The combination of these two factors yielded the teacher efficacy construct. This study asserted that the internal factor belief has a greater impact than the belief in external factors.

Later, Gibson and Dembo (1984) developed a 30-item instrument, that measured teacher efficacy more extensively and reliably, called the Teacher Efficacy Scale. The study of the Teacher Efficacy Scale was motivated by RAND's factors (Armor et al. 1976) that corresponded with the concept of self-efficacy theory (Bandura 1977). Factor analysis confirmed that there were two factors: the internal factor called personal teaching efficacy (PTE) and the external factor called general teaching efficacy (GTE), which both show high reliability.

In the Teacher Efficacy Scale, PTE corresponds to specific items (e.g. “If I really try, I can get through to even the most difficult and unmotivated students” (p.573)) that represent a teacher’s sense of personal responsibility in student learning. GTE corresponds to items (e.g. “ When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends on his or her home environment”(p.574)) that reflect a teacher’s belief about the general relationship between teaching and learning. Gibson and Dembo argue that these two respective factors emerged corresponding with self-efficacy and outcome expectancy, as suggested by Bandura (1977). As a result, the self-efficacy factor is widely known as PTE and outcome expectancy is widely known as GTE in TSE belief measures.

Although the Teacher Efficacy Scale has been used often as a teacher efficacy instrument, there is the issue of inconsistency in the meaning and instability in factor structure of PTE and GTE (Henson 2001; Tschannen-Moran an Hoy 2001; Williams, 2010). Hoy and Woolfork (1993) employed their short version of Teacher Efficacy Scale with a 10-item measure and found reliabilities in five PTE items and five GTE items, which were within the range of the longer version of the measure. The measure predicts that teachers with higher scores in PTE and GTE would persist in teaching tasks longer, give a greater academic focus in the classroom and would be active and assured in their responses to the students. Indeed, Allinder (1994) in her study of the relationship between teacher’s self-efficacy and instructional practices found that PTE relates to instructional experimentation while GTE refers more to clarity and enthusiasm in teaching.

Researchers inadvertently combined PTE with other factors, which lead to instability of the factor structure in self-efficacy measures. Using the 16-item version of Teacher Efficacy Scale, Soodak and Podell (1993) found that one GTE item was loaded onto the PTE factor, and that another item did not have a strong enough loading on either factor to be included. In another study, four school factors were found to be significantly associated with teacher efficacy: receiving positive feedback on teacher performance, collaboration with other teachers, parental involvement in the school, and schoolwide coordination of student behaviour (Rosenholtz 1989). These results empirically questioned the validity of Bandura’s theory of two distinctive factors of self-efficacy (i.e. PTE) and outcome expectancy (i.e. GTE) as stated in 2.2.1.

Addressing these issues, Tschannen-Moran et al. (1998) have extended the two-dimensional concept of Bandura in their integrated model of teacher efficacy. This teacher efficacy model integrates sources of information in a specific setting with the cognitive process in order to make efficacy judgements. The efficacy judgements are made based on two corresponding factors, GTE and PTE, that are embedded in the analysis of teaching tasks and the assessment of personal teaching competence. This model is explained in detail later in section 1.3.1.

2.2.2.1 TSE measure development in teaching science

TSE is believed to be context and subject-matter specific (Pajares 1992; Roberts and Henson 2000; Meinhardt et al. 2014). The Teacher Efficacy Scale measure for general teaching behaviours may overlook the specific content of teaching. In the attempt to address this issue, Riggs and Enochs (1990) developed the Science Teaching Efficacy Belief Instrument (STEBI) for teachers (STEBI-A) and STEBI-B for PSTs. These science-specific items were modelled after two scales that have been used in Gibson and Dembo (1984) in regards of science teaching and the learning was believed too general for a context of in-service and PSTs. Studies in STEBI-A and STEBI-B have found two unrelated factors that were consistent with the factors concept of PTE and GTE (Riggs and Enochs 1990).

In extended studies of STEBI-A and STEBI-B, teachers with high scores of PTE reported were more likely to spend time teaching to develop the science concept being considered and were related to higher science teaching performance (Riggs and Jesunathadas 1993; Riggs et al. 1994). The studies on the second factor related to the quality of teaching science but Riggs (1995) found that GTE will improve only with those whose belief was weak to begin with.

Other research has questioned the elusive measure of outcome expectancy factor in STEBI-B (Tschannen-Moran and Hoy 2001; Bleicher 2004) because of the instability in factor structure. Roberts and Henson (2000) proposed an alternative instrument, called Self-Efficacy Teaching and Knowledge Instrument Science Teachers (SETAKIST), to measure science teachers' self-efficacy to address these concerns. The development of SETAKIST used Gibson and Dambo's measure as a starting point, retained the PTE items (rewording them into a science teaching context) but introduced knowledge efficacy (KE) to assess another teacher efficacy dimension. The idea of knowledge efficacy construct was based largely on the concept of Pedagogical Content Knowledge (PCK) (Shulman, 1986). However, in a revised version of SETAKIST in item wording and scaling (SETAKIST-R), Pruski et al. (2013) revealed that the person-item separation indices (reliability) were low because of poor item wording. Thus, the study suggested SETAKIST's items needed development before further usage.

To conclude, the development in TSE belief measures, especially in quantitative measures, still needs to be improved. The review of the theoretical aspect of self-efficacy belief has been a foundation in TSE belief measures and have shown a significant role in measuring teaching behaviour for teachers and PSTs. It has also been further shown the role of knowledge factor in measuring TSE belief. The next section will discuss the empirical evidence that suggests the important influences of TSE measures in teaching science.

2.2.3 Empirical evidence of TSE role in teaching practice

Self-efficacy is a belief that someone can successfully perform a behaviour and has attracted much empirical research. It asserts that self-efficacy has a powerful influence on behaviour and performance changes. A range of research studies highlighted the important role of teachers' self-efficacy in students' learning and teaching practice.

2.2.3.1 Impact of TSE on student learning

Self-efficacy has emerged as a highly effective predictor of students' motivation and learning. As a performance-based measure of perceived capability, self-efficacy beliefs have been found to be sensitive to subtle changes in the students' performance context, to interact with self-regulated learning processes, and to mediate students' academic achievements (Zimmerman 2000).

Since the TSE belief measure concept was promoted by the RAND Corporation (Armor et al. 1976; Berman, McLaughlin, Bass, Pauly, and Zellman 1977) and the subsequent research into the TSE measure, a number of studies have pointed to the influence of TSE beliefs on children's cognitive achievements and success at school (Moore and Esselman 1992, 1994; Muijs and Reynolds 2001; Ross 1992, 1998). TSE beliefs may influence a student's achievement in several ways. Teachers with high self-efficacy beliefs are more likely than teachers with a low sense of self-efficacy to implement didactic innovations in the classroom and to use classroom management approaches and adequate teaching methods that encourage students' autonomy and reduce custodial control (Cousins and Walker 1995a, 1995b; Guskey 1988), to take responsibility for students with special learning needs (Allinder 1994; Jordan, Krcaali-Iftar, and Diamond 1993), to manage classroom problems (Chacon 2005; Korevaar 1990), and to keep students on task (Podell and Soodak 1993).

Furthermore, teachers' perceived self-efficacy has been found to be associated with enhanced student motivation (Ashton and Webb 1986; Roeser, Arbreton, and Anderman 1993), increased self-esteem (Borton 1991), strong self-direction (Rose and Medway 1981), ease in managing school transitions (Midgley, Feldlaufer and Eccles 1989), and more positive attitudes toward school (Miskel, McDonald, and

Bloom 1983). The teacher's self-efficacy may also contribute to promoting a student's sense of efficacy, fostering their involvement in class activities and their efforts in facing difficulties (Ross 1998; Ross, Hogaboam-Gray, and Hannay 2001).

In addition, other findings suggest a reciprocal effect between a teacher's perceived self-efficacy and a student's achievement, showing that teacher's perceived self-efficacy is particularly high in schools with high-achieving and well-behaved students (Raudenbush, Rowan, and Cheong 1992; Ross 1998). As teachers of talented and disciplined students are more likely to be successful in their activities and tasks than teachers of students who present learning or disciplinary problems, the repeated experiences of success with students may enrich their experience and contribute to their robust sense of efficacy.

2.2.3.2 Impact of TSE on teacher’s performance

With regard to teaching practice, the evidence suggests that teachers’ behaviour in classrooms is highly influenced by their perceptions about own ability to teach (self-efficacy) and the belief that their teaching strategies would be effective (outcomes expectancy). Although a person’s beliefs about their capabilities are not the same as their actual ability, they are closely related. Teacher's self-efficacy beliefs do not, of course, operate in isolation from other psychosocial determinants that affect their motivation and performance such as their professional aspirations, the recognition and respect they perceive to be accorded and, ultimately, the satisfaction they draw from their profession.

Previous findings support the critical influence of a teacher's self-efficacy beliefs on their performance and motivation (Bandura 1997; Ross 1998; Tschannen-Moran, and Woolfolk Hoy, 2001; Tschannen-Moran, Woolfolk Hoy and Hoy 1998; Woolfolk and Hoy, 1990; Woolfolk, Rosoff and Hoy, 1990; Woolfolk Hoy and Davis, 2006). It also shows that teachers’ behaviours, such as willingness to take a risk, persistence in tasks and the use of innovation are related to the degree of self-efficacy in individual teachers Compared to teachers who doubt their efficacy, teachers with a good sense of self-efficacy are more inclined to appreciate other school constituents' contributions to the functioning of the school, to view the principal, colleagues, staff, students and parents as behaving in accordance with their obligations, and to perceive the whole school as a system capable of pursuing its mission (Goddard et al. 2004; Takashi 2011).

Previous research has also found that teachers' sense of efficacy is related to their satisfaction with their choice of profession and their competence as rated by school superintendents (Trentham, Silvern, and Brogdon 1985). A strong sense of teacher's self-efficacy promotes a firm commitment to the profession and collaborative relationships with colleagues and parents (Coladarci 1992; Hoover-Dempsey, Bassler and Brissie 1992; Imants and VanZoelen, 1995), contributing fruitfully to the promotion of a rich and stimulating learning environment. Recent findings have shown that teachers' self-efficacy beliefs have a crucial role in affecting and sustaining their commitment to school and their job satisfaction (Caprara et al. 2003; Caprara, Barbaranelli, Borgogni, and Steca, 2003). It is likely that job satisfaction accompanies teachers' sense of efficacy and contributes towards sustaining their efforts in pursuing children's optimal scholastic attainments.

2.2.4 Summary

In general, TSE belief is rooted in a view that individuals are agents that are proactively engaged in their own development and can make things happen by their action (Pajares 1992). Thus, within the context of social cognitive theory, self-efficacy belief is able to determine teaching performance based on the perceived judgement of capabilities to organise and execute courses of action required to attain designated types of performance. Bandura's self-efficacy theory suggests that outcome and efficacy expectations are differentiated by two factors.

i) The judgement in personal capability to execute courses into action (self-efficacy)
ii) The judgement in the consequences lead by the action (outcome expectancy)

In the development of the concept underpinning TSE measure, it seems that Bandura's definition of self-efficacy can meet the concept of TSE belief as goal-directed and task-specific. This was well portrayed in the literature of the TSE measure in science teaching within the two factors that reflected the factors of self-efficacy and outcome expectancy.

The evidence supports the role of TSE in the area of student learning and teacher performances. TSE measures point significant impacts on the teacher's professionalism. It seems that the concept of the existing TSE measure is concurrently similar to the theory of Bandura's self-efficacy. Thus, the TSE concept is chosen as a fundamental concept to be used in developing an instrument which has the possibility of predicting teacher behaviour in teaching practice. The next section will explore the conceptual framework used in the study.

2.3 Theoretical and conceptual framework of my study

The study aims to develop an extensive model of TSE measures in the context of teacher education, focusing on the use of science inquiry skills in the classroom as a way of supporting student learning in science. This section will highlight the two concurrent concepts used in this research framework: teacher knowledge, and TSE.

Firstly, I drew on a broader literature of teacher knowledge with the rationale to explore the importance of teacher knowledge in teacher education development. Next, I look into the prominent model of TSE measures and explore contemporary literature about the role of the knowledge factor in measuring teaching development using TSE belief. Finally, the convergence of characters in teacher knowledge and in measuring teacher's practice in TSE are used to develop a construct of my study using the three important elements in PST development.

2.3.1 Theoretical review of teacher knowledge

According to Shulman (1986, 1987), effective teaching practice requires the development of teacher knowledge in the areas of i) content knowledge, ii) professional knowledge of teaching (i.e. general knowledge related to historical, philosophical and psychological aspects of schooling, students and education), iii) pedagogical knowledge (i.e. general effective teaching concept, theories and research) and iv) pedagogical content knowledge (PCK) (i.e. the teaching method used in subject learning). This knowledge is developed in a teacher preparation programme with the aim for the prospective teachers to become '*knowledgeable about subject matter and pedagogy and who made decisions, constructed responsive curriculum, and knew how to continue learning throughout the professional lifespan'* (Cochran-Smith 2004, p. 296). Teachers should be equipped with the base teacher knowledge during teacher training in order for them to perform teaching practice specifically and flexibly in subjects with different contextual, situational and personal influences professionally.

Among the four areas of teacher knowledge mentioned above, the concept of PCK is largely used as the teacher knowledge model for the teacher education programme. Abell (2008) and Kind (2009), in their review articles on teacher knowledge, argue that this concept is widely accepted as standard professional knowledge. PCK indicates the unique domain of knowledge for teaching in a specific context.

In the context of science learning, PCK is the knowledge of instructional strategies used to make scientific concepts comprehensible to the students by using specific teaching strategies (van Driel et al. 2014). PCK connects knowledge and practice with the two dimensions of teacher knowledge (i.e. instructional knowledge and content knowledge), upon which PSTs will cognitively construct their action behaviour in teaching (Cochran-Smith 2004). Both of these studies agree with Shulman (1987), that PCK distinguishes the understanding of the content specialist from that of the pedagogy; and differentiate a scientist's knowledge from a science teacher's knowledge.

2.3.1.1 Pedagogical teacher knowledge to measure teaching practice

In the science education field, there are considerable efforts to identify and measure a teacher's knowledge that PSTs bring to classroom practice. Park et al. (2011) have developed a quantitative measure of PCK in teacher practice. The instrument developed has used two components from PCKs: instructional knowledge, and content knowledge. These dimensions are validated and suggested as the factors upon which PSTs will cognitively construct their action behaviour in teaching (Park et al. 2011). It is argued that PCK is concerned with the way that subject matter knowledge is transformed from the mind of teachers into instruction for the teaching task requirement.

In the effort to develop a model for a new teachers 'professional vision', Seidel and Sturmer (2014) have used a video-based instrument to assess the classroom practice from PSTs' perspective. The study model suggests that teachers' professional practice can be inferred through the cognitive process of PSTs. The empirical evidence in the study shows that PSTs have the ability to predict the quality of teaching instruction in the given teaching task (in the video-based instrument). Their judgement about the requirement and goals are influenced by knowledge, belief and experience perceived by PSTs during their teacher training programme. It is concluded that the PCK may underpin the element of prediction that contributes to PSTs' professional practice view.

Further, in assessing teachers' professional enhancement in teaching primary science, Hafizan et al. (2012) conducted a survey of 329 primary teachers in Malaysia to measure their SPS teaching performance in relation to their knowledge of SPS content. The results of the survey indicated that the teacher competency level of SPS is good at the practical stage of SPS but not conceptually. This empirical data support the conclusion given by van Driel et al. (1998) in the grounded theory research among 12 science teachers with more than five years of teaching experience in teaching chemical equilibrium. The research showed that teachers develop their PCK in the classroom with their own knowledge from everyday practices. This explains why teachers can perform well in the classroom without the full understanding of the concept, as obtained from the survey study of Hafizan et al. (2012).

However, performing well in a classroom with limited knowledge of SPS will not allow teachers to explicitly teach SPS in the classroom. According to the study by Harlen and Holroyd (2007), teachers with a lack of knowledge in the science and technology subject area have employed instructional knowledge using various teaching strategies for coping. These teaching practices, when applied regularly have severely limiting impact on the students. Thus, it shows that the two elements of PCK, i) instructional knowledge and ii) content knowledge are needed to complete teachers' knowledge and allow teachers to explicitly teach SPS in the classroom.

The abilities in teaching practice refer to how PSTs think and translate their knowledge in the context of teaching in classrooms. These abilities seem to be a consequence of the way they develop their PCK (as shown in Magnusson et al. 1999; Loughran et al. 2008; Berg 2009; Park et al. 2011). Targeted instruction in a specific content area, through a good practice of PCK, can enhance a teacher's confidence in delivering meaningful lessons, thus increasing self-efficacy. Greater teacher self-efficacy results in not only more positive attitudes about teaching but also a higher level of confidence in specific content teaching abilities (Guskey 1984). The next section will explain and justify the factors involved in the study and provide a framework for the study development measure of SETSIS, which is used to infer performance in teaching practice.

2.3.2 The integrated model of TSE

Self-efficacy is chosen to portray the possibility of predicting teacher's behaviour in teaching practice from a complex belief of cognitive factors. As mentioned above, Bandura's self-efficacy theory holds on to the relationship of outcome expectancy as a basis for predicting the capability of a person to perform a certain level of behaviour. However, there is evidence showing that the two factors influence each other. Trying to overcome the issue, the prominent study of Tschannen-Moran et al. (1998) in teachers' self-efficacy identified the two distinctive factors as self-efficacy determinants in their teacher efficacy model in Figure.

In the integrated model of teacher efficacy, Tschannen-Moran and colleagues cognitively analysed the interrelation of the two factors that emerged in teacher efficacy measures. They suggested analysing teacher tasks (outcome expectancy) and assessing personal competence (self-efficacy) within the specific context of teaching. The component of analysing the teacher task assesses the strengths and weaknesses in relation to the requirements of the task. It indicates a reflection on a general belief about teaching effect in a specific context rather than to measure likely consequences of action (Hoy and Spero 2005). Further, the second component, assessment of personal teaching competency, assess personal capabilities in traits that are used to balance personal weaknesses in order to execute particular courses of action (Bandura 1977; Tschannen-Moran et al. 1998). The interaction between these two factors emerges in most of the self-efficacy instruments and is widely used to form a judgements about self-efficacy for the teaching task at hand.

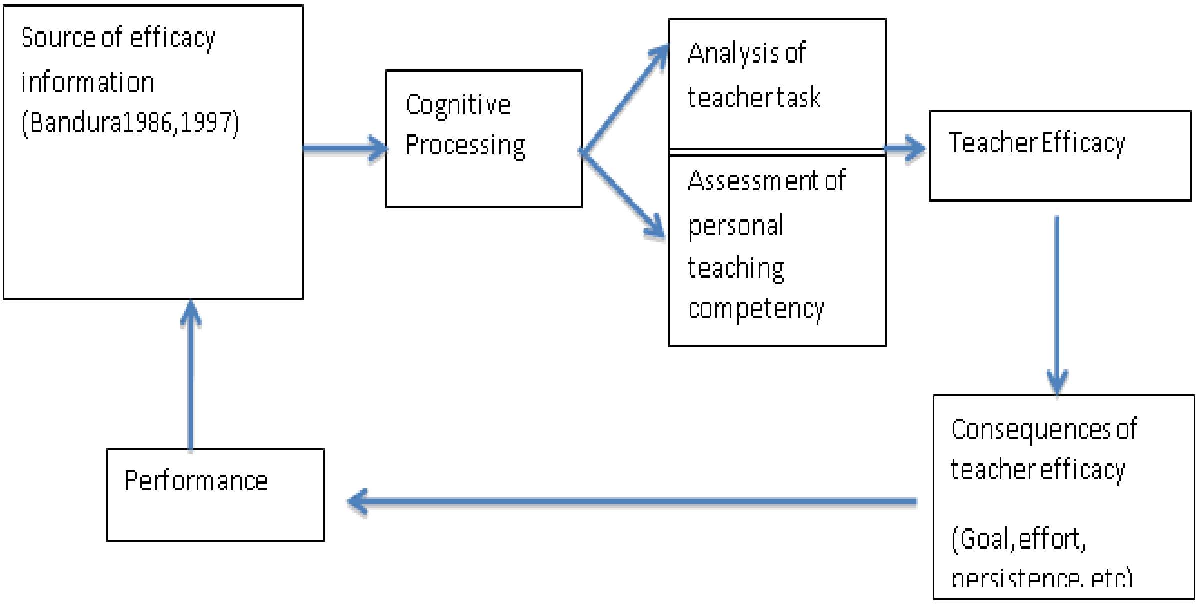
In their conceptual model of TSE belief, the first component is a judgement as to whether the person is able to organise and execute the necessary action to accomplish a specific task at the desired level. It derives from the cognitive process of assessing personal capabilities, such as skills, knowledge, strategies and personal traits, which corresponds to the self-efficacy factor of Bandura. In the study this component will be referred to as the PTE factor, which reflects self-efficacy in the personal trait of teaching practices based on the judgement in the capability of executing teaching practices/activities using science inquiry skills in the classroom.

The second component develops from the cognitive process of analysing a teaching task and its context. In the study, the second component refers to the outcome belief efficacy (OBE) corresponding to the outcome expectancy of Bandura within the specific task of teaching using science inquiry skills. The factor OBE in this study assesses the likely consequences from the action done based on specific tasks on PTE. Both of the dimensions result from the cognitive process of integrating information from sources into the analysis of judgement of favourable teaching practices using science inquiry skills in classroom teaching.

Figure 3 illustrates the cyclical nature of a conceptual model of teacher efficacy measuring. This model features a comprehensive model that was claimed to capture the goal-oriented, task and context-specific nature of TSE belief (Bandura 1996). This model recognises that the teacher assesses their self-efficacy beliefs through analysing the teaching task and its context in relation to their self-perception of competence (i.e. the skills, the knowledge, strategies and other cognitive and affective resources in that particular context). The self-efficacy then determines the behaviours teachers produced in various goals or restraints.

Besides reconciling the theoretical issue and operational definition of self-efficacy in the measurement model, this integrated model attempts to hold constant while emphasizing the specific task in the phrases. The aforementioned sources of self-efficacy suggest that teachers' behaviours in classrooms can be highly influenced by their own perceptions of their ability to teach (i.e. PTE) as well as the belief that their teaching strategies would be effective (i.e. OBE). The influence of environmental and behavioural factors such as belief, knowledge and practice have such weight in behavioural decisions and need to be mentioned within task and domain-specific (Bandura 1986).

Figure 3 Interaction of teachers' cognitive processes which results in teachers' efficacy judgments (source: Tschannen-Moran, Hoy and Hoy (1998))



This integrated model of teacher efficacy holds some promise for operationalising self-efficacy in a way that is independent of outcome expectancies and thus consistent with self-efficacy theory. This efficacy information in the specific context of a teaching task can influence how teachers translate their knowledge understanding into teaching performance in the classroom (Tschannen-Moran and Hoy 2007). Thus, the factors that emerged from the model were used as part of the study of the SETSIS measure. The next section reviews the literature on the emerging role of knowledge efficacy (KE) in TSE measures.

2.3.2.1 The role of knowledge in the TSE belief measure

Self-efficacy belief is an important issue for primary PSTs. Researchers have found negative experiences in science subjects during schooling developed a poor attitude towards science teaching practices (Pajares 1992; Wolf-Watz 2000). Poor science knowledge also contributes to a lack of ability in teaching primary science subjects. PSTs with poor ability in teacher knowledge (content knowledge and practice) can be expected to teach science poorly using reading- and writing-based strategies or avoiding it altogether (Allinder 1994; Harlen and Holroyd 2007; Rauf et al. 2013).

Research has found that science content knowledge in teacher education courses is able to lift the effect on PSTs’ confidence to teach science (Deehan, Danaia and McKinnon 2017). A well-planned model of science teaching courses can develop positive changes in self-efficacy of teaching. The positive consolidation of the effects in self-efficacy can also be enhanced with teaching practice (Hudson, Skamp and Brooks 2005; Palmer 2006). Assessing perceived knowledge about teaching should be considered for the TSE measure as this factor has shown it can contribute in the development of the TSE measure.

Further, in criticising the limitation model of Tschannen-Moran et al. (1998), Fives (2003) refutes, as the model was depicted, that the cognitive processing of psychological sources takes place prior to the assessment of personal abilities (skills, knowledge and others cognitive and belief systems) and that there is no interaction between the sources and teacher’s knowledge and belief (refer to Figure). He argues that the model was not able to connect the sources of experiences with a teacher’s beliefs about teaching knowledge from their experiences. Thus, this model required additional factors that can address interaction in belief and teacher’s knowledge experiences.

Pajares (1992) describes the connection between belief and knowledge as highly complex and intricate and discusses that belief corresponds to a filter through which new knowledge is interpreted. Bandura (1986) conceptualises the role of self-efficacy as fostering action as well as ‘a filtering mechanism for self-referent information in the self-maintaining process’ (p.356). Drawing from both, TSE belief can be described as mediating between knowledge and action (Fives 2003). It seems that the knowledge factor can be seen as an important factor of the TSE belief measure.

Moreover, the spiralling cycle of the model has been described by Wheatley (2005, 2002) as implausible. The model was described as the greater efficacy leading to greater effort and persistence, and the reverse is also true. Wheatley argues that the model fails to incorporate the idea of experiencing low efficacy can support development in self-efficacy. He explains that teachers need to experience doubt to reflect and learn to help overcome low self-efficacy belief. Thus, Wheatley (2001) suggests that the extensive model of TSE measures should account for the factor in teacher learning; thus, self-efficacy doubts measured through the model can be beneficial to support teacher education.

Further, Wyatt (2014) argues that the concept and definition of the existing model of TSE quantitative measure was rather confusing. Tschannen-Moran and Woolfolk Hoys (2001) defined task-specific as what teachers actually do to bring about desired outcomes in students' engagement and learning, and yet, as TSE belief is task-specific, it should be the teacher's individual belief in their capability to perform specific tasks at a specific level of quality in a specific situation (Dellinger et al. 2008 in Wyatt 2014). It was suggested that the TSE belief measure should take the contrary perspective to Tschannen-Moran and Woolfolk Hoys (2001) in developing TSE belief of quantitative measure. He insists that the measure should be developed as an agent-means definition (i.e. belief about ability to take actions) rather than an agent-ends definition (i.e. ability to bring about desired outcomes).

This insight gains supports with empirical evidence in teaching practices of PSTs from Settlage et al. (2009) and Wyatt (2010). In his report, Settlage reports of PSTs who held inexperience with science teaching practice in the classroom but held high levels of confidence in their prior methods courses blinded them to the self-doubt that might benefit them professionally. Thus, self-efficacy doubt related to performance on specific tasks can be beneficial with reflection to the related learning factors as then learning can be improved. This means, by incorporating important elements of teaching development (i.e. knowledge, practice and belief) the TSE measure model can produce beneficial outcome information in teacher knowledge development.

2.3.3 Summary

Instead of using two components, PTE and OBE, as indicated in the prominent model of TSE reviewed above, this study included KE in measuring self-efficacy in teaching using science inquiry skills. The SETSIS adapts a contemporary definition of the TSE model originated in Tschannen-Moran et al. (1998) with the addition of the knowledge component of KE. The study indicated KE as additional to SETSIS because it was important to acknowledge PCK as professional knowledge experiences that underpinning PSTs' teaching performance. The items will be revised in Chapter 4 to reflect the process-oriented teaching approach in the science classroom.

The SETSIS reflects the model of TSE in specific tasks of teaching using science inquiry skills. As Germann (1994) claims, through inquiry experiences, teachers help students not only to learn about science but also to think logically, ask reasonable questions, seek appropriate answers, and solve daily problems. The measure from the instrument assumes to indicate the characteristics for successful implementation of teaching with science inquiry skills instruction in a classroom of prospective science teachers.

Measuring the self-efficacy in teaching science inquiry skills will not only yield the expectation that potentially could project into a performance but can also project a teaching development in PST’s education. In order to validate the self-efficacy, the belief measure can align with teacher knowledge development in PSTs, the study includes evaluation of the SETSIS with measures of two components of teacher knowledge. The SETSIS, developed as a belief component assessment, would be tested with the two-measure component of teacher knowledge, which is a knowledge test (Shahali and Halim 2010) and teaching practice assessments. Theoretically, these two components would have a positive relationship in the TSE measure as mentioned by Bandura’s theory of cognitive social learning. The next section explores the significance of the study conceptual based on the existing literature.

2.4 Study construct and conceptual model

The SETSIS is developed to reflect on the self-efficacy in regard to teaching science using SPS with three contributing factors that emerge from measures of self-efficacy in teaching science. These factors will be represented by three dimensions, which are knowledge efficacy (KE), personal teaching efficacy (PTE), and outcome belief efficacy (OBE). The following section will review the concept and meaning of the study’s dimensions used in the existing teacher self-efficacy measures. Further, this section will explain the conceptual model used in the development of SETSIS based on the literature explored.

2.4.1 Knowledge Efficacy (KE)

The knowledge efficacy (KE) scale has been first employed along with the PTE scale in SETAKIST (Roberts and Henson 2000). KE was one of the attempts to re-develop the outcome expectancy scale, due to the issue of instability in factor structure argued in section 2.2.2 above. Roberts and Henson (2000) proposed a measure of science teacher’s self-efficacy to be looked at from the perspective of PCK (Shulman, 1986), consisting of instructional (pedagogy) constructs and knowledge of subject matter construct. In the study, the KE scale is introduced to represent the self-efficacy towards subject matter knowledge, while the remains PTE scale (from the Teacher Efficacy Scale of Gibson and Dembo (1984)) reflects the instructional efficacy. The study analysis of the sample of 274 science teachers who were involved in training had confirmed that knowledge efficacy is one of the two components in a science teacher’s self-efficacy measure. The confirmatory factor analysis yielded the two-factor model have a good fit to the data (CFI = .937, NFI = .876, TLI = .927, GFI = .917, RMSEA = .057). Thus, Roberts and Henson (2000) emphasize that the KE complements the PTE by concentrating ‘*the concept of content knowledge is part and parcel with….teaching ability’* (p.12).

In their project of evaluating teacher professional development, Pruski et al. (2013) revised items wording and response format of SETAKIST (SETAKIST-R) in order to measure science teacher's self-efficacy component. The analysis on data collected from 334 science teachers that attended a teaching conference confirmed KE is one of the two factors that fit the measurement model, which is consistent with the two-factor model suggested by Roberts and Henson (2000). However, Pruski et al. (2013) suggest further research in item development in order to capture the entire range of underlying dimension of KE.

Self-efficacy in knowledge (KE) may influence the development of learning conceptual as well as instructional approaches used. The belief about the nature of knowledge and knowledge acquisitions has been addressed in many studies into epistemology belief in teacher education (Aypay 2010; Cheng et al. 2009; Ravindran et al. 2005; Schommer 1990). In an empirical study among Hong Kong PSTs, Chan and Elliott (2004) revealed that PST's belief about knowledge has a significant impact on their concept of learning. PSTs' belief in learning effort and process has a significant relationship to the conceptions of learning to understand and learning as a means to an end, which is expected to bring success in academic achievement. The study suggests that the perceived belief is a ramification on PSTs' aforementioned knowledge in teacher education programmes and are expected to continue as well in their future classroom teaching practice (Chan and Elliott, 2004). Thus, the evidence gives sufficient conceptual ground to support KE as one of the factors in self-efficacy, to some extent still used to predict certain behaviour in teaching practice.

2.4.2 Personal Teaching Efficacy (PTE)

Many researchers associated PTE with self-efficacy construct (Zimmerman et al. 1992; Robin & Henson 2001; Smolleck et al. 2006; DeBacker et al. 2008). PTE reflects Bandura's definition of self-efficacy (Bandura 1977, 1996, 2006). PTE has been constructed with items that asked about current competency (e.g. *when I teach science, I possess the ability to allow students to devise their own problems to investigate* (Smolleck, Zembal-Saul and Yoder 2006)), current functioning (e.g. *I generally teach science ineffectively* (Riggs & Knochs 1990)) and future potential (e.g. *If a student did not remember the information I gave her in a previous lesson, I feel assured that I would know how to increase her retention in the next lesson* (Tschannen-Moran, Hoy and Hoy 1998)).

In RAND studies (Rotter 1966), PTE is associated with the internal scale of teacher efficacy. Internal scales were measured more in teachers' specific and individual accomplishments rather than the accomplishment in general. This factor is expended in much research of teacher efficacy (Toland & Usher 2015; Barros et al. 2010;

Robin and Henson 2001; Riggs and Enochs 1990), where PTE has been used to predict teacher's behaviour with the most accuracy. However, researchers have constructed PTE differently from the self-efficacy described by Bandura (1977).

As a form of self-efficacy construct, PTE associated with a prediction of the capability in designated future performance. Thus, the PTE assessment should not be presented in present performance or past functioning (Pintrich and Schunk 1996 in Tschannen-Moran et al. 1998). However, in order to assess a judgement of future capability Tschannen-Moran et al. (1998) suggested that PTE is used in order to assess personal teaching competence rather than self-efficacy.

In the integrated model of teacher efficacy, Tschannen-Moran et al. (1998) suggest that assessment on personal competence with teaching tasks reflects PTE. Thus, to measure the teacher's self-efficacy, PTE should be developed with items that assess self-perception of teaching competence and an individual's judgement on their current ability and strategies in regards the teaching task. Self-perception of teaching competence assesses the perception of current functioning, that contribute to the prediction of future capability. Besides, an individual's judgement on the current ability and strategies can assess the level of perceived competence in order to meet the demands of a particular teaching task.

2.4.3 Outcome Belief Efficacy (OBE)

The OBE was first introduced by RAND's researchers in teacher efficacy measure (Armor *et al.*, 1976) known as GTE. In the RAND instrument that used Rotter's theory of social learning (Rotter 1966), teacher efficacy was conceived as the extent to which teachers believed that they could control the establishment of their own action under the two factors: internal and external factors. GTE was defined as a teacher's belief in the power of external factors (e.g. values placed at home in students, students' social and economic factors and students' emotional and cognitive needs) compared to the influence of teachers and schools.

Later, Bandura (1977) uses social cognitive theory to introduce outcome expectancy in self-efficacy theory. He proposes outcome expectancy as the second kind of expectation that gives the predictive power of the first expectation, which is self-efficacy. As self-efficacy is about the perceived belief in the capability to perform tasks at an expected level, the outcome expectancy can add more predictive power through assessment to the extent of the performance produces a desirable outcome at the expected level. When applied to the study of teacher self-efficacy, Gibson and Dembo (1984) define that "teachers who believe student learning can be influenced by effective teaching (outcome expectancy beliefs) and who also have confidence in their own teaching abilities (self-efficacy beliefs) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback other than teachers who have lower expectations concerning their ability to influence student learning" (Gibson and Dembo 1984, p. 570).

Attempting to draw the reconciling of RAND's teacher efficacy measure conceptual and Bandura's self-efficacy theory, Gibson and Dembo (1984) suggested GTE as a second factor to reflect the outcome expectancy in their teaching efficacy instrument (i.e. Teacher Efficacy Scale). They describe outcome expectancy, essentially referring to GTE at the degree in which teachers believe that environment (external factors) could be controlled, thus labelling it as teaching efficacy. Further to that, Riggs and Enochs (1999) use GTE in their science teachers' efficacy measure, STEBI. They explain that GTE is an expected outcome to be accomplished that an individual teacher could expect from their own teaching. Therefore, they have labelled this factor as Science Teaching Outcome Expectancy .

In an effort to clarify the meaning of the self-efficacy construct in teaching effectiveness, Tschannen-Moran et al. (1998) draws a new meaning to GTE from the integrated model of teacher efficacy. Their model proposes an element of task analysis that evaluates specific elements based on the teaching situation. This element in OBE related concept of GTE introduced, but different in the way that it refers to the assessment of the four principal sources in the teaching environment. This is consistent with the concept of reciprocal causation in self-efficacy, in which teacher's self-efficacy belief stems from the dynamic relationship of environment, behaviour and personal factors (Bandura 1997).

In summary, the OBE factor is the analysis of belief in teachers' task within its context, which assesses the strengths and weaknesses in relation to the requirement of the task. Hoy and Spero (2005) in their study found that OBE rose during teacher training but fell during the first year of teaching experience due to lack of support. It indicates a reflection on the general belief about the teaching effect in a specific context rather than measuring the likely consequences of an action. Thus, the OBE in this study represents the belief in the teaching effect in regards of teaching science process skills.

2.5 Summary

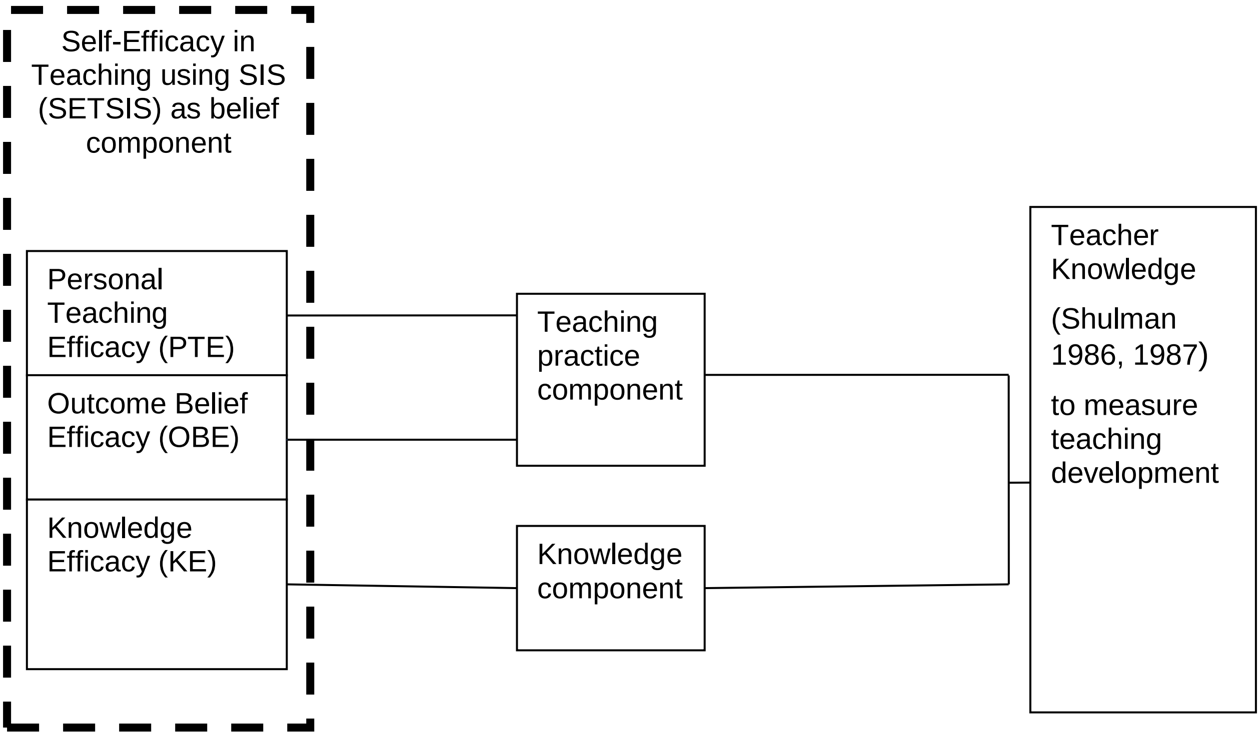
The above review acknowledges the possibility of inferring teaching practice of using science inquiry skills by using a self-efficacy belief concept. The SETSIS was developed to measure self-efficacy in the particular context of teaching science using science inquiry skills. Accordingly, the project proposed will make several noteworthy contributions.

The three self-efficacy subscales – KE, PTE and OBE – used to provide additional dimensions to the existing models of teacher efficacy measure. The most teacher self-efficacy assessments model most used were commonly reflected in the two factors of self-efficacy: PTE and OBE (Bandura 1977; Gibson and Dembo- 1984; Enochs and Riggs, 1990; Tschannen-Moran and Hoy, 2001). Later, a substantive study relating to the model of self-efficacy teaching and knowledge for science teachers was developed (Roberts and Henson 2000; Henson 2001; Pruski *et al.* 2013) and claimed that teacher efficacy should study the basis of teacher knowledge (Shulman, 1987) within the two correlated factors: KE and PTE. Realising the important outcome expectancy measure to self-efficacy (Bandura 1977), this study initiated the extensive model of SETSIS, using the three factors KE, PTE and OBE - into the model of self-efficacy teaching and knowledge for science teachers.

Figure 4 shows the conceptual framework for the study. This study used the belief concept of TSE to align with the concept of teacher knowledge use in pre-service education. PTE and OBE refer to the adapted model of TSE belief introduced by Tschannen-Moran et al. (1998). These two factors represent self-efficacy in one of the two PCK dimensions (Shulman 1986, 1987; Park et al. 2011), which is instructional knowledge (i.e. practice). Meanwhile, KE represents self-efficacy under the dimension of content knowledge, which is also proposed by Shulman (1986) and Park et al. (2011).

PTE emerges from the cognitive process of judgement on the capability of personal action through the instructional knowledge of using science inquiry skills in classroom teaching practice. Further, OBE is developed from the cognitive process of analysing the outcomes of an instructional task and context based on beliefs held by the PST. On the other hand, the KE represents the self-efficacy of the content knowledge of using science inquiry skills that is defined by the ability to use a collection of science process skills to plan teaching instruction. The KE dimension develops in order to propose the essential PCK in order to infer teacher practice from the knowledge of science inquiry skills (Park et al. 2011).

Figure 4 Conceptual framework for the study



It is believed that teacher self-efficacy and PCK should be measured within the specific context (Tschannen-Moran any Hoy 2001), but what and how specific the level of the context still needs to be developed. Thus, this project will measure teaching self-efficacy in the context of teaching science inquiry skills because of the important role of science inquiry skills, which has been explained in the introduction chapter. Research on the self-efficacy of PSTs would provide teacher educators with essential information on the perceived knowledge, which is useful in helping them develop a more balanced view of PCK in the implementation of a reformed science curriculum. Moreover, by understanding the self-efficacy factors that might influence prospective teachers in deciding on specific teaching tasks in the classroom, might help teacher educators to influence their trainees more into a better model of teaching using science inquiry skills.

The project now provides a link between three important key factors in TSE belief development: self-efficacy in knowledge (KE), self-efficacy in teaching practice (PTE) and expectancy belief about the teaching outcomes (OBE). The SETSIS measure only yields the expectation that potentially could be projected into performance. These three components of self-efficacy belief lead to inferring teaching practice developments using the two components of teacher knowledge assessment.

In order to validate the study measure, the study included two measure components of teacher knowledge. The SETSIS, developed as a belief component assessment would be tested with the two measures component of teacher knowledge which is a knowledge test (Shahali and Halim 2010) and teaching practice assessments. Theoretically, these two components would have a positive relationship with TSE measure as mention by Bandura's theory of cognitive social learning. The following chapter will demonstrate the method and research design plans to meet the purpose of the conceptual framework above.

Chapter 3 Methodology

3.1 Introduction

This chapter focuses on the research design and methodology of my study. The aims are to describe the research design and provide justification for the methods used in the study. The next section, 3.2, presents the research objectives and questions for the study. Then, section 3.3 explains the research design and sampling method with an emphasis on the instrument development procedure using construct measure approach (Wilson, 2005). This is followed in section 3.4, which explains the research methods and describes how these were employed in the study. Section 3.5 describes the instrument s used during the research field and section 3.6 describes the data collection phases, which I covered while being in the research field. Finally, section 3.7 discusses the steps taken to enhance the quality of this study.

3.2 Research objectives

My research focuses on developing and validating a defensible measure to assess primary science PSTs' self-efficacy in teaching using science inquiry skills, and to analyse the resulting data from this instrument and a range of other sources. The aim is to build a measurement model that seeks to explain the three dimensions (knowledge, belief and practice) underpinning the three variables of self-efficacy in teaching using science inquiry skills, and most importantly, focuses on those three variables that need to be assessed in order to claim a valid measure of potential ability in teaching science using science inquiry skills. The specific interrelated goals of this study are as follows:

1. To define and conceptualise self-efficacy in teaching using science inquiry skills based on the concept of teacher self-efficacy in teacher knowledge development
2. To determine the psychometric qualities of the development measure of Self-Efficacy in Teaching using Science Inquiry Skills inventory (SETSIS)
3. To operationalised and develop psychometrically defensible measures for the SETSIS model
4. To evaluate the measure of SETSIS with other related measures (e.g. test of SPS and practical assessment)

3.2.1 Research questions

This study is designed to answer the following research questions (RQ):

1. What are the belief factors of self-efficacy in teaching using science inquiry skills?
    - The focus of this question is to define and justify the theoretical construct of the SETSIS: how well the selected factors are able to interpret and represent the construct of belief when measuring self-efficacy in teaching using science inquiry skills. This is the initial process of developing the instrument. This phase includes the literature review as the main source of the interpretation and justification of the theoretical construct of the SETSIS that is used to measure the belief of self-efficacy in teaching science using science inquiry skills. On the other hand, the theory justification is also used to define the variable factors and limitations. Once defined, the items pool are selected based on the observable attributes relative to the defined factors' characteristics (Veal and MaKinster, 1999a; Wilson, 2005). Chapter 4 will report the answer for the RQ.
2. What are the psychometric properties of the SETSIS when used with PSTs in Malaysia and to what extent are the selected factors of self-efficacy in teaching using science inquiry skills (i.e. belief in personal knowledge (KE), belief in personal practice (PTE) and belief in outcomes expectancy (OBE) related?
    - The methods and analysis for the responses data are used to justify the reliability and validation of the SETSIS. Statistical evidence is used to explore the degree of correlation across the three factors defined in RQ (1). Chapter 5 will report the statistical results in answering this RQ.
3. To what extent can a valid measurement model of teachers' self-efficacy in teaching using science inquiry skills to be constructed based on the selected subscales (KE, OBE and PTE)?
    - This part will evaluate the selected subscales' responses in the model of self-efficacy in teaching science using science inquiry skills and validate the measurement model of RQ(1).

4. To what extent are the different subscales (i.e. KE, PTE and OBE) valid and reliable in measuring self-efficacy in teaching science using science inquiry skills among pre-service science teachers in Malaysia?
    - Analysis of the inter-item validity of the selected factors in order to evaluate the empirical evidence that reflects the construct process. The score interpretation for every subscale should be rationally consistent with the construct task, which is to infer self-efficacy in teaching science using science inquiry skills. This part will examine the inter-item relationship to validate the internal structure of SETSIS using the Rasch model.
5. To what extent does a valid measurement model of SETSIS relate to other components of teacher knowledge assessment in teaching science among PSTs?
    - The generalizability/ correlation of the score of the SETSIS measure (as the belief factor) with related external/other measures (i.e. tests in the knowledge of SPS and teaching practice assessment) will be assessed in terms of the relationship between the selected factors in teacher knowledge development (i.e. knowledge, practice and belief).

Table 3 shows the data source(s) for every research question mention above.

Table 3 Data sources for every research question mention

Data source	RQ1	RQ2	RQ3	RQ4	RQ5
Literature	■		■		■
Existing instruments (Tschannen-Moran, Hoy and Hoy, 1998; Roberts and Henson, 2000)	■		■		
Experts judgement	■				
Data responses in Pre-Test	■	■			
Data responses in Main Research		■	■	■	■
Score responses from Test of Integrated Science Process Skills (TISP)(Shahali and Halim, 2010)				■	
Score attainments from ITE Practicum assessments (secondary data)				■	

3.3 Research Design

This study adopted a multi-method research design. The multi-method design involves multiple types of research methods that are relatively complete on their own and then, used together, form a complete research process (Morse, 2003). Each method in this study was planned and conducted to answer a particular sub-question, and the results were used and triangulated to form the whole study.

The study was designed to comprise three phases. Phase one focuses on pre-development of the SETSIS, which includes the process of constructing the SETSIS. Phase two of the study focuses on developing the SETSIS using the data collected in the main research. Phase three in the study consists of much of the analysis of the validation and evaluation of the SETSIS. The three phases were interrelated in the process of completing the study. Figure 5 illustrates the overview of the study design.

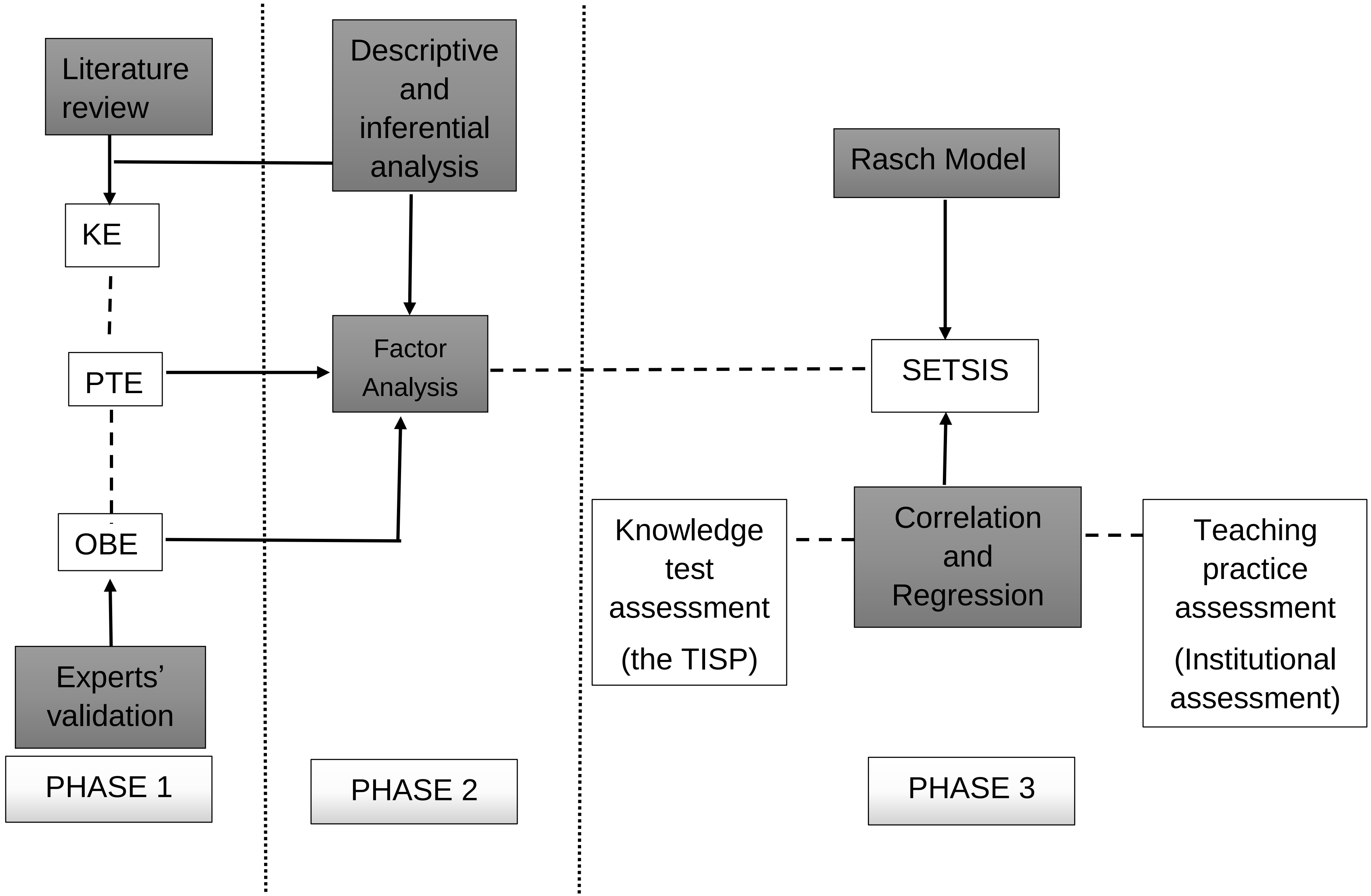
The first phase of the study used a theoretical approach to identify the concept to be used in the SETSIS. The concept was then reflected in the construct framework of the SETSIS using the three factors of self-efficacy (i.e. KE, PTE and OBE). The construct framework was used to guide the next processes of the project. Although there is a strong theoretical rationale in describing the construct framework for the SETSIS, the meaning of the factors in the construct should be validated in the representation of content and need to be empirically grounded. Thus, the first phase of the study incorporated a panel of experts' judgement screening all the items designed for the SETSIS. This approach was utilised to get practical insight from the experts in validating the content design of the SETSIS. Then, the pre-test survey and small group interview were used to gather empirical data on the content relevance and representatives of the items in the emerging SETSIS. The results from the pre-test were used to answer RQ1 and to inform the second phase of the study.

The second phase of the study involved main research data collection. Drawing on the theory and research evidence, together with the practical insights of the experts and a sample of respondents, the main SETSIS instrument with 72 items was used in the main research. It involves 325 science PSTs from 12 campuses of ITE all over Malaysia. The main data collection consists of two surveys, conducted on the same participants using two different instruments. The first survey was to obtain responses in assessing self-efficacy belief in teaching using science inquiry skills with the developed SETSIS, and the second assessed knowledge performance on a set of integrated science processes associated with science inquiry skills using the Test of Integrated Science Process Skills (TISP) for the purpose of answering RQ5. An empirical approach was employed on the main research data from the developed

SETSIS. Quantitative methods were used to produce statistical evidence to develop a reliable and valid assessment for RQ2. Factorial analysis was also used to determine the empirical evidence that might support the validity of the SETSIS structure and the consistency with the theoretical interpretation (i.e. RQ3).

The third phase of the study focuses on the validation of the SETSIS. An empirical approach was employed for the same data from the main research using the finding model of SETSIS from the previous phase. The Rasch model (Bond and Fox, 2007) was used to identify the psychometric properties (i.e. item and person fit indices) in order to explain the model of SETSIS. Next, the analysis mapped the ability-difficulty on the same scale, which identifies the distance between responses and respondent on the construct map. The results answer RQ4. Lastly, the outcome from the SETSIS was related to the outcomes of two other teacher knowledge assessments to evaluate the predictive validity of the SETSIS and answer RQ5. The correlation and regression methods were used to model the relation of the SETSIS's outcome to the knowledge-based assessment (i.e. the outcome of the TISP from the main research) and teaching practice assessment (i.e. the outcomes from the institutional assessment). Figure 5 provides an overview of how this study was conducted. During the entire process, participants, as the content experts, were voluntarily recruited through self-approach, and participants in the pre-test and main research were voluntarily recruited through the gatekeepers. The involvement in the main research process is rooted in the assumption that their responses were based on self-assessment to ensure that the SETSIS measure is developed to be as authentic as possible.

Figure 5 Overview of the study phases in development and validation of the SETSIS



3.3.1 Development and validation process

This study adapted the iterative process of a construct modelling approach (Wilson 2005) in the process of instrument development and validation. These elements were integrated into the three phases of the study. The construct modelling approach consists of four building blocks that were used iteratively but not necessarily in sequence throughout the three study phases, as suggested in Table 4. The table shows these four building blocks were designed to integrate into the three phases of this study. These four building blocks are now spelled out in greater details.

3.3.1.1 Building block I - Construct mapping

According to Graziano and Raulin (2000), a construct “is an idea constructed by the researcher to explain events observed in a particular situation. Once formulated, constructs are used as if they are true to predict relationships between variables in situations that had not previously been observed” (p.419). This first building block is used to help the instrument developer to focus on the essential latent factors of what is to be measured, mapped on the construct map. The construct map visualised a consistent definition of the latent variable and ordered the item responses into a series of levels (Wilson, 2005). It can be considered the theoretical framework that guides the instrument’s design. The construct map of the study can be referred to in Figure 6.

The construct mapping was the initial step to determine the rationale for the chosen factors representing the construct of the SETSIS and the significance of the study. A rationale content analysis of the literature text and documents of the BoTP curriculum were used in order to establish the construct mapping and to interpret the factors selected in measuring the construct.

The construct map describes the continuum of the construct from high to low self-efficacy in teaching using science inquiry skills. It was then used to guide the design and development of the instrument. The instrument was developed to describe and define the continuum with qualitatively distinct levels, so it will able to identify the levels of respondents on the construct. The construct map is the important first step in establishing the validity and reliability of an instrument (Brown and Wilson, 2011)

Table 4 Summary of research design of the study

Study Phase	Building block	Construct Modelling	Activity	Method	Research Question(s)
Phase 1 Constructing the SETSIS	I	Construct Mapping	Literature review	Content Analysis	RQ1
			Variable interpretation		
	II	Item design	Items pooling	Fuzzy Delphi Method	
			Experts review of the items		
			Pre-Test using paper & pencil survey		
			Conducting interview for technical qualities of SETSPS.	Focus group interview	
	III	Outcome space	Internal-structure validity for content relevance and representativeness of the scale and establising items mapping	Rasch Model	
Phase 2 Developing the SETSIS	II	Item Design	Establising item mapping and administering the main research for the SETSIS using		RQ2 & RQ3
			Main research using paper & pencil survey		
	III	Outcome space	Establishing the responses to the SETSIS	Descriptive and inferentian analysis	
			Validating the factors contribution with the scales interpretation	Factorial Analysis	
Phase 3 Validating and Evaluating the SETSIS	IV	Measurement model	Developing measurement model and relate back to the theoretical construct of construct map for construct validity of SETSIS	Rasch Model	RQ4
			Evaluate the SETSIS outcome with concurrent validation using i) Knowledge Test Assessment (TISP) ii)Teaching Practice Assessment	Correlation and Regrassion	RQ5

3.3.1.2 Building block II - Item design

Item design is a construction of tasks and contexts that assess the construct. The tasks and contexts were constructed in terms of statements that represent observation, which can stimulate responses about the construct that are generically called items. The items were designed according to three criteria references: high item, mean item and easy item, which provide the interpretation of the item level within the construct. Each level describes characteristics of items that form groups along the continuum of the construct. Further details are described in section 4.4.1.

In this study, item design was included in Phase 1 and Phase 2 of the study. These include a series of decisions to decide items that adequately represented the construct. It started with the item pool, in which the specific items were sampled for the SETSIS and sent for translation process (see the explanation below).

All the items, in both languages, were reviewed by the experts for the purpose of assessing the content validity of the items. The Fuzzy Delphi Method (FDM) was used for analysing the experts' judgement and obtained consensus for the reviewed items. The consensus judgement was then cross-referenced with the relevance and the association of the construct framework.

Then, the resulting items were administrated in the pre-test survey. Using a paper-and-pencil method, this survey aims to get pre-responses from the PSTs in the instrument. Feedback was sought in a small group interview, which consisted of six participants from the pre-test, in relation to the clarity of the items and the overall accessibility of the instruments.

The back-translation technique (Brislin 1970) was used to translate all the sample items of the SETSIS from the source language (English) into the target language (Malay). First, a certified translator with a science education background was chosen to translate the items in forward translation. The two versions were compared and some iterations were made in the target language based on suggestions received from the content experts panel (see 3.6.1) and pre-test survey (see 3.6.2). Then, it was given to another translator for back translation (i.e. back into the source language). The two source language versions were compared and evaluated. There were some discrepancies in the words used, but they had semantic equivalence. The information gathered in Phase 1 was used to sort the items and design the instrument for the main research survey in Phase 2.

3.3.1.3 Building block III - Outcome space

The outcome space was used to study scores and category responses for the measure. Scores from the gathered items' responses were categorized and the scores were the indicators of the construct, which lead to the outcome space (Wilson, 2005). The outcome space corresponds to the development of the scoring scale regarding the observed responses, where the individuals are on the construct map based on the context of the measure. The lower level of the construct should correspond with lower item scores and vice versa. The categories that define the outcome space are qualitatively distinct, and this can be validated with the quantitative evidence.

In this study, the outcome space was initially used during constructing response options in Phase 1. The outcome space was defined in five, qualitatively distinct categories related to confidence levels of self-efficacy in teaching using science inquiry skills (see explanation in section 4.4.2). The categories defined should be represented in the quantitative evidence. Analysis of Rasch model on pre-test data examined unpredictable responses that did not fit the model and at the same time provided pre-information on the quantitative value (i.e. reliability and separation) of responses and the level of response categories (i.e. scoring of item-response categories). This will be further elaborated in section 4.6.2.

Outcome space was also used during Phase 2. In this phase, the process related the mean score from the data observed to the response categories created in Phase 1. The quantitative evidence related the score to the categories proposed and whether the interpretation of the responses could be generalised into the population. Finally, factor analysis (Field, 2013) was used to examine the representation of the items in the construct through the responses' variances. The factor analysis was able to identify key features of the responses in the items. The result of grouping items was related to the construct framework to confirm the representative of the measure.

3.3.1.4 Building block IV - Measurement model

The final phase used the process of measurement model in order to validate and evaluate the SETSIS. Measurement model served as a process to relate scored outcomes and to compare the outcome space to the original construct (Wilson, 2005). The measurement model helps to model individual responses which are then related back into the construct map. Further, it was able to evaluate the score which interpreted the construct and guided the use of the score in practical application.

For this study, in order to validate the SETSIS as a measurement model, the method used should first be able to fit response data statistically and secondly able to validate the characteristics of the model according to the measurement framework (Wilson, 2003). The Rasch model was chosen for the formal measurement model used to validate the model of the SETSIS because it is able to explain response data and provide a probability model able to interpret the continuum between the items and the outcomes of the construct. A scaling approach based on the Rasch model is sensitive to the issue of a broader conception of construct validity (i.e. unidimensionality). The data should be able to validate the model through the construct representative with relevant variance (Messick, 1994). If the data meets the requirements of the model and the model's implications, it contributes to evidence for the construct validity of the measure.

In the final phase of the study, the responses from the main research were used within the contributed items from the factor analysis result. The rating scale model of Rasch was used to validate the data and further characterise the items and responses within the model structure. Next, the responses option was also validated, and the result was used to interpret the probability scored into the estimated true score for practicality purpose. Lastly, the correlation and regression analyses were used to evaluate the scores from the item response in conjunction with the associate knowledge test and practice assessment.

3.4 Research methods

Figure 5 illustrates the study phases and the methods used in every phase mentioned. Phase 1 consists of the two methods used to construct the SETSIS. The literature review was used to signify the three factors chosen to measure the latent variable of the SETSIS. Content validation of the constructed SETSIS was verified using a panel of experts and their consensus was acquired using the Delphi method.

Phase 2 consists of the method used to develop the SETSIS. The data from the main research was analysed using descriptive and inferential statistics for any abnormality and outliers. Then, the data was analysed using factor analysis to confirm the contributed factors in the SETSIS.

Phase 3 involves the methods used to validate the model of measurement in the SETSIS. Using the Rasch model, the data was analysed for content, substantive, structural, and generalisability of the construct. The external and consequential aspects of the construct validity was checked using the correlation and regression method. The methods used in the research is now explained in detail.

3.4.1 Literature review

In the literature review, I used content analysis as the research method, which allows the qualitative data collected in the research to be analysed systematically and reliably so that generalisations can be made from them in relation to the categories of interest to the researcher (Haggarty, 1996). The relationships among concepts that occurred in the contemporary literature of TSE and teacher knowledge in the field of teacher training were studied. The relational analysis was built based on the concepts proposing the framework of the study.

3.4.2 Expert validation

The general perspective of content validation was sought from the experts in the item pool. The aim of the expert validation was to ensure that the SETSIS contained items that related to the construct and that these items were able to discriminate the levels of self-efficacy in teaching using science inquiry skills.

In this method, experts were reviewing the items content in order to

1. evaluate how the content of each item specifies the factor's domain functioning
2. evaluate how the content of each item is tailored to the activity domain and assess ways that self-efficacy operates within the selected activity
3. evaluate how the levels of items reflect the task demands in domain function

However, the expectation was not limited to the above, as this process also aimed to gain a wider perspective from the experts.

A survey consisting of all the item pool was sent out to a panel of experts. The goal of the survey was to gain expert consensus on the need of the three factors (i.e. KE, PTE and OBE) in measuring self-efficacy in teaching using science inquiry skills. In the survey, experts needed to rate to what extent each item measured one of the three factors using a five-point scale (with 1 point being 'entirely disagree' and 5 being 'entirely agree'). The experts were encouraged to provide comments and suggestions for each item or offer their own lists of possible items for each domain. For the survey and the information sheet handed out to the panel of experts, please refer to Appendix A and Appendix E.

Analysis of consensus for the 99 items pooled in the survey was conducted using the Fuzzy Delphi Method (FDM) (Habibi, Jahantigh and Sarafrazi, 2015). This technique uses a fuzzy approach to overcome the limitations of using the traditional Delphi method, which enables summarising and sorting items in one round, compared with the traditional Delphi method.

3.4.2.1 Fuzzy Delphi Method (FDM)

FDM was used to address experts' agreement on items screening in the SETSIS. A single round of the survey was conducted with the ten chosen experts in the field. The criteria used in choosing the experts in this research and their details are listed in section 4.6.1. The experts were given the item pool, and they rated their agreement using the five-point scale (1 to 5) on the items, according to the construct. The responses received from all the experts were entered into the Microsoft Excel computer programme using the score of the five-point scale, and then transferred into the triangular fuzzy spectrum as shown in Table 5.

The fuzzy number spectrum can be used to quantify the ambiguity of responses in forecasting the items with the three-probability spectrum in each score. For instance, experts who scored 5 for agreement on an item were considered to be within a spectrum of 60 percent to 100 percent confident in their agreement. Experts who scored 3 for agreement on an item were considered to be within a spectrum of 60 percent to 20 percent confident in their agreement and experts who scored 1 for agreement on an item were considered to be within a spectrum of 20 percent to 0 percent confident in their agreement. Thus, by converting the score agreement in the fuzzy spectrum, the outcomes are more consistent with explaining the response characteristics of each individual expert within the spectra of percentage of agreement. In every spectrum, the responses given by the experts were converted to a wider range of the percentage agreements (see Table 5). By converting the score into the spectrum, the agreements were more consistent and the consensus among experts was easier to meet.

Table 5 Fuzzy spectrum for five-point Likert scale

Score for five point scale	FUZZY SPECTRUM (n1,n2,n3)		
5	0.6	0.8	1
4	0.4	0.6	0.8
3	0.2	0.4	0.6
2	0	0.2	0.4
1	0	0	0.2

The analysis of FDM was conducted according to Cheng and Lin (2002). From the fuzzified expert responses (n1, n2, n3), the values were aggregated (m1, m2, m3), and the distance between two fuzzy numbers were calculated as a threshold value (d) ($d = \sqrt{\frac{1}{3}[(m1 - n1)^2 + (m2 - n2)^2 + (m3 - n3)^2]}$). For d≤0.2, the item was considered to have the consensus from the experts, and for d>0.2, it was considered for the item to be removed or reworded with the concern of the experts who did not agree. Next, the percentage was calculated to get a 75-percent group consensus, which is the agreed percentage of consensus commonly used in the traditional Delphi method. After that, the defuzzification process is conducted, which is a method to find the average triangular fuzzy value. Defuzzification scores were used to rank the factors according to the priority characteristic. All analysis for this part was conducted using Microsoft Excel 2013.

3.4.3 Factor analysis

Factor analysis was conducted on the data gathered from the main research. This study using IBM SPSS Statistics 23.0 (IBM Corp, 2015) to conduct the analysis. The analysis was chosen on the basis that it was able to summarise the data so that relationships and patterns were easily interpreted and understood. From the interpretation of the contributed factors based on the analysis result, the analysis was able to validate the contribution of the three subscales in the SETSIS to answer RQ3.

This study used exploratory factor analysis (EFA) as a first step to uncover complex patterns by exploring the dataset and testing prediction of the SETSIS. First, the correlations between each item in the correlation matrix was determined to ensure no multicollinearity existed in the observed data. In cases of bivariate correlation scores more than 0.8, both items should be considered for removal (Field, 2013, p. 686).

Next, the data were further analysed using the principal axis factoring method as the data were to be used for further analysis of the sample population (Samuels, 2016). The number of factors was determined by using Keiser Criterion. The criterion for a factor was accepted at an eigenvalue higher than 0.5 (Keiser, 1974), which signifies the presence of factors. Investigation of the scree plot also provided a graphical way to examine the number of factors.

Then, the factor rotation was applied to find the strongest correlation between items and the latent factors. The items that generally form the factors should be correlated more than the correlation of the factors (Gie Yong and Pearce, 2013). Thus, this study uses Promax, an oblique rotation method that allows a degree of correlation between the factors in order to improve the intercorrelation between the items within the factors.

Factor loadings in items were checked for factor suppression or retention. Items with factor loading less than 0.35 were ignored because of the less variance shared. Cross factor loadings should then be considered using the described cut-off rules. All retained factors should have at least three items with loading greater than 0.4. The proportion of the total variance explained by the retained factors should be at least 50 percent (Hair *et al.*, 2010)

The factors extracted by EFA were validated subjectively using the theoretical interpretability. The items comprising each factor were thoroughly analysed for consistency and similarities across the factors. Items not coherent with the factor's items must be removed for the meaningful application of theory. The factors were interpreted based on the similarities of the consisting items. The definitions of each factor were given based on the latent factors provided within the three definitions of factors in the SETSIS that defined the meaningfulness of the variables.

3.4.4 Rasch Model

Rasch modelling was used to analyse the SETSIS for the data obtained in the pre-test and the main research. The analysis of the pre-test data (n=31) was conducted using MINISTEP Version 3.92.1 (Linacre, 2015) while the analysis of the data (n=325) in the main research was conducted using WINSTEPS 4.0 (Linacre, 2017).

The data gathered were analysed using the rating scale model (RSM). The analysis used the following criteria in selecting good items and revising problematic items and further validated the model used.

1. Fit indexes. The fit index was used as an indicator for items that fit the Rasch model well. It indicates the contribution of the item to the construct measure of the model. The fit indexes were given in mean fit square value (MNSQ). Two fit indices including infit and outfit MNSQ were used to examine the items. Infit MNSQ gives information-weighted data, which is more sensitive to response patterns observed near item difficulty. Outfit MNSQ gives information on the outlier fit which is more sensitive to the pattern observed in unexpected outlying responses. Generally, MNSQ = 1.0 is a perfect fit to the model; however, in reality it is acceptable to include items which have fit indices close to 1.0 and within the acceptable range.
2. Separation and reliability index. The RSM provides item and person separation indices for assessing item functioning. The item separation index indicates how well items can be discriminated by the person, while the person separation index indicates how well persons can be separated by the items.

3. Dimensionality. Principal components analysis of residuals (PCAR) was used to assess if there were meaningful structures of secondary dimensions in the measure. It analysed from the unexplained variance after the Rasch dimension had been removed from ordinal data. Unidimensionality was tested by looking at patterns in the residuals. First contrast of PCAR indicates the first component in the correlation matrix of the residuals. These are the standardised person-item differences between the observed data and what is expected by the model for every person's response to every item (Pallant and Tennant, 2007). After extracting the Rasch dimension there should be no further patterns in the data. Unidimensionality of an instrument is supported when the Rasch dimension explains more than 40 percent variance in the data, and the first contrast of the Rasch residual explains less than 5 percent variance of the data (Li et al., 2016).
4. Wright map of scale. The targeting of item difficulty to person ability was visually inspected using the person-item map in the Wright map of scale. These two parameters (person and item measure) were mapped onto the same logit scale. Optimal targeting occurs when the items are able to cover the full range of person ability in the map. Thus, the mean item and the mean person should be close together. The differences between the means lead to poor item targeting in the measure.
5. Category structure. Category structure analyses the corresponding level of ability score works based on an appropriate level of difficulty. It examines whether the structure of response categories provided was clear and within the appropriate range of responses so that the high performing person can choose the high response category and the low performing person can choose the low response category. The RSM was used to examine that successive categories were located in the expected order. Step measure, average measure, category fit statistics and category probability curve were used to assess category functioning.

3.4.5 Correlation and Regression OLS

Correlation analysis was used to estimate the correlation coefficient of the sample. Using the Pearson product-moment correlation coefficient, the strength and direction of the relationship between the two variables was denoted as r. The correlation coefficient, r, ranges between -1 to +1, which quantifies the direction and strength of the linear relationship between the two variables. The positive correlation infers a parallel association when one variable with a high level is associated with the other high-level variable. The negative correlation infers a contradictory association when the higher variable associated with the lower variable. The sign indicates the direction of the association while the magnitude indicates the strength of the association.

The regression analysis was used for evaluating multiple independent variables. As a result, it was particularly useful for assessing and adjusting for confounding. It can also be used to assess the presence of effect modification. Multiple linear regression analysis is an extension of simple linear regression analysis and used to assess the association between two or more independent variables and a single continuous dependent variable. The multiple linear regression equation is as follows:

$$\hat{Y} = b_0 + b_1X_1 + b_2X_2 + \ldots + b_pX_p$$,

where $\hat{Y}$ is the predicted or expected value of the dependent variable, X_1 through X_p is p distinct independent or predictor variables, b_0 is the value of Y when all of the independent variables are equal to zero. Statistical tests can be performed to assess whether each regression coefficient is significantly different from zero.

In the multiple linear regression equation, b_1 is the estimated regression coefficient that quantifies the association between the risk factor X_1 and the outcome, adjusted for X_2 (b_2 is the estimated regression coefficient that quantifies the association between the potential confounder and the outcome). Each regression coefficient represents the change in Y relative to a one-unit change in the respective independent variable

Once a variable is identified as a confounder, we can then use multiple linear regression analysis to estimate the association between the risk factor and the outcome adjusting for that confounder. The test of significance of the regression coefficient associated with the risk factor can be used to assess whether the association between the risk factor is statistically significant after accounting for one or more confounding variables.

3.5 The instruments

Two different instruments were used in this study. The first was the SETSIS, which was formed in order to measure self-efficacy of PSTs in regards of teaching SPS using the three self-efficacy constructs. The second instrument is an existing validated instrument named the TISP (Shahali and Halim, 2010). It is used to validate the SETSIS in measuring the content knowledge of science inquiry skills. The details about each instrument and the consisting constructs are addressed in the following.

3.5.1 Self-Efficacy in Teaching using Science Inquiry Skills Instruments (SETSIS)

The SETSIS was the main instrument used to study the construct of self-efficacy in teaching SPS. Three dimensions, KE, PTE and OBE were used separately in pre-existing instruments to represent the underlying traits in measuring teacher self-efficacy in teaching science (Roberts and Henson, 2000; Tschannen-Moran and Hoy, 2001). In this study, the three dimensions are used to describe the construct of self-efficacy in regards to teaching using science inquiry skills among science PSTs.

The items chosen to measure these dimensions were based on items from previously validated instruments. However, because there is no existing instrument that relates specifically to teaching using science inquiry skills, the researcher has chosen items from several research instruments to create the items pool for this study. Most of these instruments focused on the constructs of teacher efficacy, self-efficacy in teaching and knowledge of science, self-efficacy in teaching science inquiry, self-efficacy in teaching physics, and self-motivation in learning science. While developing this instrument, the purpose remained clear that the items included would measure PSTs' self-assessments of their belief and attitude towards teaching science through science inquiry skills, not their knowledge of teaching science through science inquiry skills. When necessary, item wording of existing measures was adapted to fit within the context of teaching using science inquiry skills. Additionally, new items were written in order to capture the potentially important dimension of teacher's self-efficacy in teaching SPS that were not includable in the pre-existing instrument. Details of the items of the SETSIS are described in section 4.5.

The SETSIS instrument was developed and used in two phases of the study. Firstly, this instrument was used in the pre-test study and secondly, it was used in the main research study. The details of the data of each study are described in Chapters 4 and 5.

3.5.2 Test of Integrated Science Process Skills (TISP)

The TISP was developed to assess the acquisition of integrated SPS specific to the science content defined in the Malaysian primary school science curriculum (Shahali and Halim, 2010). This paper-and-pencil test was first administered to 101year six primary school students with 30 initial items varied across five integrated SPS components (i.e. formulating hypotheses, controlling variables, defining operationally, interpreting data, and designing experiment). This study yielded a test reliability of 0.80; however, five items were discarded. In the later study by Hafizan et al. (2012), the TISP was used to examine the acquisition level of the integrated SPS (operational) of 329 primary science teachers in Malaysia. The instrument was then refined with 25 multiple-choice items with the same five components (five items in each component) with the construct reliability values ranged from 0.34 to 0.53.

The TISP was chosen because the consisting items contain conceptual materials on the Malaysia primary science curriculum as well as requiring the application of components of integrated SPS. The primary consideration relies on the validity of measuring the knowledge of SPS in primary school science. It is hoped that the test score should provide an accurate assessment of the PST's ability to perform science inquiry skills in the primary science tasks, so that it can be used to cross-validate the predictive power of knowledge efficacy in the measurement model of the SETSIS.

The skills of inquiry are based on seven basic skills of science process skills (i.e. observing, classifying, measuring and using numbers, inferring, predicting, communicating, and using space-time relationships) (Padilla, 1990) that were applied to form the integrated skills of SPS (controlling variables, defining operationally, experimenting, interpreting data, and making hypothesis). The science inquiry skills in the context of this study were defined as performance in using the knowledge of integrated science process skills. In order to become competent in using science inquiry skills as classroom instruction, PSTs should be knowledgeable of how to apply and use the correct SPS in respective novel situations.

Performance in using integrated SPS was tested using five sub-scales that consists of a total of 25 items in the TISP. Each sub-scale measures knowledge in using an integrated scientific skill. Table 6 lists the definition for each of the five integrated SPS in the TISP. Every sub-scale consists of five multiple-choice questions about novel situations that involve each respective integrated skill. In the analysis, every correct answered was scored with '1' (one) while every wrong answer scored '0' (zero). The total scores of the five constructs of integrated SPS were accumulated to determine the score of the TISP. The score of the TISP was used to represent the knowledge of inquiry skills held by individual respondents.

The TISP was conducted together with the SETSIS survey. All respondents are PSTs (PST) majoring in teaching primary science; the same individuals responded to the SETSIS. Respondents chose to answer the TISP before or after the SETSIS, in their own time. Individual responses in the TISP and the SETSIS were identified using the same student's number given on both survey papers.

The sample was presumed to have adequate knowledge of science process skills due to their admission on the programme (Bachelor of Teacher Programme) admission. Additionally, the teacher-training curriculum provides implicit content of science process skills through the courses during training. The cross-sectional samples were used with the intention to explore general performance in the knowledge of science process skills across a group of semesters (semesters of study) in the programmes.

In general, performance in science process skills measured using the TISP can be defined as a way to measure the level of knowledge in science inquiry skills held by an individual PST. Individual PSTs with good performance of the TISP would have good knowledge of science inquiry skills. The result of the analysis in Chapter 6 provided the necessary evidence in order to evaluate whether the knowledge of science inquiry skills is a factor related to the factors of the SETSIS.

Table 6 Domains of the TISP

Item Type
Controlling Variables: Identifying the fixed variables, manipulated variable, and responding variable in an investigation. The manipulated variable is changed to observe its relationship with the responding variable. At the same time, the fixed variables are kept constant.
Making Hypothesis: Making a general statement about the relationship between a manipulated variable and a responding variable in order to explain an event or observation. This statement can be tested to determine its validity
Define Operationally: Defining concepts by describing what must be done and what should be observed.
Interpreting Data: Giving rational explanations about an object, event or pattern derived from collected data.
Experimenting: Planning and conducting activities to test a certain hypothesis. These activities include collecting, analysing and interpreting data and making conclusions.

3.6 Data collection and the sample

3.6.1 Face and content validation

Content validity is about the degree to which the items representing the content area should be measured. This process will use research-based literature and an expert panel (i.e., experts in subject matter, experts in instrument development). The results will inform the development of the items in the SETSIS first place.

3.6.2 Pre-test

The first round of item piloting aims to show if there is a need to undergo a change in terms of item type and the difficulty of the items used. Isaac and Michael (1995) and Hill (1998) suggested 10 to 30 participants for pilots in survey research, which in this study meant recruiting participants (N=31) who made up 9 percent of the total number of PSTs enrolled at ITE when the study was conducted. Participation was voluntary, and no demographic data was collected at that time. After piloting, three respondents (10 percent of the sample) were recruited to participate in an interview. The group interview was used to explore the thinking of the respondents as they worked through the items. It allowed them to verbalise their decision-making and the rationale behind each response choice and helped to identify any inappropriate reading levels (i.e.reading expression received do not match the intended meaning) and ambiguous phrasing.

3.6.3 Main research

In the second round of item piloting, the revised items were administered to the study population using a cross-sectional sampling procedure (i.e. samples were taken from all levels of science PSTs from all levels of science at ITE). The demographic of participants in this sample presented as the first part of the SETSIS before the main items. Further, the SPS cognitive test assessment (Shahali and Halim, 2010) were employed on the same sample. The score of the practicum attainment of the sample was used with the participants' consent.

In this study, the survey population is defined as individuals who are currently enrolled in a teacher education programme majoring in primary science education in Malaysia. The purposive sampling was decided because these PSTs will graduate from ITE and will implement the new science curriculum in Malaysian primary schools. It also will be more informative for the purpose of developing the SETSIS.

Table 7 shows the number of students that have enrolled for the Bachelor of Teaching Programme (BoTP), which specialises in primary science education in 13 campuses of ITE using pseudonyms listed. The Pre-Test survey was conducted in one of the campuses (i.e. campus KT) with 31 respondents as a sample. These respondents were not included in the main research phase.

Table 7 Enrolment of science PSTs in ITE campuses all over Malaysia

No.	ITE Campus	Semester 1	Semester 3	Semester 5	Semester 6	Semester 7	Semester 8	TOTAL
1	**BL**			**21**		**11**		32
2	**TW**	**16**	**16**					32
3	**KT**	**16**	**15**					31
4	**KB**						**11**	11
5	**SM**		**15**	**22**				37
6	**TA**				**18**			18
7	**TI**			**19**			**12**	31
8	**RM**	**13**						13
9	**PT**	**13**	**17**		**16**			46
10	**IP**	**10**			**18**			28
11	**PP**	**12**			**19**		**16**	47
12	**TB**	**10**					**37**	47
13	**TR**	**15**						15
	TOTAL	**89**	**48**	**62**	**71**	**11**	**76**	388

The main research study used a cross-sectional sample as the participants to address various levels of experience of primary science teacher training in Malaysia based on their period of study (semester). In the main research study, the surveys were offered to all available respondents; however, the responses were obtained from 325 voluntarily participants. The details were listed in Chapter 5.

3.6.4 Score for teaching practice assessment

This study used the secondary data of the scores for Professional Practice obtained from the Department of Exams and Senate. An official application has been forwarded through ITE and the contacted person in-charge have offered limited data to be accessed for two courses, PRK3024 – Practicum II and INT3012 - Internship. I have only accessed the final scores and grades of the assessments. From all the data that have been offered, I managed to link 103 scores to the participants of my study through their student identification numbers. I used the scores to triangulate and validate the SETSIS with the teaching practice assessments conducted by the training institution. Further details are presented in Chapter 7.

3.7 Ethics

My research data were gathered using surveys, focus group interviews and data analysis that covered the science PSTs that enrolled with ITE. The participants involved in this research are more than 18 years old and the data gathered were in the form of the written, self-response questionnaires, written notes (from focus group interviews) and databased documents that did not involve risk. The ethical approval was received from ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee, University of Leeds on 20 October 2015. The approval letter can be found in Appendix 2. There are a number of ethical issues to consider and these were addressed in the following subsection.

3.7.1 Main ethical issues

Firstly, the main ethical issues in my study relate to the acceptance (permission) issue. Since the study took place in Malaysia and involve teacher trainees at ITE, I gained permission through the Economic Planning Unit (EPU) at the Prime Minister's Department in Malaysia. The approval letters from the EPU were essential for me to gain permission from the ITE department for easy access to conduct my research.

The EPU was contacted via email to seek approval for the research area and design. After getting the feedback and approval from the EPU, the Education Planning and Research Department (EPRD) was contacted to gain access to the Institute of Teacher Education (ITE). After getting the consent from the ITE for the three surveys (i.e. pilot survey, research survey and cognitive performance test survey), only then was I allowed to distribute the questionnaires and conduct the interviews as planned. In addition, I also sought consent from ITE to grant access to data archives for the professional practice scores of the participants involved. The data were needed to answer part of my RQ5.

Secondly, having a higher rank authorisation eventually made my prospective participants feel compelled to participate. As my surveys were distributed through the gate-keepers, such as the head of department, teacher educators and tutors or with their consent, the participants felt obliged to participate in the survey because they had been asked or advised by the gate-keepers to take part. This might have affected the quality of the information they provided. To address this concern, I asked for voluntary consent from participants personally during the administration of the survey and only recruited those who openly expressed their willingness to participate.

Additionally, I considered incentives in order to maximise the engagement and responses in the surveys. These incentives were inducements to compensate for the absence of factors that otherwise might stimulate cooperation (i.e. interest in the topic of the survey or a sense of civic obligation). One small incentive involved a souvenir pen that was given to attract participants to spend their time on this study. In order to maximise the responses when completing the two surveys (the SETSIS and the TISP), I offered the chance for participants who completed both surveys to enter lucky draws for 50 fast-food vouchers worth RM10 (approximately £1.50) each. It has been shown that, in a study that involves no more risk than the ordinary amount, the size of incentive becomes irrelevant on ethical grounds (Singer and Couper, 2009). Thus, in this study, the incentive would not affect the responses to the study.

3.7.2 Managing data protection

Any electronic data were stored in a password protected secure network location allocated to myself at the University of Leeds. No data were stored in thumb drives or laptops. Any personal data were stored in a password-protected secure network location at the University of Leeds, which can be accessed only from my home computer and personal laptops – the access route is password protected through a secure log-in which matches the on-site process and times out after five minutes' inactivity. The hard copies of the three surveys, writing notes that will be used to record the interview for technical qualities during the pre-test, and the documents of secondary data analysis (i.e. teaching practical scores received from ITE), were stored in a locked filing cabinet in a lockable office at the University of Leeds and were kept on site at all times.

3.7.3 Informed consent

Information sheets (see Appendix 3) and verbal inputs were provided for all participants before any phase of the research (i.e. pilot survey and main research surveys). The participants were given information about the questionnaires in advance which stated that submission of the surveys indicated that they have given their consent for their responses to be collated and analysed. Additionally, they were asked if they were willing for their data to be archived and made available for further research during the research survey. They were assured that their responses and teaching practical scores would not be available in the public domain.

In order to use the interview effectively, an initial meeting took place with the participants who volunteered to be interviewed, before the pilot survey. The meeting was to brief them about the purpose of the interview, which is to improve the technical qualities of the survey. Participants were reminded at the start point of the pilot survey of their right to withdraw from the study without the need to give reasons.

3.7.4 Anonymity

This research involves two surveys and a data archive on teaching practice scores to be analysed and cross-validated with each other. For that purpose, the participants needed to be identified with a formal and acceptable identification using their student number. To avoid exposing participants or revealing their identities, new systematic identification numbers were assigned during the process of data entry. The participants were assured that their identity would not be revealed in any part of the research. It was made clear to all participants that their responses would be respected and their anonymity guarantee.

Chapter 4 Constructing the SETSIS

4.1 Overview

This chapter explains the framework used in constructing the SETSIS. In the model of SETSIS, the three components of teacher knowledge (i.e. knowledge, practice and belief) are represented by three self-efficacy factors call Knowledge Efficacy (KE), Personal Teaching Efficacy (PTE) and Outcome Belief Efficacy (OBE). The factors were structured into hypothesis criterion-references levels of responses to explain the elusive construct. The factors mapped the measurement of self-efficacy, specifically in the theme of teaching science using science inquiry skills that correlate to the development of PSTs in their teacher knowledge. The characteristics from the definition of the factors establish the model structure. It is then used as a guide to design the items of the SETSIS.

Next, the items used in the SETSIS operationally define the factors and of their distinctive characters that stated in the construct above. The items shall be carefully chosen and developed to reflect the intended construct. All the items would measure the development of teacher knowledge according to the theme of the factors. The items then underwent expert review for evidence of the validity of the items' content. The results of the experts' judgements were analysed using Fuzzy Delphi method to ensure the validity of the items constructed. The last section presents an examination of the reliability of the measures in the pre-test survey. The pre-test survey observed the participation of 31 samples in the construct's items and the items format. The information from the data was used to improve the measure.

4.2 Constructing Factors of the SETSIS

Outcomes from the SETSIS are meant to be used in inferring competence in teaching using science inquiry skills in science classroom from the perspective of self-belief. Teaching competency in the science classroom is derived from the recognition of teacher knowledge development (Shulman, 1986, 1987; Darling-Hammond, 2006; Ben-Peretz, 2011). Thus, hypothetically, competence in teaching in the science classroom using the new curriculum among PSTs can be measured from the components of teacher knowledge in specific tasks, which is teaching using science inquiry skills. In regards to measuring the development of teacher knowledge among PSTs, the SETSIS was developed specifically to measure self-efficacy in teaching using science inquiry skills (Ministry of Education 2013). As mentioned in the previous chapter (referring to the theoretical framework), this study defines self-efficacy in teaching using science inquiry skills within the three factors: KE, PTE and OBE. The definition given corresponds to teacher knowledge development in teaching using science inquiry skills.

In this study, TSE belief is used as a key construct in measuring the SETSIS in the science classroom (Bandura, 1994; Roberts and Henson, 2000; Tschannen-Moran and Hoy, 2001). Much of the research into self-efficacy in academic achievement and health psychology competence has agreed that self-efficacy has important characteristics in measuring competency in performing specific tasks to attain designated outcomes (Zimmerman, Bandura and Martinez-Pons, 1992; Albion, 1998; Zimmerman, 2000; Caprara *et al.*, 2006; Siwatu, 2007; Cassidy, 2015), which supports the concept of the prominent model of TSE belief by Tschannen-Moran et al. (1998). However, as discussed in section 2.3, this study adapted the concept of the model within the contemporary definition that emphasises the perceived ability to take action (agent-mean) rather than bringing about desired outcomes (agent-end). Moreover, this study defines self-efficacy belief with characteristics that extensively include the role of teacher knowledge as an additional factor. The study definition of self-efficacy is an appropriate element to be integrated with the concept of teacher knowledge to describe development in teacher learning (Wheatley, 2002). The SETSIS designs to measure self-efficacy in teaching using science inquiry skills correspond with PSTs' potential ability to perform specific teaching tasks using science inquiry skills in primary science as required by the current curriculum.

The present study blends elements of self-efficacy and psychometric theory to measure self-efficacy, specifically in teaching using science inquiry skills among PST. The element of self-efficacy in the measure is defined by the three factors. The factors are constructed in three different subscales which measure perceived ability in delivering the tasks accordingly. The three subscales were psychometrically combined and interpreted as a measure of self-efficacy in teaching science using science inquiry skills.

4.2.1 Definition of factors

Table 8 below summarises the definitions of the three factors used in the development of the SETSIS. Items in the three factors were chosen based on the definition and the traits measured. All the traits reflected an outcome for self-efficacy in teaching science using science inquiry skills. The outcomes were interpreted within the three factor traits' limits.

Table 8 Summary of the three factors in the construct

Component/ factor	Knowledge/ KE	Practice/ PTE	Belief/ OBE
Trait measured	Degree of a PST judgement in poses the science inquiry skills knowledge required to organise and conduct science inquiry strategies for science teaching.	Degree of a PST judgement on personal capability in using the science inquiry skills knowledge to confront the complexity of teaching science using science inquiry strategy in classroom context	Degree of a PST judgement on belief in learning good science through inquiry strategies aided by the knowledge of science inquiry skills.
Interpretation of factor	PST perceived ability in content and instructional knowledge of science inquiry skills when teaching science.	PST perceived ability in practicing the science inquiry skills knowledge for teaching in the science classroom.	PST belief in the value of learning science by using science inquiry skills

4.2.1.1 Definition of Knowledge Efficacy (KE)

KE is introduced to represent the factor of self-efficacy in the component of knowledge of science inquiry skills. The KE scale is aimed at assessing personal belief in ability using the science inquiry skills knowledge information to support the process-content teaching approach. The KE scale neither tests understanding of explicit science inquiry skills nor how to use science inquiry skills explicitly in experiments. Instead, the KE scale is about ability in using sufficient knowledge of science inquiry skills for teaching science. Overall, the KE scale measures perceived ability in science inquiry skills knowledge for teaching science that is possessed by an individual PST.

KE measures meaningful knowledge of science inquiry skills for teaching. KE is about knowing explicit science inquiry skills and, moreover, knowing how to use science inquiry skills knowledge in teaching science. These two traits – content knowledge of science inquiry skills and instructional knowledge of science inquiry skills –are reflected in the example of the following KE item.

> *I understand about measurement and space sufficiently to help students understand the concept of length using self-measure activity (i.e. arranging paper clips/ sticks).*

The item assesses the explicit conceptual understanding of the concept of skills of measurement and space that are being used (i.e. content knowledge) and the concept of learning using self-measuring activity (i.e. instructional knowledge). Both knowledge exist as science inquiry skills knowledge required for teaching science. Thus, items in KE indicate the science inquiry skills knowledge that consists of content and instructional knowledge, which enable the PST to use science inquiry skills meaningfully for teaching.

In this study, the science inquiry skills knowledge refers to the use of 12 science process skills (SPS) in a science inquiry: seven basic SPS and another five integrated SPS (Malaysia Ministry of Education, 2013) (i.e. observation, classification, measurement and using numbers, inference, communication, predicting, using space-time relationship, interpreting data, defining operationally, controlling variables, hypothesizing and experimenting) that are required for effective planning of inquiry strategies. On the whole, KE refers to the personal judgement of PSTs in their position of the required science inquiry skills knowledge.

4.2.1.2 Definition of Personal Teaching Efficacy (PTE)

PTE is introduced to represent self-efficacy towards components of the practice of teaching using science inquiry skills in science classrooms. PTE refers to personal feelings about conducting teaching using science inquiry skills in a classroom. It assesses the judgement of personal capabilities in skills, knowledge and personal attitudes to anticipate classroom teaching. Furthermore, the PTE scale also considers anticipation in contextual factors such as the climate within the school and supportiveness of superior teachers. Thus, in general, the PTE scale assesses self-perception of personal teaching ability within teaching tasks and teaching contexts.

As noted, PTE assessments are somewhat similar to KE in terms of the science inquiry skills knowledge, but PTE includes specific aspects of the classroom situation. PTE assesses the capability to anticipate elements of tasks in a classroom, referring specifically to teaching using science inquiry skills during classroom learning. The measured trait is reflected in one of the following PTE items.

When a science process is difficult to explain, I will use an investigative approach to assist the students' understanding.

The item reflects anticipation of difficulties in the nature of science using a pedagogical of inquiry science (investigation) approach. It is intended to asses personal capability in engaging with the classroom's elements (i.e. nature of science, pedagogy, curriculum and students' knowledge) when teaching science in a classroom.

Along with the teaching tasks, the PTE scale also reflects the capability to anticipate aspects of contextual factors. This is reflected in the following item.

I choose to show inquiry methods suggested by the latest curriculum to the headmaster.

In the item above, PTE assesses personal capability to anticipate supportiveness from a superior teacher in the school. Overall, PTE is meant to assess the highest level of PCK Taxonomy attributes (Veal and MaKinster, 1999b), which is the capability to integrate with the elements that occur during the tasks of teaching classroom science.

By the combination of self-efficacy and personal capabilities, PTE scale was created to reflect the judgement of PSTs on their personal ability using the knowledge to confront the complexity of teaching science using science inquiry strategy in a classroom context. The PTE scale was aimed to assess personal ability in using the science inquiry skills knowledge and, at the same time, capture the overarching abilities to teach it in the context of the science classroom. This means that if a PST has confidence in their ability to executing the knowledge of science inquiry skills in a classroom then that PST has a good potential of using science inquiry skills to teach science in a real classroom setting.

4.2.1.3 Definition of Outcome Belief Efficacy (OBE)

In this study, OBE is used to measure the belief of effectiveness in using science inquiry skills for teaching science. The definition of OBE derived from the belief component of teacher knowledge. Belief components have important rules in developing teaching behaviours in the classroom (Magnusson, Krajcia and Borko, 1999; Kane, Sandretto and Heath, 2002; Marra, 2005).OBE is seen as a fundamental component in teacher development.

The OBE scale in this project was designed to measure PSTs' perceived belief in the value of using science inquiry skills, which encourages better teaching and learning outcomes. OBE's items reflect a belief in learning good science through inquiry strategies aided by the knowledge of science inquiry skills. This is reflected in one of the following OBE items.

> *I believe that investigative skills are needed for students to success in learning science at higher levels.*

The item reflects beliefs about the requirement of science inquiry skills knowledge for success from personal experience in learning science. It assesses general belief relating to outcomes from experiences of learning using science inquiry skills.

Moreover, the OBE scale assesses personal belief based on respondent's **experiences** of the learning outcomes rather than personal belief in the respondent's **ability to producing** the learning outcomes as posted in PTE. This is reflected in one of the OBE items, as follows.

> *I believe that a science inquiry strategy is the best method for teaching science.*

The item assesses personal belief in the advantage of science inquiry skills knowledge for teaching rather than belief in the personal ability to implement science inquiry skills knowledge for teaching. Overall, OBE is aimed at assessing general belief in the value of using science inquiry skills for teaching science, which leads to self-motivation in the future.

OBE is defined slightly differently from KE and PTE. While KE and PE are about the judgement of self-possession and self-capability while using the science inquiry skills knowledge, OBE is concerned with opinions on the *belief about advantages* of science inquiry skills knowledge in learning science. Thus, in general, OBE assesses personal beliefs in the advantages of using science inquiry skills in learning science. OBE was constructed to complement but not to influence KE and PTE (Bandura 1994).

4.3 The Construct

The construct refers to the concept of intended measure in this study. Mindful of the literature, the factors used in assessing the perceived ability of an individual PST are assumed to psychometrically measure one construct of self-efficacy in teaching science using science inquiry skills. The construct outcome intends to become a self-belief assessment that infers competence in teaching science using science inquiry skills in the new curriculum.

Based on the curriculum used for BoTP, the study construct was arranged to represent a hypothesised level of the self-efficacy of the respondents from early admission to the end of the programme. It derived from the concept of teacher knowledge in the PSTs' education. At the early stage in the PSTs' education, a PST constructs belief in the effectiveness of using science inquiry skills from their school experiences. The beliefs are used to strengthen the knowledge learned (i.e. content knowledge and pedagogical knowledge) during the training programme. Then, by reinforcing belief and knowledge, PSTs are able to craft personal practices in classroom teaching (Abd-el-khalick, Bell and Lederman, 1997; Magnusson, Krajcia and Borko, 1999; Veal and MaKinster, 1999b; Cochran-Smith, 2004; Veal, 2012). Thus, my hypothesis is that the level of self-efficacy in using science inquiry skills when teaching science follows the hierarchy order from traits related to OBE up to traits related to KE to the top with traits related to PTE (i.e. from low level to high level). The order represents the framework of my measurement model, which is used to estimate responses for the construct development.

In summary, the traits from the three factors describe the development of teacher knowledge embedded along the construct continuum. For instance, the KE factor consists of relevant items in assessing traits in the science inquiry skills knowledge. The PTE factor characterises assessments that are relevant to assessing responses in terms of traits in the ability of personal practice in teaching using science inquiry skills in the science classroom. The OBE factor assesses traits of perceived responses that are relevant to the capability of believing in the effectiveness of knowledge of science inquiry skills in learning science. As a whole, the perceived capabilities in the traits measured from the three factors represent the construct's concept of self-efficacy in teaching science using science inquiry skills.

Respondents' positions in the framework are described based on their responses to the factors. Hypothetically, the estimation of responses in the construct characterise the level of self-efficacy of an individual PST. Various confident degrees of responses within the three factors define the development in self-efficacy in teaching science using science inquiry skills. Different degrees of confidence in responses given in the items note the depth of the perceived abilities held by an individual PST within the three factors. The combination of responses in the three factors' traits establish layers of perceived abilities to teach science using science inquiry skills in the SETSIS. Characteristics that emerge from this complex combination of responses determine the outcome measured along the construct continuum. The outcomes are characterised in the level of self-efficacy in teaching science using science inquiry skills, which are clarified as the construct outcomes. I will now describe these levels of outcomes in detail using the construct map.

4.3.1 The Construct Map

The construct map (Brown and Wilson, 2011) visualises the hypothesis on the level of teaching using science inquiry skills model maps across the three factors. Figure 6 shows the relations of the item hierarchy between the three factors mapped on overall development around the theme of teaching using science inquiry skills. The model hypothesises response outcomes divided into descriptive levels of self-efficacy in teaching science using science inquiry skills. The descriptive levels would give clear guidance in creating suitable assessments to measure the intended construct. It helps in establishing construct validity during the process of developing the SETSIS especially in designing items and developing the model.

Figure 6 Construct map for the SETSIS development

Respondent	Direction	Responses to items	Interpretation to construct
	Direction of increasing potential ability of using SIS in teaching science	High responses for difficult to affirm items in OBE, difficult to affirm items in KE, and difficult to affirm items in PTE	L5- perceived ability to adapt SIS in method and strategies in science classroom teaching to enhance student learning
		high responses for; difficult to affirm items in OBE, difficult to affirm items in KE, and average to affirm items in PTE	L4-perceived ability to enhance knowledge bases on using more SIS in teaching science classroom
		high responses for; difficult to affirm items in OBE, average to affirm items in KE and easy to affirm items in PTE	L3- perceived ability to use SIS in teaching science classroom
		high responses for; difficult to affirm items in OBE and easy to affirm items in KE	L2- perceived ability to promote good influence of SIS in teaching science classroom
		high responsses for average to affirm items in OBE	L1- perceived ability to recognise effectiveness SIS in science classroom
	Direction of decreasing potential ability of using SIS in teaching science	high responses for easy to affirm items in OBE	

The construct map visualises a measurement framework from the hypothesised model of progression on self-efficacy in teaching science using science inquiry skills. It is drawn on the proposed estimation order of the factors that are developed by PSTs during teacher education training. The order (from the bottom to the top: OBE→ KE→PTE) is then descriptively fabricated into the measurement framework. The relationship between estimations of responses to items and the outcomes level on the continuum of self-efficacy in the construct is drawn in Figure 6.

The self-efficacy in the construct continuum is described and defined with five qualitatively distinct levels with the bidirectional arrow in Figure 6 representing greater and fewer amounts of self-efficacy as per the measure. The PST with the lowest response to self-efficacy in the construct measure is defined as not perceiving any confidence in personal ability, as represented by the traits of the three factors. The self-efficacy of PST increases by increment with perceived confidence in personal ability according to the traits of the factors. Complex responses in the factors are cumulated and described in five levels representing the continuum of self-efficacy in the single construct.

The continuum level is important for positioning and interpreting a PST's self-efficacy in teaching science using science inquiry skills. With low cumulative responses in OBE, KE and PTE, a PST is placed at the bottom level of self-efficacy in the construct map. Showing high affirmation of items that indicate low belief in the outcomes of science inquiry skills in science learning, low ability in knowledge of teaching science inquiry skills and low ability in practicing teaching using science inquiry skills in classroom, a PST is hypothesised as having ability in recognising science inquiry skills learning but with low possibility of using the SIS knowledge when teaching classroom science. Thus, the bottom level of the construct map is described as level one (L1) with *a perceived ability in recognising effectiveness of science inquiry* skills *in learning*, which reflects the lowest self-efficacy in teaching science using science inquiry skills.

Level two (L2) from the bottom of the construct defines self-efficacy with high affirmations of items that indicate high ability in OBE but low in KE and PTE. L2 describe respondents with high belief in the effectiveness of science inquiry skills outcomes but without confidence in their ability in the knowledge of teaching science inquiry skills and ability of practicing teaching using science inquiry skills in the classroom. In the construct measure, L2 is mapped as *self-efficacy in promoting good influence of using science inquiry skills in teaching science*.

Level three (L3) of the construct defines self-efficacy with high affirmation of items that indicate high ability in OBE, average ability in KE and low ability in PTE. At L3, a respondent is described as showing good belief in the benefit of using science inquiry skills in learning with confidence in their basic knowledge of science inquiry skills to teach but, still not confident in their ability in teaching science using science inquiry skills in the classroom. In the construct map, L3 is characterised as having *self-efficacy in using science inquiry skills in teaching classroom science*.

Level four (L4) of the construct defines self-efficacy with high affirmations of items that indicate high ability in OBE and KE but average ability in PTE. At L4, a respondent is hypothesised with good belief in the benefits of science inquiry skills with sufficient knowledge of science inquiry skills to complete learning goals or solve teaching problems in the classroom. However, the personal practice confidence at this level may come through reflections afterwards. On measuring the self-efficacy, the L4 is mapped as having *potential to enhance the knowledge bases and using more science inquiry skills in teaching classroom science*.

Level five (L5) of the construct is the top layer that defines the self-efficacy with high affirmations of items that indicate high ability in the three factors: OBE, KE and PTE. At L5, a respondent is hypothesised as possessing definite confidence in the belief in the good learning outcomes from using science inquiry skills, confidence in their knowledge of science inquiry skills and confidence in their capability of practicing science inquiry skills in teaching classroom science. Their belief has enhanced the knowledge of science inquiry skills with the possibility of using the instructional method that stimulates science learning. In the construct map, the L5 is mapped as having *potential to adapt science inquiry skills in teaching science and enhance students' learning by using science inquiry skills*.

In summary, the construct map represents an explicit model of the SETSIS. The construct five layers mapped the order of the hypothesised responses across the three factors. The pre-specified orders reflect the development of self-efficacy in teaching using science inquiry skills as it corresponds to the different hierarchy of items. The theoretical concept of the construct manifested in practice with the item hierarchy design will now be discussed.

4.4 Item design

In designing items to measure the construct of the SETSIS, I decided to make individual items correspond to specific ability in teaching science using science inquiry skills. Each item corresponds to a specific level of task affirmation. Items that correspond to certain levels of ability can supply in-depth information about the traits measured. For instance, items are designed into three levels of hierarchy, which consist of three groups of items with easy, mean and hard task statements to affirm. Adapting the model of teacher professional development (Juttner et al. 2013), the item hierarchy can correspond to three different levels of tasks of teacher knowledge according to the factors' traits.

Item hierarchy refers to the item design within the three difficulty levels mentioned. The difficulties of the items (i.e. easy item, mean item and high item) are portrayed using different levels of tasks that assess ability in teaching science inquiry skills. For instance, the easy items are designed to characterise the low-trait (basic level) tasks in teaching using science inquiry skills. High-confidence responses in perceived ability to execute the tasks of easy items inform about self-efficacy at the basic level of teacher knowledge, which reflects that the respondents meet the basic criteria in teaching using science inquiry skills. However, low-confidence responses in perceived ability to execute the tasks in easy items reflect that the respondents do not meet the basic criteria of the ability hypothesised.

The model of Juttner et al. (2013) describes ‘knowing that’ as the basic level in development of teacher knowledge. The content knowledge corresponds with ability of describing and explaining the lesson. Easy items are designed to assess this basic level of ability required for teaching using science inquiry skills. The easy items describe the trait of ‘knowing that’ which refers to meaningful science inquiry skills content knowledge, a requirement needed for teaching science lessons. Thus, these easy items are operationally designed to correspond with the basic level ability in teacher training development, which corresponds to a low level of the construct’s self-efficacy: the ability to **promote** teaching science using science inquiry skills.

Mean items are designed to correspond with the average level of knowledge in the model of teacher professional development. This level requires knowledge of students, which is needed to teach lessons in classrooms. The mean items are designed to describe trait of ‘knowing how’ (Juttner et al. 2013), which reflects the ability of interaction between cognitive decision and students’ necessity in the action of teaching science using science inquiry skills in the classroom. In this study, the mean items are operationally designed to correspond with an average level of self-efficacy, which is ability to **demonstrate** teaching science using science inquiry skills.

High items are designed to correspond with high levels of the model of teacher professional development. This level requires teachers to be able to integrate elements of PCK (i.e. context, environment, nature of science, assessment, social culturalism, pedagogic, curriculum and classroom management) in science learning. The high items describe features of ‘knowing how and why’ (Juttner et al. 2013) in teaching using science inquiry skills. The items are designed to reflect improvised practice due to teaching engagement. In this study, the high items are operationally designed to assess high self-efficacy, which is the ability to **stimulate science learning** by teaching using science inquiry skills.

In general, the items hierarchy is operationally used to characterise the items in the hypothesised order of factors that correspond with the construct measured. The hierarchy represents the structure of development in teacher knowledge, especially in teaching using science inquiry skills. The relationships between the respondent ability and the items establish a framework structure for the measurement model. The structure will be validated using empirical evidence in the main pilot study (see Chapter 6). Next, the construction of the item hierarchy will now be discussed.

4.4.1 Development of items hierarchy

Relationships between items and respondents are described in terms of relative ability based on item hierarchy perception. This section explains the development of the items hierarchy within the three factors. The above trichotomy that characterises concept of ability is used in the item hierarchy, with slightly different definitions due to distinct characteristics displayed by each factor. Items are constructed based on the hypothesised characteristics that reflect the level of ability in the SETSIS. Table 9, table 10 and table 11 describe the relationships in factors of KE, PTE and OBE, respectively. By using the items hierarchy design, qualitative information on factors of teacher knowledge development along the construct can be gained through outcomes' responses (see analysis results in Chapter 6).

Table 9 shows item hierarchy of the factor KE described in the corresponding ability. The high items in KE assess respondents showing high ability in making plans (i.e. *knowing how*) and decisions regarding effective use of science inquiry skills (i.e. *knowing why*) in science activities. The following item is one of the high item.

> *I have the necessary scientific process skills to determine the best manner through which children can obtain scientific evidence*.

It assesses possession of science inquiry skills that is used to stimulate pedagogy in science learning. This high item highlights characteristics of KE (i.e. the knowledge of science inquiry skills) in terms of tasks for high ability, integrating content knowledge and instructional knowledge with the knowledge of students.

The mean item in KE is hypothesised to correspond with average ability. The mean items anticipate tasks of *knowing how* to use the knowledge of science inquiry skills to solve problems or to achieve learning goals in teaching. For example, the following mean item, "*I am able to construct the guidelines for communicating results and explanation for students*", assesses possession of knowledge of science inquiry skills to be used with students. This mean item highlights characteristics of KE (i.e. instructional knowledge of science inquiry skills) in terms of tasks of average ability, interacting cognitive decisions with students' requirements.

Table 9 Level description of item hierarchy of KE

Item level	Level description relates to KE
High	High ability in KE - PST is confident in their capability in enriching and stimulating instruction/method/strategies in regards to teaching using science inquiry skills
Mean	Average ability in KE - PST is confident in their capability in interacting thought and decisions using science inquiry skills in lessons in science.
Easy	Low ability in KE - PST is confident in their capability to promote comprehension in science subject by using science inquiry skills.

The easy item in KE indicates that respondents have low ability in terms of KE traits. The items assess the ability to *know what*, in that they are able to identify, understand and plan to use knowledge of science inquiry skills. For example, the following easy item, "*I am able to describe my observation with a quantitative statement",* assesses recognition of knowledge of science inquiry skills. This easy item highlights characteristics of KE (i.e. content knowledge of science inquiry skills) in terms of tasks of low ability, describing the knowledge (i.e. *knowing what*).

Table 10 Level description of item hierarchy of PTE

Item level	Level description relates to PTE
High	High ability in PTE - PST is confident in the possibility that using instruction/ method/ strategies of science inquiry skills can enrich and stimulate students learning science.
Mean	Average ability in PTE - PST is confident in the possibility that practice of science inquiry skills in classroom can affect teaching and learning outcomes.
Easy	Low ability in PTE - PST is confident in the possibility that science inquiry skills can demonstrate/promote comprehension in the science subject

Table 10 shows the item hierarchy of factor PTE described in terms of the correspond abilities. High items in PTE indicate high-ability tasks with the ability to use instruction/method/teaching strategies based on science inquiry skills to stimulate science learning. The following item is one of the high items.

> *Whether the science content is difficult or not, I am sure that I can teach it using the science process approach*.

It assesses personal inclination of using science inquiry skills to complete teaching tasks. This high item highlights teaching competency in integrating science inquiry skills within the nature of science and the curriculum (i.e. *know how and why*).

Mean items in PTE are hypothesised as the items that correspond to the average-ability tasks of integrating planning and execution of science inquiry skills during teaching action. For example, the following hypothesised mean item, "*When a student has trouble understanding a science concept, I prefer to use scientific process approach to help him/her to better understand it*", assesses inclination of using science inquiry skills to aid students' learning. This mean item highlights the characteristic of PTE of *knowing how* to interact within the knowledge of the student.

Easy items in PTE indicate tasks with low ability which support learning comprehension using science inquiry skills. For example, the following item, "*I am able to encourage my students to independently examine resources in attempt to connect their explanations to scientific knowledge",* assesses the recognition of science inquiry skills usage in lessons. This easy item highlights the characteristic of PTE (i.e. promote the usage of science inquiry skills for learning) with *knowing why*, using science inquiry skills to complete tasks.

Table 11 Level description of item hierarchy of OBE

Item level	Level description relates to OBE items
High	High ability in OBE- PST is confident in plans and decisions about use of science inquiry skills lead to effective science classroom activity.
Mean	Average ability in OBE - PST is confident that science inquiry skills can solve teaching problem/achieve learning goal.
Easy	Low ability in OBE - PST is confident in recognising science inquiry skills advantages in science learning.

Table 11 shows the item hierarchy of OBE describing the correspond ability. High items in OBE indicate tasks with high ability in instruction/ method/strategy using science inquiry skills that can enrich and encourage students learning science. The following item is one of the high items.

> *I believe that science inquiry skills creates an opportunity to satisfy children's curiosity when learning science*.

It assesses the belief that science inquiry skills usage leads to good learning outcomes. This high item highlights characteristics of OBE in terms of *knowing how and why* integrating science inquiry skills in classroom stimulates science learning.

Mean items in OBE are hypothesised as the items that correspond to an average ability to believe that practice of science inquiry skills in classrooms can affect the outcome of learning science. For example, the following mean item, "*I think that teaching science by using science process skills is important because children can learn and understand science concepts better in class*", assesses the belief that demonstrating science inquiry skills in classrooms helps students to understand better. This mean item highlights the characteristics of OBE in terms of average ability in belief of knowing how science inquiry skills learning interacts with students' needs.

Easy items in OBE indicate tasks associated with low ability of belief. It assess tasks with the possibility of science inquiry skills supporting understanding in the subject of science. For example, the following easy item, "*In science, I think it is important for children to learn to solve problems",* assesses recognition of science inquiry skills in science learning. This easy item highlights characteristics of OBE in terms of low ability in belief, shown by only describing the importance of science inquiry skills in learning science.

The items in the measure are developed with the three levels of item hierarchy corresponding to the characteristics from the three factors. This items hierarchy is hypothesised to assess the three levels of ability in respondents. Empirical evidence from Chapter 6 will inform the validity of the item hierarchy characteristics and at once give qualitative information to add to the factors that develop along the self-efficacy in teaching using science inquiry skills. The response format for the items will now be discussed.

4.4.2 Response to Items

For all the items, a fixed format of response options is developed to represent the range of the hypothesised responses. The response options in fixed format are chosen to adequately reflect the expression of the respondents to the items. Using fixed format options in obtaining responses might limit the information given, but they describe responses which are significant in the context of the construct measured.

Different responses are expected for every item in correspondence with the various potential abilities in teaching science using science inquiry skills. To measure these abilities, multiple closed-ended items are used to portray tasks drawn upon pre-specific levels of abilities, as above. Tasks are portrayed in the items for measuring pre-specified components (i.e. factors) of the underlying construct. Responses to the items reflect the respondents' perceptions of confidence in their ability to execute the tasks that have been portrayed in the items.

A rating scale with five-point options establishes the range of possible choices that indicate the variability of the perceived confidence in ability to accomplish tasks. The five-points rating scale is used to categorise response properties in terms of confidence in a quantitative measurement continuum. The response options are described from the lowest confidence (i.e. not confident at all) to the highest confidence (i.e. definitely confident). The five-points rating scale is appropriate in representing the gradation range of perceived ability in teaching tasks using science inquiry skills (Toland and Usher, 2015), in which the ability is noted in the construct map visualisation (see Figure 6).

Category options and descriptions represent the magnitude and direction of the five-point rating scale in Table 12. The numerical options for the five categories are used in the instrument to identify the magnitude of the responses in the rating scale. The category descriptions with numerical options are placed in the survey instrument as visual supplements (see Appendix 4 – instrument the SETSIS) to help respondents indicate their magnitude of response in the provided scale.

The rating scale is labelled from category option 1 (lowest confidence) to category option 5 (highest confidence). The category options indicate continuity of learning progress in ability to teach using science inquiry skills. The progress in ability shows the unipolar direction of perceived ability progression. With the unipolar rating scale, respondents are asked to indicate the rating option that best reflects their confidence in ability measured by the item, without a neutral option.

The five category options above relate responses to the self-efficacy progress level explained above by using the scoring order. Responses to the items are scored from 1 – not confident at all – to 5 – definitely confident. The scoring orders are interpreted as indicated in Table 12 according to the construct map. The scores are used to quantify responses into measuring the factors. A total score of responses from all items is summed up to represent the measure and use in a Rasch model estimation to measure the self-efficacy of teaching science using science inquiry skills. The reliability of the five categories to propose an estimation of the respondent's ability is tested in section 6.2.2.1 (i.e.Category functionality).

Table 12 Intensity and direction of categories of responses present in five-point rating scale

Category Option	Category description
1	not confident at all
2	not confident
3	slightly confident
4	confident
5	definitely confident

In summary, the common information regarding abilities that need to be assessed by items in each factor are generally described using the item characteristics in the hierarchy. The response abilities in the factors explicitly clarify the component structure of the construct. The descriptions help to guide item construction for the SETSIS instrument. The items are connected to the responses using the five categories option in the rating scale. The response options correlate the perceive abilities in the construct's components (i.e. the three factors) with the measure of the SETSIS. The same direction and intensity are used in five category responses of the rating scale measuring the same continuum of the construct.

4.5 Items Construction

4.5.1 Generating items

Items generated in the SETSIS correspond to the construct's component with an appropriate level of the items' hierarchy. The items are chosen to assess not only which of the factors' characteristics represent the underlying construct but also assess the depth in measuring the self-efficacy in the construct. Items generated in relation to the construct framework have focussed on the pre-specified elements that need to be measured. This allows the construct to be measured within the items and the self-efficacy to be measured between the items.

4.5.1.1 Sources of items

In this study, the several existing scales and items regarding self-efficacy in science education are adapted to the context of teaching science using science inquiry skills with the addition of new items constructed where necessary. Table 13 shows four pre-existing sources that are used to generate initial items for the SETSIS. All are sources used to measure teacher efficacy in science education.

Table 13 Sources of items pool

Sources	Number of item(s)			Total
	KE	PTE	OBE	items
TSI (Smolleck 2004)	14	20		34
SETSKIST-R (Pruski 2013)	10	2	2	14
Self-efficacy for secondary school physics teachers (Barros et al. 2010)	9	2	11	22
Students' Motivation Towards Science Learning (SMTSL) (Tuan et al. 2005)		5	7	12
New item	6	8	3	17
Total items	39	37	23	99

Teaching Science Inquiry (TSI) measures (Smolleck 2004) contributed 34 percent of the items in the SETSIS. Essential features of the scientific method inquiry instruction as captured in TSI reflect the definitions of KE and PTE. The items chosen reflect the relationship between the operational and conceptual definitions of the dimensions.

Twenty-two percent of the items were taken from a measure of self-efficacy for secondary school physics teachers (Borros et al. 2010). The items were chosen to emphasise the efficacy of laboratory activities which were adapted to fit the context of the SETSIS measurement construct. The items were distributed according to appropriate definitions among the three factors.

There were ten items taken verbatim from SETAKIST-R into KE. SETAKIST-R (Pruski et al. 2013) is a revised measure of the self-efficacy of the knowledge component of teaching science. Though SETAKIST-R measures underlying self-efficacy in knowledge, there were four items adapted into PTE and OBE to suit the operational concept of the factors.

Items were adapted from the self-efficacy scale of a measure called Students' Motivation towards Science Learning (SMTSL) (Tuan et al. 2005) to reflect PTE and OBE. Five items were adapted into PTE in order to describe personal hindrances in completing teaching tasks; another seven items were adapted into OBE to reflect influence of beliefs of the efficacy in science learning, which are congruent with the definition of OBE.

Additionally, new items in KE were constructed to meet all the SPS that were not highlighted in the pre-existing sources. The new items for PTE and OBE were constructed to specify the challenges of teaching inquiry science in the context of the Malaysian primary science curriculum. All items are developed and chosen to manifest the theoretical factors into realisation of the construct of the SETSIS.

4.6 Content and Format Validation

In this section, the items pool for the three factors generated (refer to Chapter 3) was used to establish items for the SETSIS measure. All the items are arranged according to the hierarchy within the three factors. A questionnaire survey consisting of all 99 items in the pool was sent for translation into the Malay language.

The back-translation technique (Brislin 1970) was used to translate all the sample items of the SETSIS from the source language (English) into the target language (Malay). First, a certified translator with science education background was chosen to translate the items in forward translation. The bilanguages versions were compared and some iterations were made in target language based on suggestion received from the content experts panel (see 3.6.1)and pre-test survey (3.6.2). Then, it was given to another translator for backward translation (i.e. back into source language). The two source language versions were compared and evaluated. There are some discrepencies in the words used, but are semantic equavelence.The final questionnaires were composed in a dual-language format (Malay and English) for a complete set for experts use in content validation .

4.6.1 Expert Review

Expert review is one of the construction phases of the SETSIS. The panel consists of 10 experts with a range of relevant expertise (represent in alphabet listed in Table

14), chosen on the basis of expertise in knowledge and teaching experience in the field of science teacher training for more than 10 years. The expert panel provides general insights regarding face validity and content validity of the items listed for the intended measure purpose of the SETSIS. A survey consisting of 99 statements from the items pool above (see Appendix 5) is given out to the experts for their judgement. The survey of item consent aims to gain experts consensus on the need of listed items for KE, PTE and OBE. Obtaining expert consent for the items would establish the validity of contents in items used in the measure.

Table 14 Expert panel list

Expert panel	Area of expertise
A	Science Education research
B	Science Education practice
C	Science Teacher Training
D	Science Teacher Training/Science laboratory and resources management
E	Science Teacher Training/Science laboratory and resources management
F	Biology Education/Science Teacher Training
G	Science Teacher Training/Physics education
H	STEM Education (Science Process Skills, Science Education, Learning Environment, Assessment and Evaluation) research
I	Education measurement/Science Teacher Training/Curriculum design
J	Science Teacher Training/Continuous Professional Development

The agreement on the items screening criteria are rated using a five-point Likert scale. Each expert evaluates the relevance of items in terms of the item's functionality to the factors' purposes, activity statements that correspond with the factors' purposes and statements are appropriate within the item hierarchy measured. They express their agreement in five categories of the Likert scale (1=

entirely disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = entirely agree). Experts also have the opportunity to express their opinions regarding the content and terms used in the listed items according to the factors by writing comments and suggesting items that they think fit the purposes. The details about the design and method of expert review were described in Chapter 3.

4.6.1.1 Results and Analysis of the Item Content Survey

Table 15 shows that the median scores (i.e. referring to the five categories of Likert scale) in all items are above category 3, whereas the interquartile scores range from 0 to 2.25. The median scores for all items except for K20 show majority agreement with category 4 = agree and category 5 = entirely agree with statements listed in the survey. However, the interquartile values reflect different levels of opinions exist among the experts. The interquartile scores determine level of consensus as follows:

> *Interquartile 0 to 1.00; high consensus level,*
> *Interquartile 1.01 to 1.99; average consensus level, and*
> *Interquartile 2.00 and above; no consensus level.*
>
> (Habibi, Jahantigh and Sarafrazi, 2015)

The median scores show a majority opinion about the relevant items while interquartile scores shows the relationships between the items with individual opinions. For example, item K4 ("*I feel comfortable with my experimenting knowledge in order to improvise if the scientific apparatus needed is not available"*) shows a median score at 5 which means that the majority of the experts scored 'entirely agree' in the statement of K4. However, the interquartile value of 2.0 reflects that not all the experts have agreed with the majority opinion; thus, there is no consensus level achieved in the statement of K4. The above results in Table 15 give indicative information on the experts' agreement in the items pool. The result here is subjective as some experts' opinions are not reflected in the others. The next analysis is conducted to determine the complete opinion and accurate results from the expert panel.

Following a similar methodology to Cheng and Lin (2002), analysis using fuzzy Delphi method (FDM) below (section 4.6.1.2, section 4.6.1.3 and section 4.6.1.4) use the fuzzy score to yield a distance (d) between an individual fuzzy score and group average fuzzy score (see details in Chapter 3). The expected range of consensus should yield d less than or same as the threshold value of 2.0 ($d \leq 0.2$). An acceptable consensus value of d reflects agreement of the individual experts with the item statement, which aligns with the group range consensus. Table 16, Table 17 and Table 18 show the frequency and percentage of experts that state opinions within the expected range of the group panel consensus (d≤0.2) in the items' statements according to the factors.

Table 15 Response statistics for the items reviewed by the expert panel in the Expert Survey

Item	Median	Interquartile	Item	Median	Interquartile	Item	Median	Interquartile
K1	4.0	0.5	K34	4.5	1.3	P28	5.0	0.3
K2	5.0	1.0	K35	4.5	1.3	P29	5.0	0.3
K3	5.0	0.0	K36	5.0	1.0	P30	5.0	1.0
K4	5.0	2.0	K37	5.0	1.0	P31	5.0	1.0
K5	5.0	1.0	K38	5.0	1.0	P32	4.5	1.0
K6	5.0	1.0	K39	5.0	1.0	P33	5.0	2.0
K7	5.0	1.0	P1	5.0	1.0	P34	4.5	2.3
K8	4.5	1.0	P2	5.0	1.0	P35	5.0	2.0
K9	4.0	1.3	P3	5.0	2.3	P36	4.0	1.0
K10	4.5	2.5	P4	4.5	2.3	P37	5.0	1.0
K11	4.5	2.3	P5	5.0	1.0	B1	5.0	0.3
K12	4.5	1.0	P6	5.0	1.0	B2	5.0	0.0
K13	5.0	1.0	P7	5.0	1.0	B3	5.0	0.3
K14	5.0	1.0	P8	4.5	1.3	B4	5.0	1.0
K15	4.0	0.5	P9	5.0	1.3	B5	4.5	1.3
K16	5.0	1.0	P10	5.0	0.3	B6	5.0	1.0
K17	4.0	2.3	P11	5.0	1.5	B7	5.0	1.0
K18	4.5	2.5	P12	4.5	1.0	B8	4.0	0.5
K19	4.0	1.3	P13	5.0	1.0	B9	4.0	1.0
K20	3.5	2.3	P14	5.0	1.5	B10	4.5	1.0
K21	4.5	1.3	P15	4.0	1.3	B11	5.0	2.3
K22	4.0	2.0	P16	5.0	1.0	B12	5.0	1.0
K23	4.0	1.0	P17	4.5	2.0	B13	4.5	1.5
K24	5.0	1.0	P18	4.5	1.0	B14	4.5	1.0
K25	4.0	2.0	P19	5.0	0.3	B15	4.5	1.5
K26	4.5	2.3	P20	5.0	0.3	B16	4.0	1.3
K27	4.5	2.3	P21	5.0	1.0	B17	4.5	1.3
K28	5.0	1.0	P22	5.0	1.0	B18	4.0	1.3
K29	5.0	1.0	P23	4.5	1.0	B19	4.0	1.0
K30	5.0	1.0	P24	5.0	1.0	B20	5.0	1.0
K31	5.0	1.0	P25	5.0	1.0	B21	5.0	1.0
K32	4.5	1.3	P26	4.5	1.3	B22	5.0	1.0
K33	4.0	2.0	P27	4.5	1.0	B23	4.5	1.0

4.6.1.2 Knowledge Efficacy (KE)

Table 16 FDM analysis shows all items except K4 have received consensus in the content of items' statements. However, the percentage of group consensus is calculated, showing more than 75 percent consensus among the expert panel shows items are acceptable for the SETSIS. Only 25 items of KE achieved more than the 75 percent panel group consensus for having good content validity from the expert panel.

The panel of experts have shown high group agreement on 25 items. The items are considered as items with valid content with which to measure the KE factor. The items are retained for pre-test phase survey of the SETSIS. In contrast, 14 items (K1, K4, K10, K11, K15, K17, K18, K20, K22, K25, K26, K27, K33 and K34) which show less than 75 percent of expert consensus are revised based on written comments received from the expert survey.

Table 16 Analysis result of item panelling for KE

Item	Consensus with d ≤ 0.2	Percentage consensus with d ≤ 0.2	Item	Consensus with d ≤ 0.2	Percentage consensus with d ≤ 0.2
K1	7	70%	K21	8	80%
K2	10	100%	K22	3	30%
K3	10	100%	K23	10	100%
K4	0	0%	K24	9	90%
K5	10	100%	K25	3	30%
K6	9	90%	K26	2	20%
K7	10	100%	K27	2	20%
K8	10	100%	K28	10	100%
K9	8	80%	K29	9	90%
K10	2	20%	K30	9	90%
K11	2	20%	K31	9	90%
K12	9	90%	K32	8	80%
K13	9	90%	K33	3	30%
K14	10	100%	K34	3	30%
K15	6	60%	K35	8	80%
K16	10	100%	K36	9	90%
K17	4	40%	K37	10	100%
K18	3	30%	K38	10	100%
K19	8	80%	K39	9	90%
K20	6	60%			

4.6.1.3 Personal Teaching Efficacy (PTE)

Table 17 shows all 37 item statements of PTE have received various consensus from experts. The frequency and percentage of acceptable consensus shows that 29 items statements have been accepted by more than 75 percent of the panel with good content validity. The analysis shows there are eight (8) items that did not gain enough group majority consensus (more than 75 percent) on measuring the content as needed for the PTE factor. These eight items show less than 75 percent of the panel consensus and are revised based on comments given by the experts.

Table 17 Analysis result of item panelling for PTE

Item	Consensus with d ≤ 0.2	Percentage consensus with d ≤ 0.2	Item	Consensus with d ≤ 0.2	Percentage consensus with d ≤ 0.2
P1	10	100%	P21	10	100%
P2	10	100%	P22	9	90%
P3	1	10%	P23	9	90%
P4	2	20%	P24	10	100%
P5	9	90%	P25	10	100%
P6	9	90%	P26	8	90%
P7	9	90%	P27	10	100%
P8	8	80%	P28	10	100%
P9	8	80%	P29	10	100%
P10	10	100%	P30	10	100%
P11	8	80%	P31	10	100%
P12	10	100%	P32	9	100%
P13	9	90%	P33	7	80%
P14	2	20%	P34	2	20%
P15	4	40%	P35	6	70%
P16	10	100%	P36	10	100%
P17	2	20%	P37	10	100%
P18	9	90%			
P19	10	100%			
P20	10	100%			

4.6.1.4 Outcomes Belief Efficacy (OBE)

Table 18 shows 18 items of OBE with various frequencies and the percentage of experts that have opinions within the expected range consensus (d≤0.2). The frequency and percentage of acceptable consensus shows that 17 item statements have been accepted by more than 75 percent of the panel with good content validity. The analysis shows there are six (6) items that did not gain enough group majority consensus (more than 75 percent) on measuring the content as needed for the OBE factor. These six items show less than 75 percent of the panel consensus and are revised with concern to the comments given by experts.

Table 18 Analysis result of item panelling for OBE

Item	Consensus with d ≤ 0.2	Percentage consensus with d ≤ 0.2
B1	9	90%
B2	9	90%
B3	10	100%
B4	10	100%
B5	9	80%
B6	9	90%
B7	9	90%
B8	8	80%
B9	10	100%
B10	10	100%
B11	3	70%
B12	10	100%
B13	3	30%
B14	10	100%
B15	3	30%
B16	4	40%
B17	8	90%
B18	4	40%
B19	6	60%
B20	10	100%
B21	10	100%
B22	9	90%
B23	9	90%

4.6.1.5 Items Revision

Table 19 lists number implications for items with less than 75 percent consensus. The total to be revised is 28 items, consisting of items from KE, PTE and OBE. All these items received less than 75 percent consensus except for K4. Decisions on the necessity for the items to be removed or reworded are made according to concerns given by the comments/suggestions in the survey.

The items' statements are decided to be reworded based on the comments given, including the following:

- Items have problems in translation. Malay version items did not reflect precise meaning of the English version, especially in the terms used.
- Please reword.
- Malay versions are too long and hard to understand.
- Simplify the questions.
- Please specify the ability of SPS.
- Use terms that describe the Malaysia context.

Based on the comments received, items which received suggestions on terms to use are amended and the items with language problems are reworded. Seven (7) items out of 14 (K1, K4, K10, K17, K18, K22 and K26), it was decided, were reworded based on the comments received.

For instance, Items P3 and P17 were reworded into clearer sentences, while P15 was reworded using terms that described the context of Malaysia. Item B13 was reworded to reflect the concept more clearly. Items B15 and B18 was reworded in order to reflect the belief domain instead of the knowledge and practice domain However, Item P35 (60% consensus) was retained as it shows ability in specific knowledge of using SPS (communication) and Item B16 was retained, even only 60% consensus, for psychometric reasons (to see how a negatively worded item compare to a positively worded item).

On the other hand, seven (7) other items (K11, K15, K20, K25, K27, K33 and K34) were discarded; Items P4, P14, P33 and P34 were rejected; and Items B11 and B19 were discarded on the basis of redundancy based on the comments as follow:

- Questions are not clear.
- Items not measuring the objective.
- More than one factors measured in one items
- Redundancy items
- Not reflecting the practice in a Malaysia context

Table 19 Item revised for 75% less expected consensus.

Item	KE	PTE	OBE	Total
Removed	7	4	2	13
Rephrased and retained	7	4	4	15
Consensus less than 75%	14	8	6	28

Table 20 shows items before the content validity process and the resulting items that will be used in the pre-test survey. The pre-test of the SETSIS contains three factors approved by ten experts with a total of 87 items achieving consensus in content validity. The pre-test survey was conducted on a small part of the sample that represents pre-service science teachers in Malaysia.

Table 20 Items before and after the content validity process

Items SETSIS	KE	PTE	OBE	Total
Items pool	39	37	23	99
Items pre-test	32	34	21	87

4.6.2 Pre-Test Survey Result

The pre-test survey was conducted to check for the survey format and item validity. The survey collected demographic data as well as scores for the 87 items of the SETSIS. First, descriptive statistics outlining the range of background details of the respondents are presented. Then, results regarding the responses to the 87 items are presented. Suitability of the items are checked with the model of expected responses and items considered to be included in the next pilot phase.

4.6.2.1 Descriptive Statistics

Pre-test sessions were conducted on 31 respondents from one of the ITEs in Malaysia (campus KT). The respondents were chosen as a convenient sample and consisted of two groups of PSTs in different training years (third semester and first semester). All respondents were briefed on the purpose of the survey and volunteered to answer the survey at a convenient time.

Table 21 Demographic information

Demographic	Factors	Frequency	Percent	Valid Percent
Semester	1	16	51.6	51.6
	3	15	48.4	48.4
	Total	31	100.0	100.0
Gender	Female	25	80.6	80.6
	Male	6	19.4	19.4
	Total	31	100.0	100.0
Former school	Boarding school	6	19.4	19.4
	Daily public school	23	74.2	74.2
	Others	2	6.5	6.5
	Total	31	100.0	100.0
Entering grades in science subject (Chemistry, Biology and Physic)	1A	3	9.7	9.7
	2As	7	22.6	22.6
	3As	21	67.7	67.7
	Total	31	100.0	100.0

All variables for the demographic data are listed in range of the unordered nominal option. Table 21 shows the option categories collected from the respondents in acceptable range except for former school attended. The existence of other responses in former school variables suggested that the categories option for the variables needed to be emphasised more to cover respondents' information for the variable. All the others variables (Semester, Gender and Entering grades in science subjects) show appropriate responses as intended.

4.6.2.2 Result of the Pre-Test Survey Responses

The results discussed are based on responses collected from pre-test questionnaires consisting of a total of 87 items from the three factors; KE (32 items), PTE (34 items) and OBE (21 items). All respondents managed to complete the questionnaires including the demographic details in less than 30 minutes. This time duration is taken into consideration for time allocation in the next study, the main pilot.

The responses data for all items collected are checked using the rating-scale model of Rasch analysis. Psychometric properties of the 87 items on the pre-test responses (31 respondents) are examined using MINISTEP Version 3.92.1. Summary statistics generated by Rasch analysis in Table 22 show that all 31 respondents completed all the items. Person[1] mean measure at 1.43 (SD=0.92) indicates that average ability among respondents are 1.43 units more than mean item difficulty (item mean measure at 0 (SD = 0.81)). High separation of person (5.18) with high reliability (0.98) indicates that the items are enough to differentiate the sample into seven strata groups of ability performers. The person reliability is also used as a test reliability for Cronbach Alpha KR-20 and indicates that the measure (test) targets the relevant sample well (Bond and Fox, 2007). However, easy item separation (< 3.00) with less than <0.90 item reliability implies that the sample size was not enough to confirm the three groups of item difficulty hierarchy. Thus, the data in the pre-test will now be used to check items that are appropriate for the model but not to distinguish the position of the items in hierarchy.

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[1] For result and data analysis using Rasch, person refers to the respondents of the collected data. Throughout the thesis, it will be used interchangeably.

Table 22 Person Reliability for the SETSIS

Person (31 measured)		Infit	
	Measure	MNSQ	ZSTD
Mean	1.43	1.04	-0.10
SD	0.92	0.46	2.90
Separation	5.18		
Reliability	0.96		
Item (87 measured)		Infit	
	Measure	MNSQ	ZSTD
Mean	0.00	1.00	-0.30
SD	0.81	0.70	2.00
Separation	2.64		
Reliability	0.87		

Compatibility of the data to the expected mathematical model of Rasch was checked using fit statistics. Table 23 lists parameters in fit statistics for items that produce unpredictable responses according to the Rasch model. Parameter point measure correlation (PtMeaCorr) in the items except for B13 show negative value in the linear relationships of the pre-test items. The negative values indicate the opposite direction of measure exists in these items. A check on the pre-test items identified these items as negative statement items with reversed codes entered in the data. Thus, it could be argued that negative statements might mislead respondents' responses. This suggests that all negative statement items should be rephrased.

All items in Table 23 show MNSQ values higher than 1.40 (MNSQ>1.40), which indicates unreasonable noise produced in the responses (Linacre 2002). Extensive checking on these items show that only B13 has statistically significant data (-2.0<Zstd<2.0) with a MNSQ value of 1.5, slightly above the suggestion value of acceptable noise. With a strong, positive correlation showing in PtMeaCorr, Item B13 was retained for next stage.

Table 23 Fit statistic for items with unpredictable responses

ITEM LABEL	PT-MEA CORR	MNSQ	ZSTD	DECISION
P3	-0.3	1.9	3.0	Rephrase (Technically removed)
P6	-0.6	2.3	4.1	Rephrase
P9	-0.4	2.4	4.4	Rephrase
P34	-0.2	4.2	7.6	Rephrase
B3	0.2	3.8	6.8	Rephrase
B12	0.0	3.3	6.0	Rephrase
B13	0.6	1.5	1.7	Retain
B14	-0.2	3.9	7.1	Rephrase

Table 24 lists 12 items with positive and strong PtMeaCorr values that indicate that a single underlying construct is being measured by the items. However, values of MNSQ in all the items show lower than the reasonable MNSQ range accepted (0.6<MNSQ<1.4) in rating scale models (Wright and Linacre 1994). It means that all the items produce redundancy responses which are easily predicted and less productive for measurement (Linacre 2002) in which case the data show they are not statistically significant (Zstd<2.0) to the measure. This suggests that all 12 of the items should be considered for removal in piloting.

Table 24 Fit statistics for removed items

Item Label	PtMeaCorr	MNSQ	ZSTD	Implication
K1	0.7	0.5	-2.2	Remove
K12	0.7	0.5	-2.4	Remove
K20	0.7	0.5	-2.4	Remove
K23	0.7	0.5	-2.3	Remove
K27	0.8	0.5	-2.1	Remove
K31	0.7	0.5	-2.5	Remove
P1	0.8	0.4	-2.9	Remove
P26	0.7	0.5	-2.5	Remove
P29	0.8	0.4	-2.8	Remove
B1	0.9	0.6	-2.1	Remove
B7	0.8	0.6	-2.1	Remove
B9	0.8	0.6	-2.1	Remove

Figure 7 Wright map: distribution of person ability (left) and item difficulty (right)

```
 PERSON - MAP - ITEM
      <more>|<rare>
 4          +
            |
            |
            |
           T|   P6
 3      XX  +
         X  |
        XX  |
         X S|   P3     P9
        XX  |
 2      XX  +   B14
       XXX  |
       XXX  |T
         X M|   B12    K18    P34
       XXX  |
 1       X  +
        XX  |S K10    K17    K2     K7     P10    P11
         X S|   K13    K25    K31    K6     P14
       XXX  |   B3     K1     K5     K9     P17
         X  |   K12    K14    K15    K24    K26    K27    K30    K8     P18
                P23
 0       X  +M K11    K3     K32    K4     P12    P15    P16    P22    P26
                P29    P31    P33    P8
         X  |   K16    K21    K23    K28    P1     P13    P2     P24    P25
                P30    P7
         X T|   K22    K29    P28
            |   B18    B19    B20    B7     B8     K19    P19    P20    P21
                P32    P4
            |S B10    B16    B17    B9     P27    P5
-1          +   B11    B13    B15    B21    B4     B6     K20
            |   B1     B2     B5

            |
            |T
            |
-2          +
      <less>|<frequ>
```

Figure 7 shows a Wright map that represents conjointly person ability and item difficulty plotted on the same scale. The map visualises the ability estimation of each person (marks by ‘x’ on left of the map) to the difficulty estimation of each items (marks using item labels on the right of the map) based on the responses given to the items. The distribution of items overlaps the distribution of person, indicating that the difficulty ranges of the items listed in the survey appropriately target the abilities of the respondents. It could, however, be argued that the horizontal gaps between the items show there were not enough high items to differentiate persons of top abilities of the map. Further investigation will be conducted with a bigger sample in the pilot study.

In summary, the result of the Rasch analysis of the re-test survey data suggests a total of 72 items selected with four variables of demographics included for piloting (see the attachment for full questionnaires of the Main Pilot Survey.) Table 25 shows the development of items for the SETSIS in the three phases of item construction.

Table 25 Items construction of two phases

Result of Analysis	KE	PTE	OBE	Total
Experts review	32	34	21	87
Pre-Test	26	28	18	72

4.7 Summary of Chapter Findings

This chapter provides the initial framework to construct the measure of the SETSIS. The proposed factors emerged from contemporary research in TSE belief that have been defined and used to establish a construct framework for the SETSIS instrument. The framework through which the construct map hypothesises the items-responses of the SETSIS using the three factors to measure the latent variable. The construct map was developed to estimate level of self-efficacy in teaching using science inquiry skills that corresponds to the development of learning to teach in teacher education. It estimated the measurements of the construct of self-efficacy in teaching using science inquiry skills from the lower level that predicted belief of OBE to belief of KE and finally in belief of PTE. The estimated items-responses mapped in the construct continuum is able to reflect the development of the measure in teaching using science inquiry skills.

The construct map is able to guide the item generation and construct the responses options for the SETSIS. The items were rigorously generated based on the three levels of the item hierarchy to measure the proposed ability as mentioned in the construct framework. The items and responses options were generated to represent the continuity of the construct. It is important for meaningful measurement responses of intended variables.

Finally, this study was able to present evidence of the validity of the content of construction of the SETSIS instrument. Through an iterative process, items designed to measure the construct were reviewed by experts in areas of science education and science teacher training. Evidence presented confirmed that experts agreed to the initial 87 items used to measure the construct. The initial items were then given to 31 respondents in pre-test surveys. The responses suggested high test reliability at 0.96. Evidence in the data survey using the Rasch model fits the statistic, suggesting that 72 items were productive in the measurement. The 72 items were used in the main study in Phase 2.

Chapter 5 Developing the SETSIS measure

This chapter presents the analysis and results from the data collected for the main study of the SETSIS. Results from this provide the first groundworks in testing the feasibility of the instrument in measuring the intended variables within the targeted population. The outcomes arising are combined to inform the model development.

5.1 Introduction

In this phase, a total of 72 items were administered to 325 respondents who are enrolled in the Bachelor of Teacher Programme (BoTP), majoring in science primary education. In the surveys, the SETSIS instrument consists of four parts of questionnaires. Parts I to III include items from the three subscales of the SETSIS accordingly. Part I comprises 26 items (K1 to K26) of the subscale of Knowledge Efficacy (KE) which measure the self-efficacy component in the science inquiry skills knowledge. Part II comprises 28 items (P1 to P28) of the subscale of Personal Teaching Efficacy (PTE), which measures the self-efficacy in teaching practice. Part III comprises 18 items (B1 to B18) of the subscale of Output Belief Efficacy (OBE) which measure the perceived belief in outcome values of learning using science inquiry skills. Additionally, Part IV of the instrument consists questionnaires about background information of respondents.

This chapter mainly provides the report and the analysis to answer the study's RQ2 – *What are the psychometric properties of the SETSIS when used with science PSTs in Malaysia?* In section 5.2, the demographic information about the participants is presented. Then in section 5.3, descriptive and inferential statistics were performed to reveal information about the responses in a general trend of self-efficacy in teaching using science inquiry skills, scoring differences in the SETSIS across the group levels of pre-service science teachers in Malaysia and the group of background factors' interaction that might exist in the responses given to the SETSIS. Next, in section 5.4 exploratory factor analysis (EFA) was performed to determine the factors that explain the latent construct of the SETSIS from the interrelated items constructed earlier. Finally, the summary of the key findings will be presented in section 5.5.

5.2 The respondents

5.2.1 Who are the respondents?

The data show that the respondents in the main survey were made up of PSTs from various groups and levels that represent the population of PSTs majoring in Primary Science Education in Malaysia. The group levels were defined by the semester of study. The BoTP offers a total of eight semesters of study in total to complete the training. The admission to the programme, however, was offered in cohorts (groups) of semesters and did not happen for every semester of study. The recruitment for BoTP majoring in Primary Science Education was granted as projected by MOE in teachers requirement in the field (primary science education) . At the present time of the study, the BoTP has six cohorts of PSTs in semesters 1, 3, 5, 6, 7 and 8 majoring in Primary Science Education study (source: Department of Exams and Senate, Institute of Teacher Education of Malaysia 2016).

. **Table 26 Background information of the respondents**

Demographic	Factors	Frequency	Percent
Semester	1	65	20.0
	3	44	13.5
	5	61	18.7
	6	70	21.5
	7	10	3.1
	8	74	22.7
	Total	**325**	**100.0**
Gender	Female	227	69.8
	Male	98	30.2
	Total	**325**	**100.0**
Ethnic	Malay	104	32.0
	Chinese	133	40.9
	Indian	52	16.0
	Others	35	10.8
	Total	**324**	**99.7**
School attended	Boarding school	37	11.4
	Daily public school	221	68.0
	SMJK	41	12.6
	Others	24	7.4
	Total	**323**	**99.4**
Science qualification (Chemistry, Biology and Physic)	1'A'	47	14.5
	2'A's	88	27.1
	All 'A's	138	42.5
	None A in science subject	51	15.7
	Total	**324**	**99.7**

Table 26 represents the background information of the cross-sectional sample of respondents for the study. The frequency table shows a total of 325 respondents from across 12 campuses of ITE in the current year of study, June 2016. In total, the respondents group of semester 7 is represented only by approximately 3% of the sample as it was sufficient to represent the total of 19 pre-service science teachers that were currently in semester 7 for the programme all over Malaysia. Further, almost 70 percent of the respondents were female compared to only just over 30 percent of male PSTs. This ratio is approximately similar to those surveys of Teacher's Sense of Efficacy Scale in PSTs (Tschannen-Moran and Hoy 2001; Duffin et al. 2012).

Additionally, the table shows information on the backgrounds in ethnicity, former school attended and grades in three science subjects (Physics, Biology and Chemistry) in the Malaysia Certificate of Education (SPM), which is equivalent to the British GSCE. These background characteristics will inform my research as independent factors that might or might not influence responses in the measure in later analysis. Next, the data of responses to items are tested for statistical representation of the SETSIS.

5.3 Analysis of responses

5.3.1 Descriptive statistics

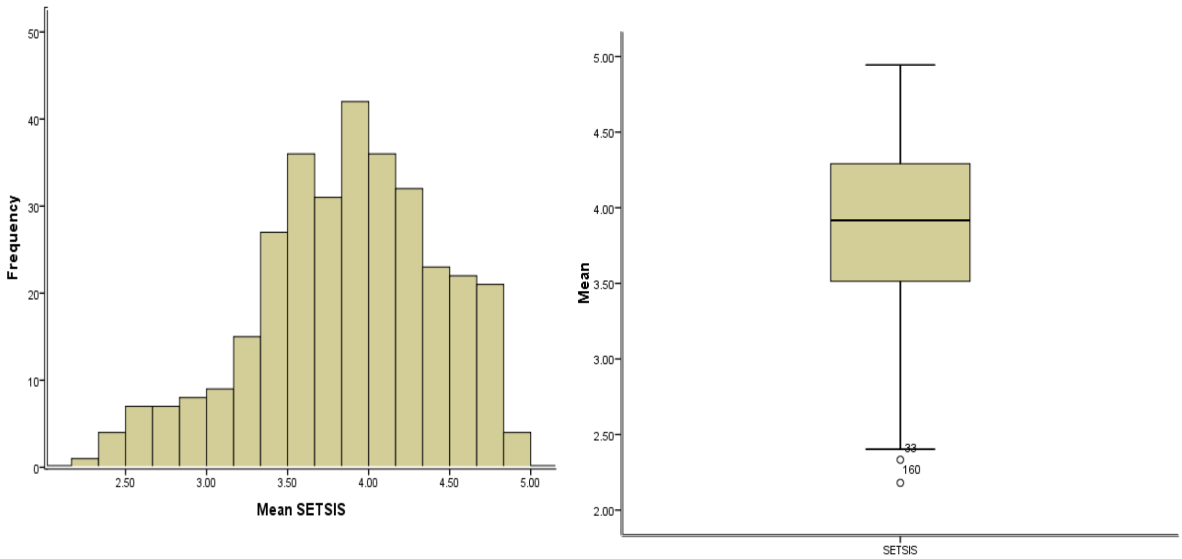
Table 27 Summary statistics of responses in the SETSIS measure

	Minimum (Min)	Maximum (Max)	Mean (M)	Standard Deviation (SD)
Cumulative score	157.00	356.00	278.65	41.15
Mean score	2.18	4.94	3.87	0.57

Table 27 shows the summary of statistics responses to the items tested in the SETSIS. The responses were scored based on the rating category chosen. The total cumulative score for all the items in the SETSIS is 360 (72 items x 5 categories). The respondents' cumulative scores show a wide range of responses from the minimum 157 to the maximum 356. The mean score range indicated that responses vary from the minimum (average) response in category 2 (2.18), which represents the response of *not confident*, to the maximum (average) response in category 5 (4.94), which represents the response of *definitely confident* to the items administrated. Overall, the result indicates that the data collected using the instrument developed is able to reflect various confidence levels within the range of categories provided in assessing self-efficacy among the respondents in teaching using science inquiry skills.

Figure 8 illustrates the distribution of the 325 responses in mean score. The histogram shows the frequency of responses with significant shape of normal distribution (Shipiro-Wilk test = 0.98, df=325, p<0.001). Visual analysis on the error bar on the right side of Figure 8 indicates that distribution of the data is fairly symmetric (Median = 3.92). The figure, however, marks two extreme responses at the bottom. A close check on the mean score (M) of the two individual responses confirmed the responses are within the acceptable range (-2.0 <M<+2.0) (Field, 2013) and not considered as outliers.

Figure 8 (Left) Histogram of the SETSIS responses and (right) a box and whisker plot



5.3.2 Outliers

The visual analysis in Figure 8 did not find sufficient evidence for the outliers. For the SETSIS, which consists of three subscales, potential outliers are detected and decided from examination of every subscale from the perspectives of univariate, bivariate and multivariate variables (Hair *et al.*, 2010), as shown in Table 28. Within the perspective of the univariate, outliers were identified from the standard distribution of observed scores (Z score) in each subscale. The outliers listed in Table 28were cases that fall at the lowest or highest standards more than ±2.5 of Z-score.

From the perspective of bivariate, the scatterplot from each set of subscales were examined for outlier detection. Observation cases that distinctively fell out of typical distribution were identified and listed as potential outliers inTable 28. For multivariate perspectives, outliers were inspected using Mahalanobis distance (MD) analysis. This diagnostic method measures the position of each observation compared with the centre of all observations on a set of three subscales. The potential outliers listed in Table 28 exceeded critical chi-square value of 16.27 at degree of freedom (df=3) and alpha level=0.001 (critical chi-square value (df=3)16.27, p<0.001) (Pallant, 2013).

Table 28 Univariate, bivariate and multivariate potential outliers profile

Univariate Outliers		Bivariate Outliers		Multivariate Outliers	
Variable	Cases with standardised value exceeding ±2.5	Bivariate	Cases fall outside the typical distribution	Cases with a value of Mahalanobis distance (MD) exceeding Critical Chi-Square value 16.27	
				Case	MD
KE	TR3 , PT9, PT42, PT1	KE with PTE	PT9,PT43,PT42,TR3	TR25	16.95
PTE	PT9, PT43, PT42,BL10, IP8	KE with OBE	TR3,PT9,PT42,PT25	PT42	17.25
OBE	PT2,PT17, IP9, IP7, TB18	PTE with OBE	PT9,PT42,PT43,PT25	PT43	17.89
				TR3	107.01

The univariate observation found that samples PT9 and PT42 occurred in more than one variable and were repeatedly detected in bivariate and multivariate detections. It was also noted that PT43 and TR3 were detected in only one variable in the univariate but also occurred repeatedly in bivariate and multivariate detection analysis. Meanwhile, PT25 contained the observation that uniquely affected the combination subscales in bivariate and multivariate analysis but not in univariate.

All the potential outliers offer uniqueness of information to the study, but as the main aim of the study is to explore and assess the validity and reliability of the measurement model, the decisions are based on the representatives of the measured population (Field, 2013). From a practical standpoint, the extraordinary observations that appeared repeatedly across subscales represent unique elements of population. Thus, this analysis will include all the outliers except TR3. TR3 had the most extreme, lowest value in KE that affected the bivariate measures of sets that combined with KE (KE with PTE and KE with OBE) and again appeared in multivariate detection, massively exceeding the critical chi-square value. Therefore, TR3 will be omitted from further analysis and considered as an extraordinary event, which only accounts for the uniqueness of observation but does not represent the population. Thus, the next analysis will now on use responses from 324 respondents (n=324) without responses from TR3, unless otherwise notified.

5.3.3 Reliability and normality of the responses data

Table 29 Reliability and normality test of the SETSIS data

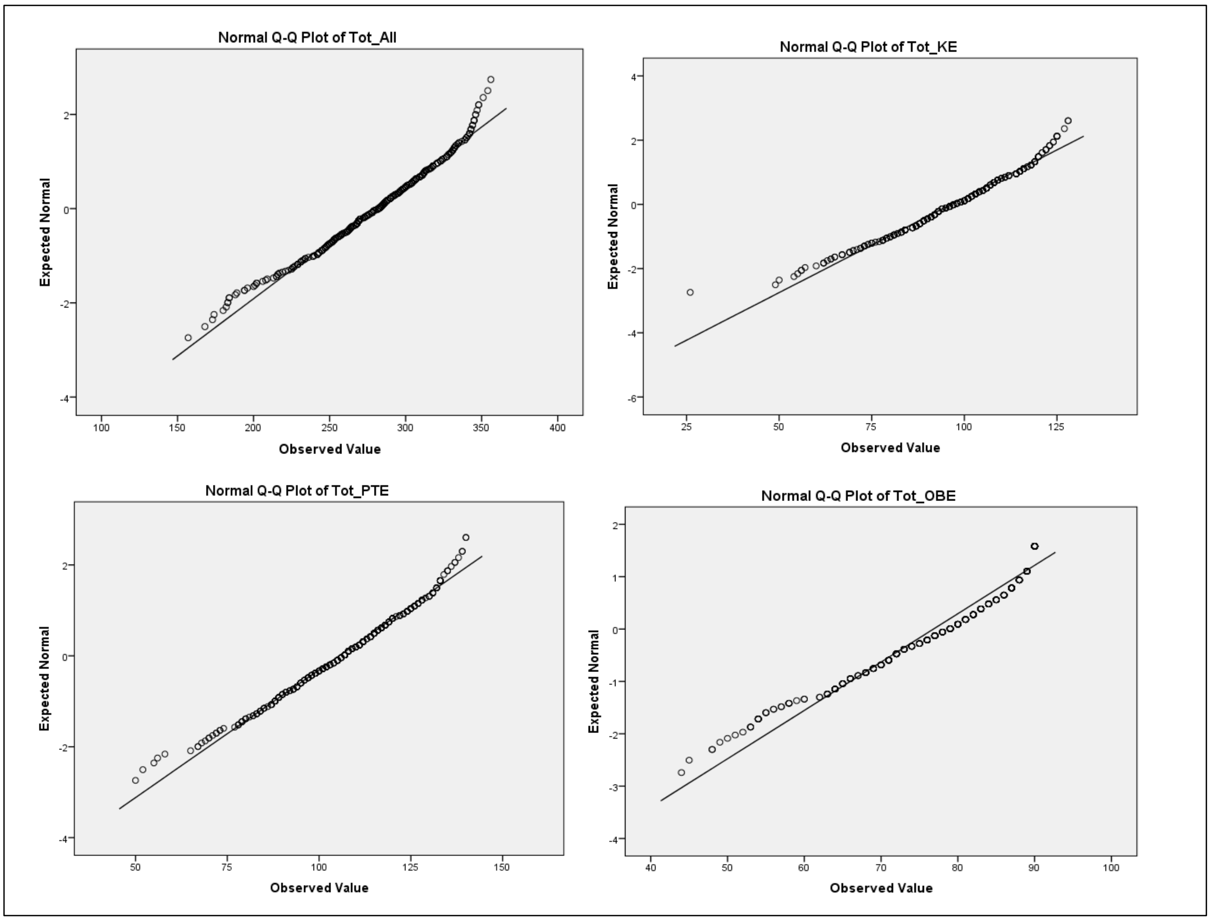
Subscales/ scale	Reliability,α (Cronbach's Alpha)	Skewness	Kurtosis	Shapiro-Wilk Normality Test		
				Statistic	Df	P value
KE	0.96	-0.42	-0.14	0.98	324	.00
PTE	0.97	-0.40	-0.01	0.99	324	.00
OBE	0.96	-0.74	-0.11	0.93	324	.00
Overall the SETSIS	0.98	-0.45	-0.14	0.98	324	.00

The reliability of the response data within the targeted sample in the study are checked using Cronbach's alpha consistency measure, and the results are shown in Table 29. The Cronbach's alpha coefficients for the SETSIS including individual subscales show excellent reliability (α>0.9) (Kline, 2005). This means that the SETSIS has shown consistency in the measure taken. The total of 72 items have shown good internal consistency as a scale. The high reliability in three subscales also indicates good internal consistency between the items accordingly. The results confidently reflect that the SETSIS instrument used in the study is able to produce a consistent measure within the sample distribution and thus can be generalised for the targeted population.

Additionally, Table 29 provides the results of the normality test. The Shapiro-Wilk test is used to detect the normality of responses from the data distribution. The negative skewness values for all the subscales reflect that the data inclined toward the higher category of responses. Figure 8 shows visualisation checks for the data distributions. The histograms show a visible inclination to the right especially in OBE. Instead, the kurtosis values are approximately 0 which apparently show a light tails in the data distribution. The data then were checked further for normality.

Cross checking with the Q-Q (quartile-quartile) plot in Figure 9 for each subscale and the overall scores illustrated that the data are distributed along the normal line and do not divert far from the normal line. A normality test has then confirmed a significant departure from the normal distribution of the data in the SETSIS and the three subscales at $p< 0.05$. These results are statistically allowed for the outcomes of the SETSIS to be generalised and compared to the targeted population (Glass et al. 1972). Next, inferential statistics will be used based on the descriptive data of responses to describe and make inference in the population.

Figure 9 Q-Q plot for overall the SETSIS (upper left), KE (upper right), PTE (lower left) and OBE (lower right)

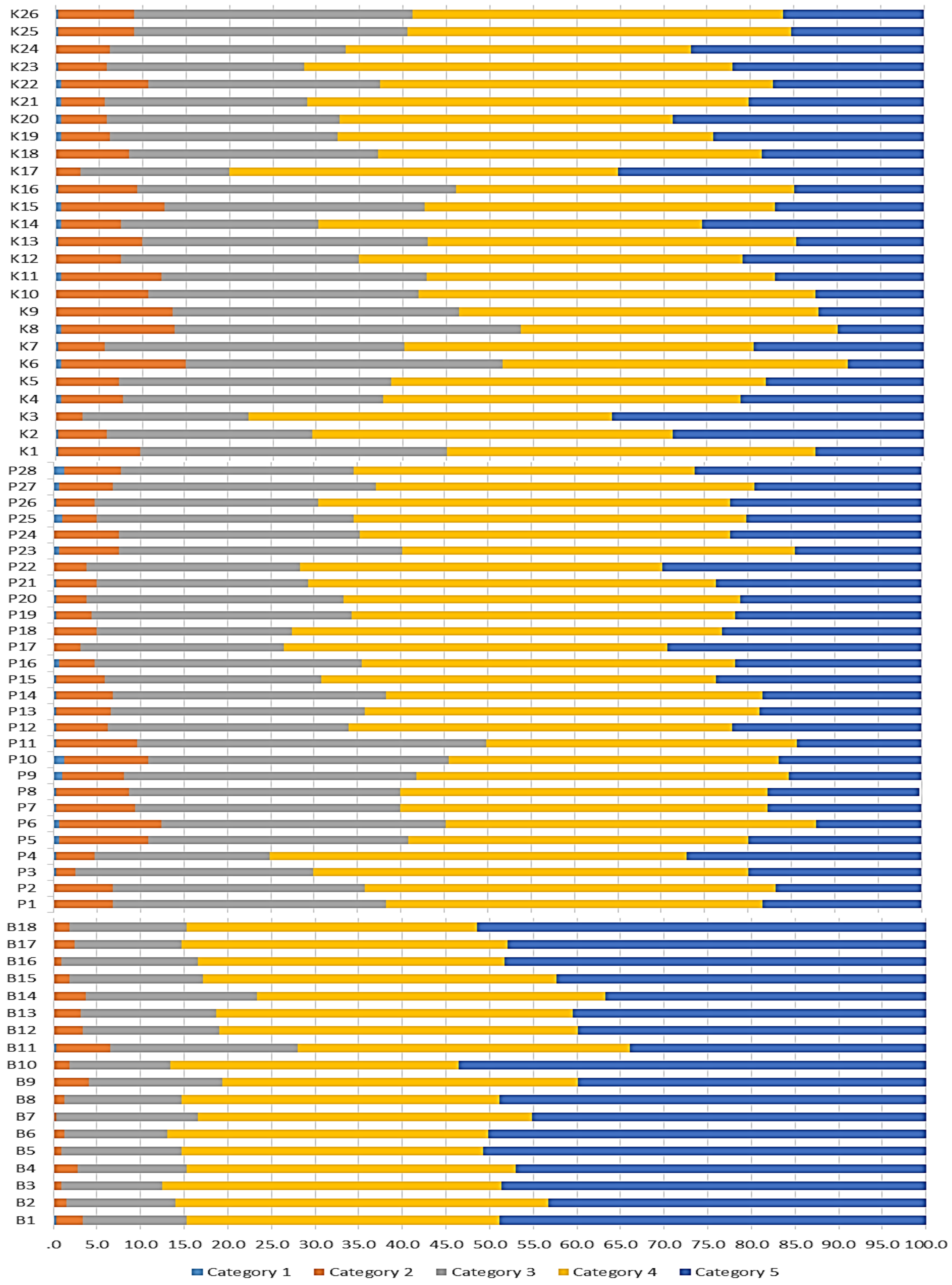


5.3.4 Responses according to subscales

Figure 10 shows the frequency of responses to the items using the same rating scale with five categories of responses (see section 4.3.3) across the three subscales. The frequency graph has illustrated patterns of responses in the items accordingly. Even though there are variations in responses throughout the five rating categories, the responses pattern shows very high affirmation in the three higher categories, which are categories 3, 4 and 5. The pattern of the responses in the later categories is clearer at the bottom part of

Figure 10, for the items in the OBE subscale. The majority of the items in OBE received more than 95 percent response affirmation in category 3 and above. The pattern of the responses indicates that most responses showed a perceived high level of confidence in their self-efficacy in teaching science using science inquiry skills, especially for their self-efficacy of OBE.

Figure 10 Frequency (in percentage) of responses in category across the subscales KE (top) PTE (middle) and OBE (bottom)



The pattern of the responses above has been confirmed with the statistic of mean scores in Table 30. The results show that the highest mean score was in OBE, followed by PTE and then KE. The result in this study suggests a higher mean score of outcomes expectancy in teaching using science inquiry skills compared to the mean scores in outcomes expectancy scales in the TSI study (mean=3.85,s.d.=0.40) (Smolleck, Zembal-Saul and Yoder, 2006).

However, the mean score in KE shows the widest difference in score range, which demonstrates that the responses show more variability range in KE compared to PTE and OBE. This can be an early indication of KE as one of the prominent features in self-efficacy measure among PSTs.

Table 30 Mean and range of responses' score in KE, PTE and OBE

Sub-scales	Mean(SD)	Range		
		Minimum	Maximum	Difference
KE	3.72 (0.65)	3.40	4.10	0.70
PTE	3.76(0.63)	3.53	3.99	0.46
OBE	4.27(0.60)	4.00	4.30	0.30

Referring to the rating scale, the mean score statistics indicate the general category endorsed by the respondents in each subscale. The response variability in KE is reflected from the minimum (mean) score at above 3.00 to the maximum at just over 4.00. This result indicates the responses were in general in between the category 3 (*slightly confident*) and category 4 (*confident*). Perhaps, the responses in KE show uncertainty in self-perception of the knowledge of teaching using SIS, which might reflect PSTs' learning phase during the training programme (Palmer, 2011).

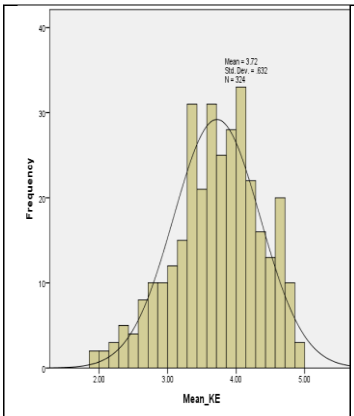
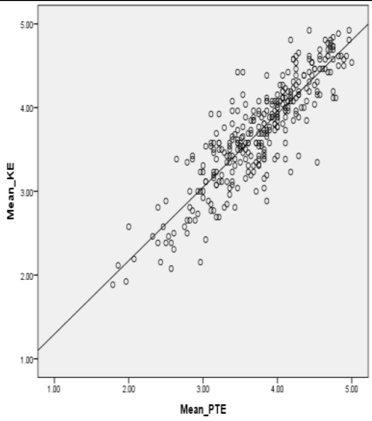
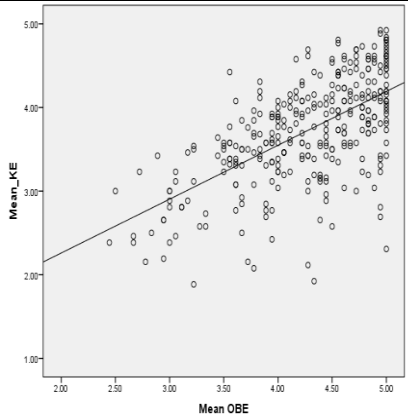
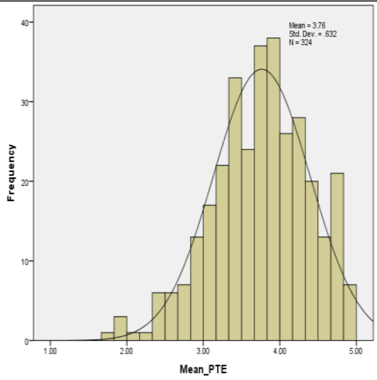
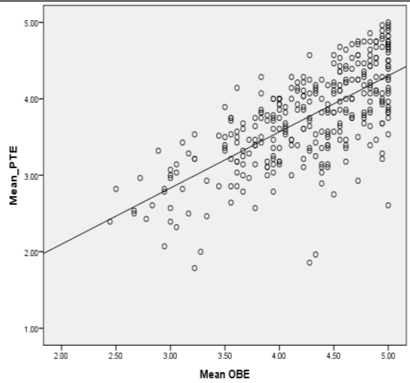
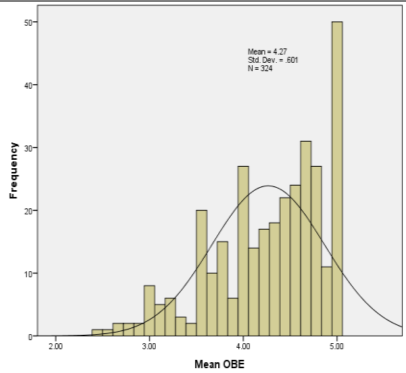
In parallel, the responses in PTE with mean scores below 4.0 indicates that in general, the respondents' perceived their personal capability in teaching were below the category 4.0 (confident), which reflects below confident level. Contrarily, the responses in OBE demonstrate mean scores above category 4.0, indicating that, in general, the respondents' OBE was above the confident level. The patterns reflect that PSTs perceived that their personal capability in practicing science inquiry skills in the classroom (as reflected in PTE) was not as confident as their perceived confidence in their belief in the value of learning using science inquiry skills in the classroom (as reflected in OBE).

The response data from the items were analysed for relationship across the subscales. Table 31 summarises the results with the bivariate profile accordingly.

Firstly, the table diagonally profiles the distribution illustrated using the histogram. As expected, the responses disperse with negative skewness on normality distributions except for OBE, which shows as non-symmetrical but within the normal line distribution, as discussed in the above result.

The relationship between the three subscales, KE, PTE and OBE, was assessed using Pearson product moment coefficient and scattered plot. The resulting coefficients are shown below the table's diagonal line. The relationships between the variables is then illustrated in the scatter plots above the table's diagonal. The results indicate the three bivariate relationships that are significantly positively correlated with various strength. The analysis demonstrated that the strength between KE and PTE ($r= 0.82$ ($p<0.01$) is the strongest of the three. They closely align in the scatter plot with a linear pattern indicating that the data have a strong association between the two components of self-efficacy. On the other hand, the scatter plots involving OBE shows a quite scattered points when associating between KE and PTE. However, both bivariate plots show a positive, with a linear pattern that gradually concentrates towards the upper end. Pearson coefficients have statistically determined that OBE has a stronger association with PTE rather than KE. The coefficient between OBE-PTE shows a higher relation magnitude, $r=.70$ ($p<0.01$), compared with the OBE-KE relation magnitude at $r = 0.58$ ($p<0.01$).

Table 31 Profiling of relationship between subscales: values below the diagonal are bivariate correlations, with corresponding scatterplot above the diagonal. Diagonal portrays the distribution of each subscale

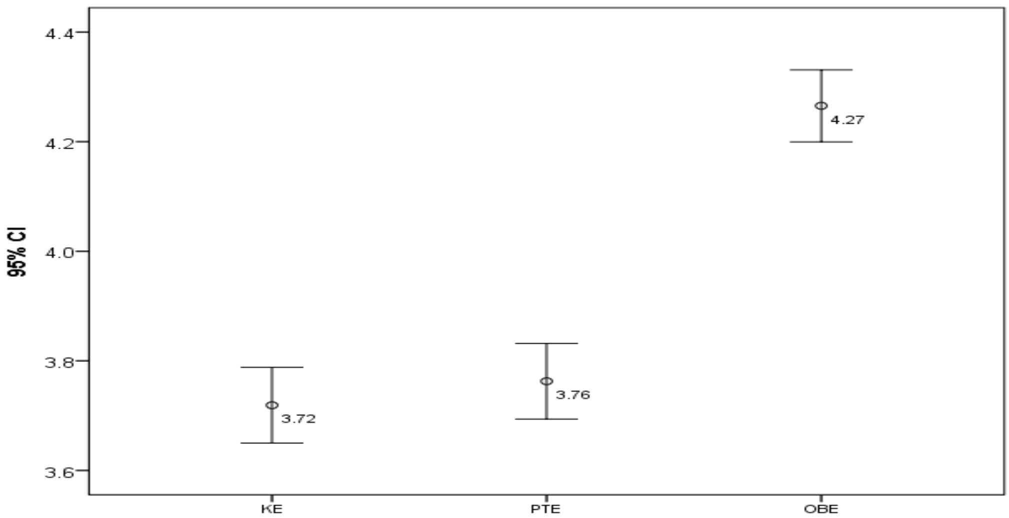
<table>
<tr><th></th><th>KE</th><th>PTE</th><th>OBE</th></tr>
<tr><td>KE</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>PTE</td><td>0.82</td><td>
</td><td>
</td></tr>
<tr><td>OBE</td><td>0.58</td><td>0.70</td><td>
</td></tr>
</table>

These results reflect that PSTs' perceived belief of outcomes learning of using science inquiry skills (i.e. OBE), has a stronger relationship with the perceived capability of teaching practice using science inquiry skills (i.e. PTE), than it is with perceived ability in the knowledge possession (KE). However, all the correlations suggest large-effect size correlation between the three subscales (Cohan 1998). Thus, it can be presumed that self-efficacy in the three subscales is positively proportional with a high relevance across the three proposed factors in the model. Next, the inferential statistics will be used to examine the response trend interaction across the groups of respondents in the three subscales.

5.3.5 Inferential statistics

The plotted location of the mean scores with the uncertainties can be seen in Figure 11. It shows the difference in the mean scores with approximate reliability and variation of responses across the three subscales. However, the gaps between the error bars plotted indicate that the mean differences are not likely due to sampling errors or chance. Perhaps, there are potential effect factors with significant differences between the mean scores.

Figure 11 Error bar graph score for KE, PTE and OBE with 95% confidence interval (CI)



A one-way repeated measure using analysis of variance (ANOVA) was conducted to test overall differences between the three means in the SETSIS. The results in Table 32 indicate significant differences in the mean score for at least two of the subscales, Wilks' Lambda=0.165, F (1.825, 591.244) = 906.278, p <0.01 with 73.7 percent of variance explained. Follow-up comparisons indicate that in each pairwise comparison differences are significant, p<0.05. The mean score for KE (mean=96.38, s.d. = 16.87) is significantly different from the mean score for PTE (mean=105.45, s.d. =17.78); t= -15.80, p= 0.001. A second pair sample t-test comparing the mean score for KE is significantly different from the mean score for OBE (mean= 76.82, s.d. =10.83); t= 25.57, p=0.001. A third pair t-test indicates the mean score for PTE (mean=105.45, s.d. =17.78) is significantly different from the mean score for OBE; t= 40.37, p=0.001.

Table 32 Result for mean differences analysis

Paired Samples Test

Paired subscales	Paired Differences: Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper	t	df	Sig. (2-tailed)
KE - PTE	-9.07	10.35	0.57	-10.20	-7.94	-15.80	324	.000
KE - OBE	19.56	13.79	0.76	18.06	21.07	25.57	324	.000
PTE - OBE	28.63	12.79	0.71	27.24	30.03	40.37	324	.000

The results confirm that the mean differences between the three pairs of subscales are significant. The differences in mean scores shown in Figure 11 have significant in the scores effect. Across the three mean scores, the statistic test shows the biggest mean scores effect is between PTE and OBE, followed by differences in KE and OBE. It means that the differences in PTE to OBE have more effect than KE to OBE, while the smallest effect in mean scores difference is between KE and PTE.

5.3.5.1 Analysis across the group of semesters

The theoretical framework of the SETSIS is based on the assumption that the curriculum of BoTP was tailored to provide an essential development in the knowledge of PSTs starting at the early level (semesters 1, 2, 3 and 4) and to be used and developed in the later semesters (semesters 5, 6, 7 and 8). During the professional teaching practice that takes place in the later semesters of the programme, PSTs should developed their knowledge with practice of real situation in teaching.

With the assumption that pre-service primary science teachers (PSTs) develop their teacher knowledge through each level of semester, the analysis will tests the null hypothesis with self-efficacy in knowledge of science inquiry skills (i.e. which is measured using the KE subscale), self-efficacy in practice teaching science using science inquiry skills (i.e. which is measured by the PTE subscale) and self-efficacy in the belief of learning using science inquiry skills (i.e. which is measured by the OBE subscale). In other words, this study has an assumption (null hypothesis) that there are no differences between groups of semesters in the three subscales: KE, PTE and OBE.

Table 33 Univariate test results for factor of semester

Subscale	df	F	Sig.	Partial Eta Squared	Observed Power
KE	5	8.41	.00	0.12	1.00
PTE	5	2.68	.02	0.04	0.81
OBE	5	1.80	.11	0.03	0.61

The statistic tests of variance analysis are used to confirm differences across the groups of semesters in all the subscales. The MANOVA test result has confirmed there are at least two significant differences between semesters of study with levels of the three subscales: $F(15, 918)=3.92$, $p<0.05$: Pillai's $\lambda= 0.18$ with $\eta^2= 0.06$. However, the result of the main effect in Table 33 shows that significant differences exist between groups of semesters in KE and PTE but not in OBE. In KE there were significant differences in the groups ($F\ (5, 306)=8.41$, $p<0.05$) with 12.0 percent of the explained differences in KE. There was significant difference between groups of semesters with PTE ($F\ (5,306) = 2.68$, $p<0.05$) with only 4.0 percent of the explained differences. Meanwhile, differences between groups of semesters were not significant in OBE at $p=0.11$.

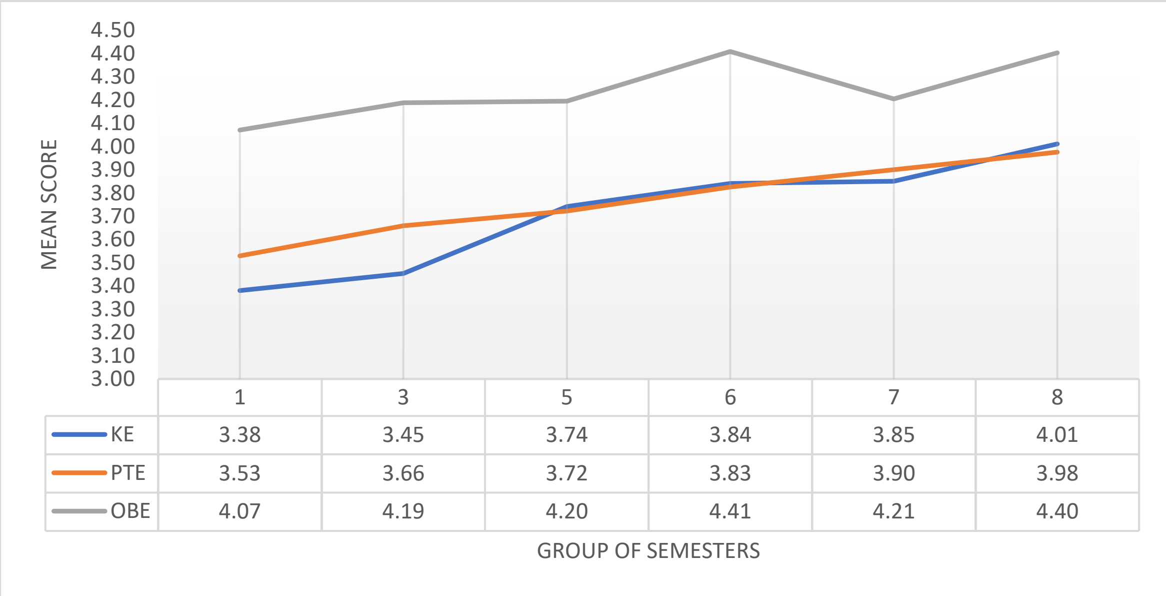
Table 34 lists the post-hoc tests in all three subscales, KE, PTE and OBE. Post-hoc comparison using the Games-Howell test (for homogeneity variance not assumed in the data) indicated that, in the KE subscale, the mean score for semester 1 (mean=3.38, s.d. =0.69), the mean score for semester 3 (mean=3.45, s.d.=0.60) and the mean score for semester 5 (mean=3.74, s.d.=0.56) are significantly different from the mean score for semester 8 (mean=4.01, s.d.=0.52) at $p<0.05$. Meanwhile, the mean score for semester 6 (mean=3.85, s.d.=0.40) and the mean score for semester 7 (mean=3.85, s.d.=0.40) did not differ significantly from the mean score for semester 8.

Table 34 Post-hoc contrast result in groups of semesters

Semester Simple Contrast		Subscale	
		KE	PTE
Semester 1 vs. Semester 8	Contrast Estimate	-12.146	-8.065
	Std. Error	2.488	2.791
	Sig.	0.000	0.004
Semester 3 vs. Semester 8	Contrast Estimate	-14.253	-8.333
	Std. Error	2.695	3.023
	Sig.	0.000	0.006
Semester 5 vs. Semester 8	Contrast Estimate	-6.541	-6.282
	Std. Error	2.452	2.750
	Sig.	0.008	0.023
Semester 6 vs. Semester 8	Contrast Estimate	-3.123	-2.652
	Std. Error	2.350	2.636
	Sig.	0.185	0.315
Semester 7 vs. Semester 8	Contrast Estimate	-4.453	-2.133
	Std. Error	4.743	5.320
	Sig.	0.348	0.689

The post-hoc test also indicates that in PTE, the mean score for semester 1 (mean=3.53, s.d.=0.71), the mean score for semester 3 (mean=3.66, s.d.=0.63) and the mean score for semester 5 (mean=3.72, s.d.=0.58) are significantly different from the mean score for semester 8 (mean=3.98, s.d.=0.55) at $p<0.05$. Meanwhile, the mean score for semester 6 (mean=3.83, s.d.=0.64) and the mean score for semester 7 (mean=3.90, s.d.=0.55) did not differ significantly from the mean score for semester 8.

Figure 12 Mean score for KE, PTE and OBE across groups of semesters



	1	3	5	6	7	8
KE	3.38	3.45	3.74	3.84	3.85	4.01
PTE	3.53	3.66	3.72	3.83	3.90	3.98
OBE	4.07	4.19	4.20	4.41	4.21	4.40

The graph plotted for the group mean score in Figure 12 illustrates the differences amongst the group of semesters in all the subscales. The plotted graph demonstrates the group mean score increment between semesters 3 and 5 and between semesters 7 and 8 in KE. The graph plotted for PTE shows a linear increase from semester 1 to semester 8 in the mean score. The plotted graph for OBE semester group mean scores shows a tremendous increment in semester 6 but a setback in semester 7 and again an increase in semester 8. This suggest that perhaps there are effects of group of semesters in subscales of the SETSIS and the analysis results conducted above have empirically confirmed that.

5.3.5.2 Interaction between groups of factors

This study focuses on investigating the main effect of the semester groups and their interaction with the other background factors. The interaction of independent factors may contribute to the relationship between responses in the SETSIS and the semester they are in. Two-ways MANOVA analysis was used to find the interactions that might exist between the group of semesters and other factors (i.e. gender, ethnicity, school attended and science qualification).

Figure 13 Interaction between group of semesters and ethnicity groups

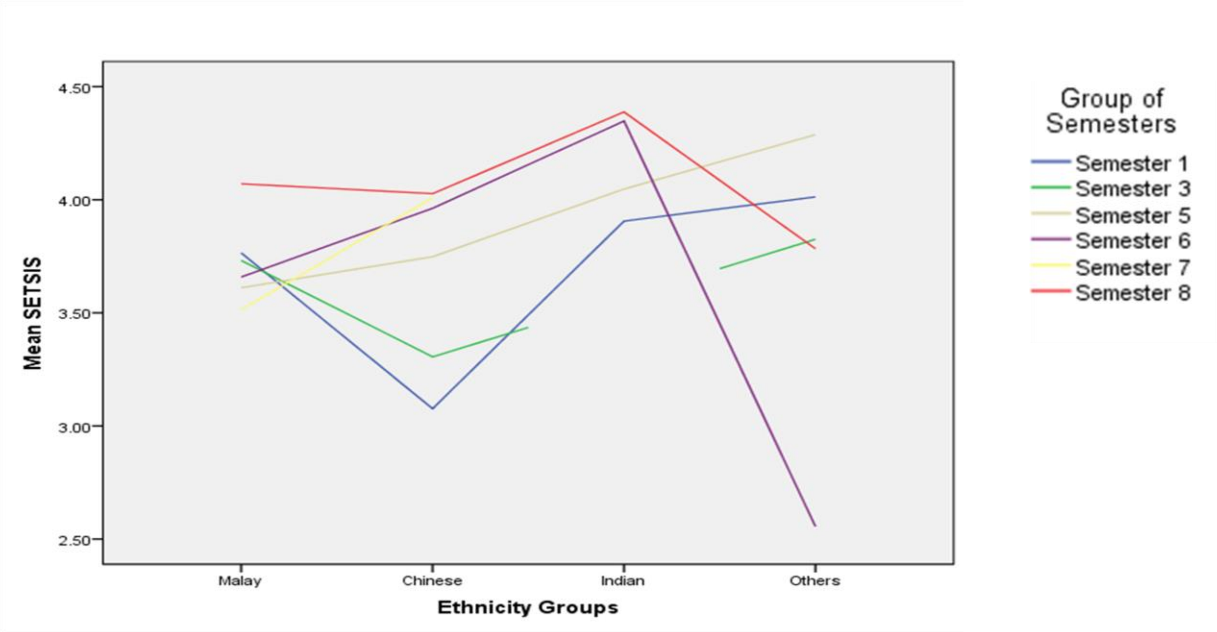


Figure 13 shows lines of the group of semesters intersect with the ethnicity groups at more than one intersection. These show that there is an interaction between the group of semester and ethnicity groups. Table 35 confirms the interaction with the result of a significant interaction effect between semesters and ethnicity groups at p=0.03 (p<0.05). However, the interaction between the group of semesters and the other factors are shown not significant. The statistics result reveals there is only one significant interaction occurred, which is between the group of semesters and the ethnicity factor.

Table 35 Multivariate test for interaction of group of semesters with other factors

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.96	1374.689b	3.00	181.00	.00	.96
Sem * Ethnicity	Pillai's Trace	.26	1.55	33.00	549.00	.03	.09

a. Design: Intercept + Sem * Gender + Sem * Ethnicity + Sem * Qualification + Sem * School

b. Exact statistic

c. The statistic is an upper bound on F that yields a low er bound on the significance level.

d. Computed using alpha = .05

Further, the results of the univariate ANOVA stated in Table 36 shows the effect across the three subscales. By using Bonferroni procedure to test each ANOVA in the three subscales at the 0.016 adjusted alpha level (Field, 2013), the interaction effect is statistically significant with responses in the two subscales of the SETSIS, which are KE and PTE at $p<0.001$. These results show that the significant differences in mean score of KE and PTE across the group of semesters are also significantly dependent on the ethnicity.

In summary, the data demonstrate high reliability in gaining information from the sample using the SETSIS with particular information within the three factors measured. Noticeably, the SETSIS is compatible with TSI (Smolleck, Zembal-Saul and Yoder, 2006) as the obtained standardised mean scores of the present study are within the range of the mean of the five components of self-efficacy in the essential elements of inquiry of Smolleck's (range M=3.79 to 4.16).

Table 36 Result of univariate ANOVA analysis for significant interaction between factors group of semester and groups of ethnicity

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Powerd
Corrected Model	KE	74.029a	136	.54	1.84	.000	.58	250.57	1.00
	PTE	74.462b	136	.55	1.85	.000	.58	251.62	1.00
	OBE	55.322c	136	.41	1.23	.092	.48	167.93	1.00
Intercept	KE	902.33	1	902.33	3054.11	.000	.94	3054.11	1.00
	PTE	935.18	1	935.18	3160.18	.000	.95	3160.18	1.00
	OBE	1185.28	1	1185.28	3597.87	.000	.95	3597.87	1.00
Sem * Ethnicity	KE	8.79	11	.80	2.70	.00	.14	29.74	.97
	PTE	11.83	11	1.08	3.63	.00	.18	39.98	1.00
	OBE	3.37	11	.31	.93	.51	.05	10.24	.51
Error	KE	54.07	183	.30					
	PTE	54.15	183	.30					
	OBE	60.29	183	.33					
Total	KE	4557.77	320						
	PTE	4658.54	320						
	OBE	5935.82	320						
Corrected Total	KE	128.10	319						
	PTE	128.62	319						
	OBE	115.61	319						

a. R Squared = .578 (Adjusted R Squared = .264)
b. R Squared = .579 (Adjusted R Squared = .266)
c. R Squared = .479 (Adjusted R Squared = .091)
d. Computed using alpha = .05

As predicted, the relationship is strong in the subscales between KE and PTE compared to the moderate correlation between the two subscales with OBE. This relation perhaps because the two components are the base of teacher knowledge (Shulman 1987; Richey and Klein 2005; Park et al. 2011; Gess-Newsome et al. 2016) that are widely used in the present curriculum of BoTP and have an important role in PSTs' self-efficacy. Moreover, the extended relations with OBE also indicate that PST efficacy in teacher knowledge traits intertwine with the expectancy of outcomes belief(Pajares, 1992; Magnusson, Krajcia and Borko, 1999; Veal, 2012). The relationship variability between responses across the three subscales KE-PTE, OBE-PTE and OBE-KE were able to show association across the three factors in model.

Main effect of semester is as predicted, however the interaction of the semester with ethnicity is new and might relate to the context in that BoTP programme was dedicated across multiple races.

5.4 The SETSIS - Analysis of structure

This part of the study would be the exploratory study, aiming to derive the factor structure of the SETSIS based on the responses received from the participants. Prior to the factor analysis application, the checks were taken on internal reliability and validity. One outlier (TR3) was detected and omitted leaving 324 samples for the analysis on 72 items. The reliability using Cronbach's Alpha test to the 72 items yielded a score of 0.98 (72 items, $\alpha = 0.98$, scale mean = 278.86, S.D = 41.39) and was thus rated as excellent (Kline 2000). The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) index is 0.97 (KMO>0.50), thus qualifying the data for the analysis. The Bartlett's test of sphericity $\chi^2(2556)$ = 18296.27, p=0.001 ($p<0.05$) shows that there is a significant pattern in relationships between items and thus confirms the usefulness of factor analysis.

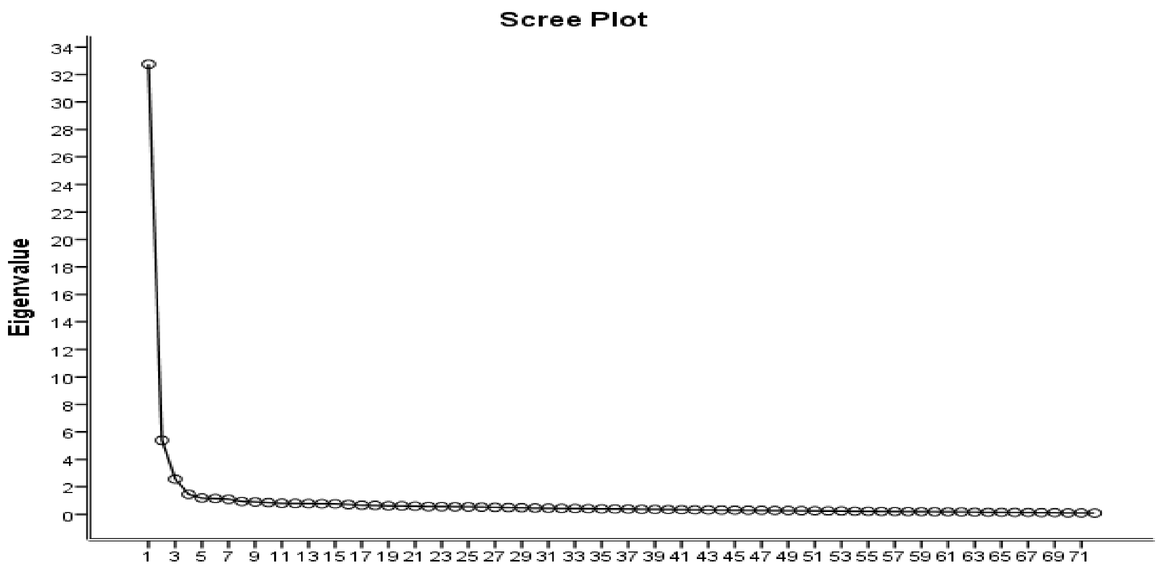
I am using EFA consisting of Principal Axis Factoring (PAF) extraction method and rotation performed with 72 items (see Appendix 6). The PAF method analyses the 72 observed items (variables) and determines factors that explain the co-variances of the variables. It extracts estimation factors from communalities based on the common variance of a variable shared with other variables. This method was considered the most appropriate due to the focus of my study, which is to identify the latent constructs from interrelated sets of items that may represent the SETSIS.

5.4.1 Factor structure

Analysis of factor extraction demonstrates shared variance (communalities) in each variable varying with range 0.45 to 0.70. By using Kaiser Criterion with Eigenvalue more than 1.0, the data are reducing into seven factors criterion. The three first factors explained 45.5 percent, 6.7 percent and 2.3 percent of the variability accounted for by these factors, respectively. The fourth, fifth, sixth and seventh factors had Eigenvalues just over one, with a total of 4.7 percent of the variance that was accounted for by the last four factors.

On the other hand, the scree test criterion with cut-off Eigenvalue at 2.0 reduced the data into a three-factor solution. Figure 14 shows the scree test with Eigenvalues plotted on the line graph. Inspection of the scree plot shows three ‘obvious’ factors that have substantial amounts of common variance above the cut-off Eigenvalue. The smooth decrease in Eigenvalue appears to level off after the third Eigenvalue to the right of the plot can be presumed as factorial scree or debris (Cattell, 1966). This means after the third factor, the successive factors account for very small variances, too small to be considered as meaningful. Moreover, the three-factor solution corresponds to the predetermined number of factors based on the research objectives, which fit the criteria for the number of factors to extract.

Figure 14 Eigenvalue plot for scree test criterion



Latent root (eigenvalue)

The three-factor solution is chosen based on theoretical applications explaining a cumulative variance of 54.5 percent after extraction. The factor-loading matrix produces unrotated-loadings for each variable on each factor. In this study, the significant factor loading based on sample size (n>250) at significant level 0.35 (BMDP Statistical Software, in Hair et al. 2010: 117) is used. Examining the unrotated factor-loading matrix shows that all variables (72 variables) are loading significantly (factor loading >0.35) under the first factor with a loading range 0.56 to 0.77. There is also significant factor loading (factor loading>0.35) accounted for by 17 variables for the second factor (factor 2) with a loading range 0.37 to 0.49. However, the maximum loading in the third factor is 0.28, with no significant loading accounted for by any variables for the third factor (factor 3). Thus, using unrotated extraction resulted in the largest amount of variance accounted for factor 1 but left only a small amount of variance accounted for by the sequences factors.

The initial unrotated solution demonstrated the variance extraction accounted for by each variable but not yet sufficient to obtain meaningful contribution from the variables in the factor structure. It was difficult to identify distinctive factors with unrotated extraction. A further factor rotation is needed to form a simple structure for meaningful interpretation (Hair et al. 2010). The next section explains the analysis of the factor solution in order to get a simple structure for it.

5.4.2 Factor rotation

I am using Promax, a process using oblique rotation to manipulate extracted variance to load simple factor solution. Oblique rotation was chosen as it allows the factors to correlate. This method was implied to simplify the factor solution into meaningful and pragmatic interpretation.

Although oblique rotation method is able to improve the intercorrelation between items' factors, the factor interpretation is difficult based on the nature of dependency. Considerable correlation between factors was first examined to confirm the essential usage of oblique rotation. Table 37 below shows the correlation between the driven factors resulted from Promax rotation. The correlations between the three factors are range 0.78 to 0.58. Since all the correlations are above 0.32, the factor variances are claimed to overlapping more than 10 percent (Tabachnick and Fidell 2007). The overlap variances are consider enough to justify the correlation between factors and suggest usage of oblique rotation method to simplify the structure.

Table 37 Correlation matrix for three factors in the EFA with Promax oblique rotation

Factor	1	2	3
1	1.00	0.58	0.78
2	0.58	1.00	0.64
3	0.78	0.64	1.00

The result of factor solution using Promax rotation explains a total of 54.26 percent of the variables' variance. The variance accounted for by factor 1, factor 2 and factor 3 after rotation are explained by the sum of square loading 28.62, 22.40 and 27.82, respectively. This explains that the variance distribution among the three factors after the rotation are evenly dispersed compared with the initial unrotated extraction.

The rotated factor loading in the pattern matrix (see Appendix G) represent the loading of variance accounted for by each variable for every factor. The loading values also represent correlations between the variables with the factors. For a substantive interpretation, the output factors loading above 0.35 with no significant cross loading are considered for factor interpretation of the factor result.

5.4.3 Factor Interpretation

Table 38 shows six items that are not included in the factor structure based on the factor loading interpretation. Inspection of loading reveal two items with no significant loading in all three factors. Item P5 has a maximum factor loading 0.31 and item P17 maximum loading 0.34. These items are removed as it might not give meaningful description to any of the three factors. Further inspection discovered item B11 has two significant loadings in different factors (factor 2 and factor 3). A close check in communality loading explains 43 percent of the variance shared by B11 for the two factors. This means that B11 shared less than half of its unique variance and yet it also shows ambiguity between the two factors. Thus, item B11 is considered for removal.

The inspection in factor 1 indicates significant primary loading in item P9 (factor loading 0.43) and item P15 (factor loading 0.41). However, a closer inspection reveals that these items have consistent cross loading more than 75 percent of the primary loading. Item P2 also shows significant primary loading 0.36 for factor 3 but has a high cross loading (more than 75 percent of primary loading) in factor 1. Even though all three items have cross factor loadings that are not significant (loading< 0.35), with the high cross loading items lower cut-off loading values are acceptable in the decision (Samuels, 2016). Thus, items P9, P15 and P2 are considered for removal based on the ambiguity of variance that is shared on more than one factor.

For the final stage, a principal axis factoring is used to explain factors that cause the observed variables. The remaining 66 items scores are rotated used Promax rotation (assuming there is a relationship among the three factors) with three factors. Results of the factor analysis are shown in Table 39. Analysis with 66 items explaining 54.70 percent of the variance, which is more variance explained compared with the 72 items analysis. A smaller range sum of square loadings shows better variance distribution of each of the factors with 66 items. All items have primary significant loading over 0.4. There was no cross-loading in the three subscales items. The items are listed under three factors according to the significant loading results in Table 39.

Table 38 Removed items according to factor loading interpretation

Label	Item	Factor 1	Factor 2	Factor 3
P9	I can provide proof needed to support an investigation by students.	**0.43**	0.02	**0.34**
P15	I believe I can teach science concepts easily using the science investigation approach.	**0.41**	0.13	**0.31**
P2	When a science process is difficult to explain, I will use the investigative approach to assist the students' understanding.	**0.34**	0.07	**0.36**
B11	I believe that the science investigation approach is an applicable teaching strategy.	-0.03	**0.39**	**0.35**
P17	I believe I can encourage students to get involved during science investigation activities in class.	0.22	0.22	0.34
P5	I choose to provide data from real experiments as instructional materials rather than data from workbooks.	0.28	0.10	0.31

Table 39 Exploratory Factor Analysis (EFA)

Factors	Eigenvalue	% of Variance	Cumulative % of variance	Rotation sum of squared loadings
1	29.87	45.26	45.26	26.15
2	4.66	7.05	52.31	20.60
3	1.57	2.38	54.70	24.97

5.4.4 Summated scale

The interpretation of the factors considering only 66 items from 72 were listed with significant loadings with no cross loadings and acceptable communality loadings (Hair *et al.*, 2010). From the loading order and number of items, it was found that factor 1 listed all 28 items with a loading range 0.41 to 0.91. The factor 1 consists of all 26 items of KE with an additional two items from the PTE subscale (P3 and P4). High-loading items were dominated by KE items. Item P3 loads with 0.53 for factor 1 while P4 loads with 0.43 for factor 1. A close inspection on the wording of item P3 (*I can provide explanation to my students about the activity of the science process*) and P4 (*I am able to plan science process activities with provided modules*) are concerned about knowledge in explaining and planning inquiry skills. Thus, all 28 items are concluded as items in Knowledge Efficacy. The reliability of 28 items of KE is α=0.97 with item mean = 3.73.

The perception held by participants about belief are reflected in factor 2. All 17 items on belief were highly loading in range 0.60 to 0.84 for factor 2. This factor can be interpreted as a variable that measure self-efficacy in belief of outcome of teaching and learning by using inquiry skills. There was no item from other subscales loading in the same factor. Since the factor was dominated by items in the OBE subscale, the factor 2 was labelled as Outcome Belief Efficacy (OBE). The reliability of 17 items OBE is α= 0.96 with item mean = 4.28.

As for factor 3, all items loading for this factor were from the PTE subscale. There were 21 items in PTE clustering under factor 3 which reflects that all these items underlying a factor directed to self-efficacy in ability of doing tasks of teaching using inquiry skills. Considering overall items were dominated by PTE items, this factor was labelled as Practice Teaching Efficacy and all 21 items were used in the summated scale of PTE. The reliability of the PTE scale with 21 items is α = 0.96 with item mean = 3.75. Table 40 summarises the factor solution with the three factors interpretation.

Table 40 Three factors solution interpreted into three subscales

Factor	Items	Number of Items	Scale Reliability	Summated scales (sub-scales)
Factor 1	K1 to K26, P3 and P4	28	0.97	Knowledge Efficacy (KE)
Factor 2	B1 to B10, B12 to B18	17	0.96	Outcome Belief Efficacy (OBE)
Factor 3	P1, P6 to P8,P10 to P16, P18 to P28	21	0.96	Practice Teaching Efficacy (PTE)

In summary, the result of this factor analysis has provided probabilistic power in validating a structure of the SETSIS measure. The factor solution provides a clear understanding of latent factors that are reflected through the observed variables (items). The three summated scales are produced from 66 items, which validate the SETSIS as a three-factor measurement model. Even though the SETSIS is a three-factor model, the existence of a general factor with several small group factors (i.e. multidimensionality) does not mean that the total score is a poor indicator of the SETSIS as a common factor that runs through all the 66 items. This suggests that the total score of the SETSIS should be carefully interpreted/construed and the external interaction might have different correlation with different aspects of factors. The issue should then be further investigated and addressed empirically rather than assuming small factors will misdirect the common trait of the SETSIS. The next section will investigate empirically and practically the impact of the observed items in the Rasch measurement model.

5.5 Summary of findings

The findings from this chapter provide psychometric evidence on the usability of the SETSIS in measuring levels of self-efficacy in teaching using SIS among the sample of pre-service science teachers in Malaysia. The findings from descriptive and inferential analysis provide information to evaluate reliability in terms of the equivalence, stability and consistency of the SETSIS. The descriptive analysis showed that the SETSIS is able to identify levels of self-efficacy in teaching using science inquiry skills. The respondents have expressed various levels of confidence from *not confident* to *definitely confident* in the items provided in the SETSIS with a normal distribution. Overall mean scores show good confidence among PSTs in self-efficacy in teaching using science inquiry skills and the confidence level in the self-efficacy increases from KE to PTE and to OBE. The SETSIS shows high internal consistency with KE, PTE and OBE having Cronbach's Alpha values more than 0.9. Moreover, the Pearson correlations show that the three subscales have stability in their bivariate relationships with Pearson coefficients, $r = 0.82$ (KE-PTE), 0.70(KE-OBE) and 0.58(PTE-OBE).

Meanwhile, the inferential statistics provide analysis of the agreement regarding the SETSIS scores. The ANOVA analysis shows that the gap in the mean scores of the SETSIS across KE, PTE and OBE was significantly different, which confirmed the differences in the responses across the three subscales. The findings reflect that the three subscales are able to measure different factors of self-efficacy in teaching using science inquiry skills. Further analysis confirmed that the level of semesters has been the main effect in the mean scores of KE and PTE. The study also found that, instead of the group of semesters, the score of self-efficacy in teaching using science inquiry skills in KE and PTE also depends on the interaction with the ethnicity factor. The findings have empirically shown that level of study in BoTP has been the main effect in the score of the SETSIS, especially in KE and PTE. This reflects that the SETSIS manages to measure significant development in self-efficacy of knowledge and personal practice across the level of study of the training programme.

Finally, in the factorial analysis of the SETSIS, the study has confirmed there are three factors contributing that explain 54 percent of the responses' variances. The interpretation based on the item-factor allocation confirmed the three factors as KE, PTE and OBE. This has empirically validated the existence of the factors in the study framework. Table 41 summarises the findings in this chapter. The next chapter analyses the model responses to validate the SETSIS as a measurement model and uses it to infer the science teaching practice development.

Table 41 A summary of findings in Chapter 5

No	Findings
1	The descriptive analysis • Responses frequency indicates that the SETSIS is able to measure various responses within the five-category rating scale. • Normality tests and visual inspections indicate normal distributions in the responses received for the overall the SETSIS and in KE, PTE and OBE. • Mean score of the responses indicates the highest confidence of self-efficacy in teaching using science inquiry skills in subscale OBE, then in subscale PTE and lastly in subscale KE. • The SETSIS and the three subscales, KE, PTE and OBE have gained high reliability in the study with $\alpha > 0.90$ • The SETSIS is able to establish strong relationships across the three factors of KE, PTE and OBE indicate early evidence in the association of the three-factor model.
2	The inferential analysis indicates that • Repeated measure ANOVA confirms there are significant differences of scores across groups of semesters in the three subscales: KE, PTE and OBE. • MANOVA analysis confirms there are significant differences in the mean scores of KE and PTE in interaction between groups of semesters and ethnicity groups.
3	Results from EFA indicate that • There are three factors contributing to the SETSIS that explain 54 percent of the variance. • The SETSIS established a structure validity with 66 items from the three subscales.

Chapter 6 Validating the Model of SETSIS

6.1 Properties of measure

This section is a part of the analysis to answer my third research question. I am using the Rasch model to investigate the contribution of items and responses to the SETSIS in defining the hypothetical model used in the study. The analysis of relations and the magnitude of the responses to the items in the subscales can provide meaningful information to validate the elements of the overall model of the SETSIS. The information helps to improve the model and moreover can provide an empirical framework to validate the usability of the model in measuring the intended variables of the study.

The following sections use the Rasch analysis to establish the model proposed from the evidence in the psychometric characteristics of the SETSIS instrument. Firstly, measures of responses with fit statistics are examined to determine whether the data fit the Rasch model. Then, this analysis examines the difficulty level of the hypothesised items based on the responses observed. The function of the rating scale is checked upon providing validation of the category of responses.

6.1.1 Item measure

Items in the SETSIS were constructed based on the hypothesised levels of items (see the construct mapping in Chapter 4). The analysis was conducted to validate the item levels in the model. Sixty-six items from the SETSIS and 324 responses (persons) were used to produce fit analysis results. The items were measured using a difficulty parameter relative to the responses' ability using fit analysis. The level of agreement on items (difficulty measure) ranked in a scale and interpreted from easy to agree items to hard (negative to positive measure). The measure scale unit use is log odd unit (logit) with the mean of item difficulty as '0' and used as the reference point in the logit scale. Table 42 shows the summary of measure and fit statistics for 66 items of the SETSIS in logit scale units.

Table 42 Summary of the SETSIS Analysis Result – 66 items (n=324)

	MEASURE	INFIT		OUTFIT	
		MNSQ	ZSTD	MNSQ	ZSTD
MEAN	0.00	1.00	0.00	1.00	-0.10
SD	0.73	0.14	1.70	0.13	1.60
MAX.	1.17	1.33	3.80	1.28	2.90
MIN.	-1.42	0.68	-4.70	0.75	-3.60
ITEM SEPARATION		7.76	ITEM RELIABILITY		0.98

All 66 items in the SETSIS have high item reliability with good item separation. The item reliability in the SETSIS is 0.98, indicating high reliability items with 7.76 of estimated separations. It means that the items have high reliability in measuring the persons with wide difficulty ranges. Items were estimated to have spread into a separation index of 7.76 with 11 separate strata groups. This reflects that the items have managed to form the intended levels of items hierarchy in the measure. Thus, it is possible to have the three levels of item hierarchy as intended – high, mean and easy levels of items (i.e. item separation > 3).

Overall, the items are distributed in range 2.59 (logit) within 1.17 logit to -1.42 logit. The mean of item measure at 0.00 (SD =0.73) (logit) is used as the scale's reference point. The distance suggests that more items are located below the mean level, which reveals that the measure contains more items with difficulty level below the mean than items with difficulty level above the mean.

The overall data on the items significantly fit the model. Fit analysis using MNSQ indices indicate that the data is compatible with the model. The mean measure shows critical MNSQ value in the range 0.5 to 1.6 (Curtis, 2004) for infit and outfit analysis. These imply that all 66 items' variation is acceptable according to the model expectation. However, the infit ZSTD and outfit ZSTD for the highest measure and the lowest measure show out of the range values (-2.00 < ZSTD <+2.00), warning of erratic responses that not significant to the items measure. Misfit person measures are checked in a later section to examine the implication of erratic responses to the properties of measurement. These fit analysis results for the item measure suggest that even though some responses are erratic to the top and bottom items, but it supports the overall contention that items of the SETSIS spread well with more easy items on the measure.

6.1.1.1 Item measure in KE subscale

Table 43 Item measure of KE sub-scale

ITEM	Difficulty Measure	S.E.	Infit MNSQ	Outfit MNSQ	PTMEA CORR.
K1	0.81	0.10	0.99	1.00	0.66
K2	-0.05	0.10	1.15	1.17	0.67
K3	-0.56	0.10	1.13	1.20	0.66
K4	0.46	0.10	1.14	1.18	0.68
K5	0.48	0.10	0.89	0.89	0.74
K6	1.27	0.10	0.99	0.99	0.69
K7	0.47	0.10	1.16	1.15	0.64
K8	1.31	0.10	1.03	1.02	0.69
K9	1.06	0.10	0.98	0.97	0.72
K10	0.80	0.10	1.04	1.05	0.66
K11	0.68	0.10	1.12	1.11	0.72
K12	0.26	0.10	1.10	1.07	0.67
K13	0.85	0.10	0.94	0.95	0.74
K14	0.05	0.10	1.05	1.03	0.72
K15	0.86	0.10	1.17	1.15	0.70
K16	0.85	0.10	1.10	1.11	0.67
K17	-0.66	0.10	0.92	0.98	0.69
K18	0.45	0.10	0.91	0.92	0.73
K19	0.12	0.10	1.04	1.12	0.70
K20	-0.02	0.10	1.27	1.25	0.65
K21	0.14	0.10	0.95	0.96	0.69
K22	0.59	0.10	0.91	0.91	0.75
K23	0.06	0.10	0.96	0.96	0.69
K24	0.12	0.10	1.13	1.12	0.70
K25	0.71	0.10	0.97	0.96	0.71
K26	0.78	0.10	0.95	0.94	0.73
P3	0.10	0.10	0.74	0.81	0.73
P4	-0.21	0.10	0.95	1.04	0.71

The KE subscale is the factor that is hypothesised to measure efficacy trait of the science inquiry skills knowledge. There are 28 items (K1 to K26, P3 and P4) that are statistically predicted to measure the trait (see section 5.4). Table 43 of the point measure correlation (PTMEACorr.) shows positive values above 0.6 in all items, indicating that the items are working together measuring the same trait. The infit and outfit mean square indices show a reasonable value in between 0.6 to 1.4 in all items. This indicates that all the observed items in KE fit according to the Rasch model.

A close inspection of the fit analysis in the table reveals that 24 items in KE are measured above mean difficulty measure (0.00 logit) and only four items out of 28 items are measured below the overall mean measure. Examining the measure reveals that the three top items of KE were measured at above 1.00 logit. The items

K8, K6 and K9 were measured at 1.31, 1.27 and 1.06, respectively. In the subscale, these items were the most difficult items of KE to affirm and described as high level items. The high items measure high ability that corresponds to the highest level of self-efficacy in the knowledge of teaching using science inquiry skills that can be measured by the constructed items in KE.

Meanwhile, items K14 and K2 are the items with difficulty measure at 0.05 logit and -0.05 logit respectively, the nearest measures to the mean. Both items and the items around the mean were the middle items described at the mean item level that measure average ability in KE. These items correspond to the average level of self-efficacy in the knowledge of teaching using science inquiry skills that can be measured by the constructed items in KE.

Lastly, the lowest difficulty measure was in item K17 *(I am confident to teach a scientific concept which I understand through experiments*) at -0.57 logit. The item was described at the easy item level that measures low ability in in KE. The item corresponds to the low level of self-efficacy in the knowledge of teaching using science inquiry skills that can be measured by the constructed items in KE. The range between the highest difficulty measure and the lowest difficulty measure of items in KE is 1.74 logit, which reflects the range of ability that can be measured by the constructed items of KE.

6.1.1.2 Item measure in PTE subscale

Table 44 shows the detail of the Rasch measure of all items of PTE. All 21 items show fitting the Rasch model (0.6<MNSQ<1.4). The PTMEACorr. values for all items are positive with loading more than 0.6 indicating 21 items are working well in measuring one trait of PTE.

A close inspection of the fit analysis in Table 44 reveals that 19 items in PTE measured above the mean difficulty measure and only two out of 21 items are measured below the mean difficulty measure. Examining the measure reveals that only one item of PTE was measured above 1.00 logit. Item P11 was measured at 1.04 logit, the most difficult item of PTE to agree and described as at the high item level. The high items measure high ability that corresponds to the highest level of self-efficacy in the personal teaching practice in teaching using science inquiry skills that can be measured by the constructed items of PTE.

Table 44 Item of PTE sub-scale

ITEM	Difficulty Measure	S.E.	Infit MNSQ	Outfit MNSQ	PTMEA CORR.
P1	0.48	0.10	0.85	0.84	0.75
P6	0.95	0.10	1.02	1.03	0.70
P7	0.65	0.10	1.01	1.02	0.71
P8	0.62	0.10	0.91	0.91	0.73
P10	0.87	0.10	1.04	1.03	0.72
P11	1.04	0.10	0.77	0.77	0.76
P12	0.29	0.10	0.81	0.82	0.76
P13	0.35	0.10	0.78	0.78	0.77
P14	0.54	0.10	0.83	0.82	0.76
P16	0.32	0.10	1.03	1.07	0.67
P18	0.01	0.10	0.89	0.91	0.72
P19	0.22	0.10	0.99	0.97	0.69
P20	0.19	0.10	0.93	0.93	0.70
P21	-0.03	0.10	0.99	0.99	0.69
P22	-0.14	0.10	0.89	0.86	0.74
P23	0.65	0.10	0.84	0.85	0.74
P24	0.37	0.10	1.04	1.01	0.70
P25	0.39	0.10	0.93	0.92	0.71
P26	0.15	0.10	0.83	0.82	0.73
P27	0.48	0.10	0.86	0.86	0.76
P28	0.28	0.10	1.12	1.09	0.73

Next, examination on the nearest measures to the mean difficulty measure reveals items P18 and P21 with difficulty measure at 0.01 logit and -0.03 logit, respectively. Both items and the items around the mean were the middle items described at the mean item level that measures average ability in PTE. These items correspond to the average level of self-efficacy in the personal teaching practice in teaching using science inquiry skills that can be measured by the constructed items of PTE.

Lastly, the lowest difficulty measure in PTE was in item P22 *(If given the opportunity, I will encourage students to give various explanations from the same observation*) at -0.14 logit. The item was described at the easy item level that measures low ability in PTE. The item corresponds to the low level of self-efficacy in the personal teaching practice in teaching using science inquiry skills that can be measured by the constructed items of PTE. The range between the highest difficulty measure and the lowest difficulty measure of items in PTE is 1.18 logit, which reflects the range of ability that can be measured by the constructed items of PTE.

6.1.1.3 Item measures in OBE subscale

An inspection of Table 45 reveals that the PTMEACorr. shows positive values above 0.6 in all items, indicating that the items work well together in measuring the same trait. The infit and outfit mean square indices show a reasonable value in between 0.6 to 1.4 in all items. This indicates that all the observed items in OBE are compatible with the model.

Further inspection of the difficulty measures in Table 45 reveals all 17 items in OBE were measured below the mean difficulty measure. Item B14 is the most difficult item to affirm in OBE at -0.70 logit of difficulty measure. This item is described as a high item that measures high ability in OBE. Instead of corresponding to a high level of self-efficacy in outcomes expectancy of teaching using science inquiry skills, item B14's difficulty measure is way below the easy item level for KE and PTE.

On the other hand, item B6 was inspected as the easiest item to affirm at -1.47 logit. This item is supposed to measure low ability in OBE and should correspond to the low level of outcomes expectancy of teaching using science inquiry skills. The range between B14 and B6 is 0.77 logit. This range indicates that the items constructed in OBE are only able to measure low range of self-efficacy in OBE at the easy item level.

Overall, 66 items suggest the three subscales fit reasonably to the model with a good range of measure. Values of PTMEACorr. for all 66 items are positive with loading more than 0.6. These quantitative evidences support that, even though the subscales consist of three different factors, the model can be used together in measuring one latent trait, which is self-efficacy in teaching using science inquiry skills. The items constructed for the SETSIS were able to measure intended variables at the three differences item level – high, average and easy item levels, as proposed.

Table 45 Items of OBE sub-scale

ITEM	Difficulty Measure	S.E.	Infit MNSQ	Outfit MNSQ	PTMEA CORR.
B1	-1.15	0.11	1.20	1.13	0.65
B2	-1.14	0.11	0.99	1.11	0.65
B3	-1.43	0.11	0.95	0.96	0.66
B4	-1.25	0.11	1.11	1.06	0.64
B5	-1.32	0.11	1.04	1.03	0.67
B6	-1.47	0.11	1.05	1.02	0.65
B7	-1.17	0.11	0.95	1.20	0.65
B8	-1.33	0.11	1.15	1.18	0.63
B9	-0.85	0.11	1.25	1.23	0.63
B10	-1.60	0.11	1.12	1.16	0.61
B12	-0.96	0.11	1.01	0.99	0.68
B13	-1.03	0.11	0.92	0.90	0.69
B14	-0.70	0.10	1.07	1.04	0.68
B15	-1.04	0.11	0.97	0.94	0.70
B16	-1.28	0.11	0.94	0.91	0.70
B17	-1.33	0.11	1.10	1.19	0.64
B18	-1.46	0.11	0.93	0.85	0.71

6.1.2 Person measure

Table 46 Summary of the SETSIS Analysis Result – Persons (n=324)

	MEASURE	INFIT		OUTFIT	
		MNSQ	ZSTD	MNSQ	ZSTD
MEAN	2.15	1.00	-0.30	1.00	-0.30
SD	1.46	0.44	2.60	0.45	2.60
MAX.	6.33	2.57	6.80	2.65	7.00
MIN.	-1.76	0.21	-7.30	0.23	-7.10
PERSON SEPARATION		6.47	PERSON RELIABILITY		0.98

Person measure observes the variation of a person's abilities relative to the items difficulty. Table 46 summarises the results of the sample person measure (n=324) on the 66 items. The measure shows high person reliability and good person separation. Person reliability 0.98 (equivalent to test reliability Cronbach alpha KR-20) indicates that the sample has wide ability measured with good length of rating scale. Person separation 6.47 indicates good person classification with possibility to distinguish respondents into more than high and low performers (i.e. person separation > 2).

On the same scale as the item measure, mean of person measure located at 2.15 (logit) above the mean of item measure (0 logit). Maximum person measure was located at 6.33 units above the mean item difficulty measure, which recommends a wide range of abilities spread above mean item difficulty. Minimum person measure at -1.76 (logit) shows a smaller range of abilities are spread below the mean. Accordingly, the higher the abilities of respondents are higher, the more than that can be measured by the items.

Nevertheless, the responses pattern matches the expected model significantly. Infit MNSQ and outfit MNSQ for mean measure show value of 1.00 indicate that the observed data fits the model with significant ZSTD (-2.0<ZSTD<2.0). However, the maximum infit MNSQ 2.57 (MNSQ>1.6) and minimum infit MNSQ 0.21 (MNSQ<0.5) are not in range of the critical0 value. The results suggest responses that not fit the model are contributed by *misfit* persons (Bond and Fox, 2007).

The high values of MNSQ (MNSQ>1.6) suggest the existence of random responses that lead to *underfit* cases. On the other hand, the low values of MNSQ (MNSQ<0.5) suggest responses that are overly consistent with the respond pattern lead to *overfit* cases. Inclusion of *underfit* cases of pattered responses and careless responses contribute noises that may compromise the calibration precision of the measurement properties (Curtis, 2004). Possible *overfit* responses that came from social acceptance and desirability and intermediate category responses (Anderson, 1997) contribute less noises than *underfit* cases. Overfit cases are not good measure but do not degrade the measurement (Bond and Fox, 2007). Practically, *overfit* responses can indicate feasible views of respondents compared to *underfit* responses. Thus, detail inspection of *misfit* cases is conducted and 34 *underfit* cases are excluded for model estimation measures (N=290) report in Table 47.

Table 47 Summary of model estimation measure without misfit cases (N=290)

PERSON (N=290)		INFIT		OUTFIT	
	MEASURE	MNSQ	ZSTD	MNSQ	ZSTD
MEAN	2.48	1.00	-0.30	1.00	-0.20
SD	1.66	0.36	2.30	0.37	2.3
SEPARATION	7.03				
RELIABILITY	0.98				
ITEM (66 ITEMS)					
MEAN	0.00	1.00	-0.10	1.00	0.00
SD	0.81	0.12	1.40	0.12	1.40
SEPARATION	7.71				
RELIABILITY	0.98				

Table 47 shows the summary of the fit analysis result after discarded *underfit* cases. The result showed compatibility data to the model. The fit statistics for infit and outfit show that the data significantly fits the model well with infit and outfit indices showing values in acceptable range at MNSQ = 1.00 with significant ZSTD (-2<ZSTD<2). Reducing the sample size to 290 responses does not affect person and item reliability as it remains the same at 0.98. Separation in person ability (person separation = 7.03) and item difficulty (item separation = 7.71) show increasing dispersion in the item parameter. Increment in mean item SD to 0.82 logit increases the effectiveness of the measurement upon separation of items along the scale (Wright andand Masters 1982, pp 90-91).

However, increment of the persons estimate with the removal of *underfit* cases have lowered the estimates of item position. The lower location of items estimate suggests it is easier to endorse items at the positive end of the scale. After cross-plotting the person estimate results fromTable 47 to the person estimate resulting from Table 46, the removal of *underfit* cases didn’t produce noticeable changes in the person measure. Thus, at this stage of calibration, the *underfit* cases are highlighted but remaining for the next analysis.

6.1.3 Dimensionality of the model

Analysis of the Rasch PCAR decomposes the model’s variance to test for unidimensionality in measuring one latent variable. The Rasch model extracts variances of a latent variable in the measure. After the extraction, the variance residuals are not supposed to form any pattern (i.e. factor). The hypothesis: if the item’s variance measures one latent variable, then the items’ residuals are random noises. Besides investigating the assertion of the three factors’ existence as unidimensional, the analysis also identifies the core of items contributing toward the characteristics of the factors’ contrasts.

6.1.3.1 The model variance

Figure 15 Standardised variance parameter component scree plot

```
        +--+--+--+--+--+--+--+--+--+--+--+
   100%+  T                               +
       |                                  |
 V 63%+                                   +
 A     |     M                            |
 R 40%+                 U                 +
 I     |        P                         |
 A 25%+                                   +
 N     |           I                      |
 C 16%+                                   +
 E     |                                  |
   10%+                                   +
 L     |                                  |
 O  6%+                                   +
 G     |                   1              |
 |  4%+                                   +
 S     |                                  |
 C  3%+                      2            +
 A     |                                  |
 L  2%+                         3         +
 E     |                           4   5  |
 D  1%+                                   +
       |                                  |
  0.5%+                                   +
        +--+--+--+--+--+--+--+--+--+--+--+
          TV MV PV IV UV U1 U2 U3 U4 U5
              VARIANCE COMPONENTS
```

Variance component	Parameter
TV	Total raw variance in observations
MV	Raw variance explained by measures
PV	Raw variance explained by persons
IV	Raw Variance explained by items
UV	Raw unexplained variance (total)
U1	Unexplained variance in 1st contrast
U2	Unexplained variance in 2nd contrast
U3	Unexplained variance in 3rd contrast
U4	Unexplained variance in 4th contrast
U5	Unexplained variance in 5th contrast

Figure 15 illustrates decomposition of variance components in a scree plot. The top part of the scree plot shows location of parameter measured by the model while the bottom part shows components of unexplained variances (U). Variance in the data indicates that the model has explained 55% of measured variance (M), which is approximately parallel to the result of EFA in 5.4.3. Rasch person ability (P) explains 33 percent of the measured variance and Rasch item difficulty (I) explains 22 percent of the measured variance.

The result shows five factors (U1 to U5) for total of 45% of the residual variance. The first and the second factors (U1 and U2) explain more than 2 % of the residual variance that indicates noticeable strength of more than three items for additional measure to the model (Kline, 2005). The following three factors of residual show subdued items strengths to disregard.

The first factor in the residuals explains 5.3% (U1) of the variance in the data indicates strength of about 6 items (out of 66 items) formed in as an additional factor (contrast). Second contrast (U2) has 2.6% of variance that derived 4 items strength for another additional contrast. The factor sensitivity ratio (U1 divided by P) yields 0.15 for first contrast and 0.08 by second contrast respectively. These mean that 15% and 8% of the model stability affected by the two additional factors respectively (Wright andand Stone 2004).

Figure 16 Standard Residual Plot with three dominated cluster groups

```
      -3    -2    -1     0     1     2     3     4     5     6     7
      -+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+- CLUSTER
   .7 +                  |                                          +
      |        A         |                                          |   1
   .6 +         DEFCB    |                                          +   1
C     |        IHJGK     |                                          |   1
O  .5 +           ONLM   |                                          +   1
N     |          P Q     |                                          |   1
T  .4 +                  |                                          +
R     |                  |                                          |
A  .3 +                  |                                          +
S     |                  |                                          |
T  .2 +                  |                                          +
      |                 R|                                          |   2
   .1 +               S  |T                                         +   2
      |                  | U                                        |   2
L  .0 +------------------WYVXZ--------------------------------------+   2
O     |                  2 2                                        |   2
A -.1 +                 1|2 11                                      +   2
D     |              1   |1 1  1                                    |   3
I -.2 +                  1 ywptzx                                   +   3
N     |                 sqv our                                     |   3
G -.3 +                  |mlknij                                    +   3
      |                  |   gh                                     |   3
  -.4 +                  |   df e c                                 +   3
      |                  |   b   a                                  |   3
      -+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-
      -3    -2    -1     0     1     2     3     4     5     6     7
                              ITEM MEASURE
```

The map in figure 16 illustrates position of the items' residuals of the data by plotting item difficulty measure (x-axis) against magnitude of factor residual (standardised residual) loading (y-axis) of each item in the measure. Instead of random spread in the residual plot, the map reveals distinctive pattern of items at the top left of the map dominated by six items (label A, F, D, E, B, C) in the circle and other 11 items in Cluster 1. The group of items in Cluster 1 have the highest residual loading and negative item difficulty measure. All items in cluster 1 were identified as items from OBE subscale. Close inspection on the items residual loading identify the six dominated items (B10, B1, B4, B6, B8, B16) and were used to represent the group character analysis next. The statistical concepts of the six dominated items in Cluster 1 (first contrast) are presented in Table 48 below.

Table 48 Dominant items in first added group (Cluster 1)

	Item	Residual loading	Item measure
B10	In science, I think it is important that students are involved in investigation activities.	0.66	-1.60
B1	I think that the use of Science Process Skills (SPS) is important in science investigations because students can learn and understand science concepts better in class.	0.62	-1.15
B4	I am confident that activities involving science processes nurture students to be more interested in science.	0.62	-1.25
B6	I think that teaching science through investigations is important because it stimulates the students to think.	0.62	-1.47
B8	Teaching science through the investigative approach will attract students' attention to learning science.	0.58	-1.33
B16	I believe that mastering the SPS will help teachers to teach using science investigation approach.	0.58	-1.28

Items listed in Table 48 were the items marked in the top circle in Figure 16. All the items seem to measure belief on consequences of inquiry approach in student learning and belief on consequences of inquiry skills focus on teachers. With the highest loading of residual, the items reflect least variance that accounted for the measure. It means that items in cluster 1 explained least trait of the SETSIS measure among the sample.

The variances were expected in OBE factor because it was characterised as a complement of the self-efficacy trait measure (Bandura, 1994). The items' statement using third person referred to student and 'teachers' instead of self-referred might lower the variance accounted for this self-efficacy measure. All the six items have negative value of items measure suggest that all the items' statements were easy to agree with.

Next, Figure 16 shows the other two groups of items residuals identified at middle of map. Items that form pattern at the top middle of the map were grouped and identified as cluster 2. Items that form pattern at the bottom of the map were grouped and identified as cluster 3. These two grouped of items were discrete from cluster 1. Random pattern among items at the middle suggest that the items measuring same latent variable.

The residual in the items of Cluster 2 reflect low variance that accounted for the measure. The top four items (P22, K3, P26 and P25) were marked in the middle circle as dominated items from cluster 2 and sampled for the character analysis in Table 49.

On the other hand, six bottom items (K6, K11, K8, K25, K9 and K26) were marked in the bottom circle as items with the lowest residual loading in cluster 3. The six bottom items reflect the highest variance accounted for the measure and were sampled for the next analyse of group character in Table 49.

Table 49 Dominated items in the middle variance

Item		Residual loading	Item measure
K6	I have knowledge in constructing scientific ideas to provide guidelines for students to explain their scientific results.	-0.45	1.27
K11	I know I possess sufficient SPS knowledge to teach science through scientific investigations to primary school students.	-0.41	0.68
K8	I have knowledge in guiding students to plan their own problems to solve.	-0.38	1.31
K25	I am confident I have sufficient investigation skills to teach important scientific concepts effectively.	-0.38	0.71
K9	I know how to provide guidance so that students can develop their own issues to solve through scientific investigation.	-0.36	1.06
K26	I can always answer scientific enquiries from students using my understanding of the science process.	-0.36	0.78
P25	I want to guide the students to self-evaluate the consistency between their explanation and the scientific ideas given to them.	0.07	0.39
P26	I plan time to give students a chance to explain their investigations and discovery in class.	0.09	0.15
K3	I understand SPS is a basis to assist students in collecting data to answer their questions.	0.11	-0.56
P22	If given opportunity, I will encourage students to give various explanations from the same observation.	0.15	-0.14

Table 49 presents the 10 dominated items arranged from the lowest residual loading to the highest residual loading at the middle of the map. Evaluation on the items description explain distinct characteristic of the items. The six items (the lowest circle in Figure 16) were measuring the KE factor including the three items (K8, K6 and K9) which were described as the high items in KE subscale in section 6.1.1.1 above. These items consist the lowest residual variance that reflect the highest items that able to explain the variance in the SETSIS. All the items' statements focus on measuring perceived confident in knowledge of teaching science using skills of inquiry. Meanwhile the other four items at bottom of Table 49 (P25, P26, K3 and P22) show higher residual variance from the six top items. All the items' statements have similarity in stating the implementation of teaching using skills of science inquiry. While the items P25, P26 and P22 stated about instructional implementation in teaching using skills of inquiry, K3 stated about basic knowledge needs in implementing teaching using skills of inquiry. Thus, these four dominated items marked at the centre of map in Figure 16 explain the trait of the SETSIS that much represent the implementation of teaching using science inquiry skills in mixture of items that represent more into PTE factor.

Checking on the item measures show that the difficulty measure for top items in contrast 2 were lower compared to items in contrast 3 but the level of difficulty is not far apart. However, the vertical differences in the residual loading explain that these two groups contrast with each other and have a different subtle factor underneath. Inspection of full list of items residual loading reveal that cluster 2 has most of the items that come from PTE subscale and items in cluster 3 are mostly from KE subscale. This result supports that every subscale has dominated by items characterised according to the proposed factors as proposed in Chapter 4.

In conclusion, the empirical result in data variance suggest that OBE (cluster 1), PTE (cluster 2) and KE (cluster 3) exists as the three factors in the SETSIS measurement model with different measure characteristics. These three factors have established measurement characteristics as intended at the beginning of measure construction. However, items' variance position plot suggests that the OBE items in cluster 3 has possibility to measure a second dimension. Thus, further commonality for the items' clusters were investigated for it dimensionality based on correlation of person measure error now.

6.1.3.2 Correlation of person measures in the model

Table 50 Person measure relationship between the three clusters

Person Clusters	Pearson Correlation	Disattenuated Correlation
1-3	0.61	0.68
1-2	0.73	0.80
2-3	0.87	0.91

*Cluster 1 measure trait of OBE, Cluster 2 measures trait of PTE, Cluster 3 measures trait of KE

Table 50 shows the relationship of the three clusters based on the person measures. The Person correlation (r) indicates the direction and degree of linear correlation in the three clusters have positive correlations with the different magnitudes. This statistics evidence shows that the three factors described using the three clusters measure the same direction but the degree of correlations vary between the clusters. Sample correlation coefficients between OBE and KE (r = 0.61), OBE and PTE (r=0.73) and PTE and KE (r= 0.87) show moderate to strong correlation.

The disattenuated correlation results explain that the three measures in Table are correlated. The disattenuated correlation coefficient does not exceed unity (disattenuated correlation = 1.00) with values just below 0.7, which is near unity, revealing that the correlations of OBE-KE and OBE-PTE are low due to randomly distributed errors (Schumacker 1996). The evidence suggests that OBE do not have strong correlations with PTE and KE but are still significantly correlated to the factors. On the basis of sample corrected correlation coefficients being near unity, it is not strong enough to conclude that OBE items measure different dimensions than the SETSIS.

6.1.4 Summary

Section 6.1 was reported to answer the RQ3. The analysis was conducted using the Rasch model as a comparison model. It was reported in three different Rasch model parameters – item measure, person measure and dimensionality measure – to judge the appropriateness of the SETSIS for the sample group.

Good distribution of item difficulty in the measure

The item parameter is reported to examine the spread of the item difficulties and was used to judge whether the items constructed in the SETSIS were targeted to the level of desired ability in teaching using science inquiry skills based on the three selected subscales (i.e. KE, PTE and OBE). The results shows good distribution of item difficulty. The high item reliability at 0.98 indicates that the item parameter has measured level of item difficulty relative to the measure of the sample ability. The item separation confirmed that all the items can be discriminated into more than seven groups of separations. Thus, this result indicates the possibility of the existence of the three levels of item difficulty, as desired. Instead, the items distributed well with more easy items in the SETSIS. Analysis of item in all the subscales show that each subscale has a good spread range with the item measure ranges varying more than the standard deviation (SD) of the mean item.

Sample provides good range of ability

Analysis of the person measure can explain the level of ability (trait) estimation among the sample. The parameter informed about reliability in the estimation of the trait level in teaching using science inquiry skills for the sample group used in this study. The result of high person reliability at 0.98 provided that the sample was able to provide a wide range of the trait level based on the items provided in the SETSIS. The sample distinguished group of traits for more than six separation groups that lead to positive possibility to differentiate traits of teaching using science inquiry skills in the three proposed levels. However, the model estimated that the sample has a higher level of trait in teaching using science inquiry skills than that can be measured by the items in the SETSIS. This result is expected as the members of the sample group chosen for this study have strong backgrounds in science and were trained to teach science using science inquiry skills.

Moreover, the analysis indicated the existence of random responses that might contribute to the noise of measurement. Further, the random responses were detected and unweighted for measurement calibration. Instead, the new calibration without the random responses did not affect the reliability of the measure; thus, the whole sample (N=324) was retained for the next analysis.

The three factors measure a single SETSIS dimension

Using Rasch analysis of dimensionality, this study intended to explain the information provided by the SETSIS over the trait measured. Using the characteristics provided by items that explained a pattern of variances for the measure, this study is able to describe the contribution of the items to explain information in the SETSIS. The analysis concludes that the items chosen from the random residual in the model can explain the three factors' characteristics. All three factors function as expected in terms of measurement characteristics.

Further analysis of commonality among the items in OBE and items in KE and PTE suggested that there is not enough evidence to suggest that the SETSIS is constructed with more than one dimensional variable. Thus, in conclusion, all three factors are able to measure a latent trait underlying the SETSIS measurement model.

6.2 The Model Structure

This section investigates the validity of the three factors as a measurement model in measuring ability of teaching science using science inquiry skills. First, the validity of the internal structure of the measure is checked, based on the hierarchy of targeting items to each person's ability measure. Item hierarchy analysis explains the validity of the construct mapping proposed at the beginning of the project. Next, the five-point Likert scale used in the measure is evaluated for appropriateness and functionality of each category in measuring the ability of sample. Interpretation of the measure based on the raw score of the measure gives the validity score and purpose of the measure.

6.2.1 Mapping person-item relationships

Analysis of location of items and person parameters is conducted to evaluate construct validity for 66 items in the SETSIS. A graphical representation of the relationship between item difficulty and person ability was plotted on the same scale, as shown in the Wright map in Figure 17 below. The plot displaying a vertical histogram of item difficulty estimates on the left and a vertical histogram of person ability estimates on the right. The map identified item difficulty distribution using the label *rare* at the top and the label *frequent* at the bottom. On the right side, the top of person distribution was identified with the label *more* and the bottom of person distribution with the label *less.* The person location distributed from top to bottom of the map indicates that the sample shows the various abilities of the measure.

On the left side of the map in Figure 17 items were positioned according to the difficulty measure in the scale of logit. The distribution of the items shows a good spread that can be grouped into three levels of difficulty. The mean item difficulty measured at 0 logit is marked with ‘M’ (in circle) and is used as a reference point of the scale. The levels can be identified with the marks along the left side of the middle dash line. The ‘S’ and ‘T’ markers indicate levels of item difficulty, respectively within one sample and two sample SDs from the item mean, M. Items that sit closer to the top are the high items with high levels of affirmation to agree, while items that sit closer to the bottom are the items with easy affirmation to agree with.

Figure 17 Wright map (Winsteps 4.0)

```
MEASURE                    ITEM - MAP - PERSON
                             <rare>|<more>
    7                              +
                                   | Semester 8          Semester 6&7          Semester 1, 3 & 5
                                   |
                                   |                       PP15
    6                              +
                                   |  TB35
                                   |T PP7                  PP18
                                   |  TI30 TI33                                   SM30 TW18 TW29
    5                              +  PP8  TB1  TB6        PP29                   SM10 SM19
                                                                                  TI4  TW22
                                   |  TB32 TB36
                                   |  PP3  PP5             PP20 PT37              TI11 TR12
                                   |  TB2  TI32            PP17 TAA11 TAA4        SM1  PT24
                                                           TAA8                   RM11 TR4
    4                              +S PP4  TB28 TB5        BL21                   RM8
                                   |  PP1  PP6             BL24 PP14 PP22
                                      TB37 PP9  TI21       PT39 TAA10             TI14 TW01
                                   |  TI31                 PP23 PP30 TAA3         TI10 TW23
                                   |  KB7   KB8            BL22 PP24              RM7  BL2
                                      TB30                 TAA5                   TI19 TI26 TI3
                                      TI29                                        PT22 SM24
    3                              +  KB9                  IP17 IP22 IP23         RM9  PT14
                                      TB20  TB26           TAA16 TAA6             SM34 SM3  SM32
                                      TB31  TB27                                  TI16
                                                                                  PT20 SM27 TR6
                                   |  PP2   TB13           IP11  TAA17            IP2  SM36
                                      TI27
                                   |M TB11  TB14 TI23      IP14  IP25             RM4  BL13 BL15
                                                           TAA15 TAA18            TI5  TI7  TW09
                                                           PP31                   PT15
                                   |                       IP21  IP26             PT7  PT8
                                      TB4                  PT35  IP18             TI9  TW04
    2                              +  KB4                  PT41                   TW11 TW15 RM10
                                      TB25                 TAA13 TAA7             TR2  IP10
                                 T|   KB11  TI28           BL29  IP20             BL6
                                      TB15  TI22           PP27  PP32             SM15 SM26
                                      TB21                 TAA2                   TW16 RM6  BL17
                                   |  KB1   KB10           BL26  PT30             IP1  BL1
                                                           PT31                   TW25 TW26
             K6  K8                |  KB3    KB6           BL27  PP25             BL12 BL14
                                      TB10   TB9           PT29  PT36             SM28 SM31
                                                                                  TW14 TW05 TW08
    1  K13 K15K9 P10 P11P6 K16+S                           PT28  PT33  PT40       RM2  BL5  PT11
       K1 K10 K11                S|   TB17      TB19                              BL4  TI17 SM9
       K25 K26 K23 P7                                                             TW10 PT4
       K18 K22 K5 K7 P1            |  TB16                 IP12                   SM17
       P14 P24 P25 P27 P8
       K12 K19 K21 K4 P12 P13      |                                              BL11 BL7 TW13
       P16 P29 P20 P26 P28
    0  K14 K2 K20 K23 K24         M+  TB18                                        I13 IP3
       P18 P21 P22 P3
                 P4                |                                              TW03
                 K3                |T                      IP16                   PT12 PT13
        B14 B9  K17              S|                                               IP6 PT1
   -1   B1  B12 B13 B15            +                                              BL10
        B17 B2 B4 B5 B7 B8         |                                              IP9
        B16 B18 B3                 |                                              IP8 PT2
        B10 B6                   T|
   -2                              +
                             <freq>|<less>
```

On the other side, the abilities are grouped and the level marked on the right side of the middle dash line. The ‘M’ marker indicates the mean level of ability of the sample. The ‘S’ marker indicates the level of ability in the SETSIS within one SD of the mean sample, while the ‘T’ marks level of ability within two SD of the mean sample. The persons with the most ability in teaching using science inquiry skills are located closer to the top and those with the least ability in teaching using science inquiry skills are located closer to the bottom part of the map. The result from the map above suggests that ability in the SETSIS among the sample is spread widely and that can be measured and grouped accordingly.

The levels were used to infer the ability of the sample relative to the level of item difficulty in the SETSIS measure. Section 4.4.1 proposed three levels of item hierarchy to measure level of ability in teaching using science inquiry skills among the targeted sample. Within the item and the person distribution on the map in Figure 17, three levels of the items can be drawn upon. The item levels were based on item difficulty on the right side of the map relative to person ability measure .

The high person ability in teaching using science inquiry skills located above the mean sample SD 0.82 logit. This probability indicated that the items above the mean were more difficult to affirm compared to the items below the mean. Thus the items above the mean are categorised with the high level of item difficulty.

Persons located within ±0.82 logit (± the mean sample SD) have the average ability in teaching using science inquiry skills. This probability indicated that the items within the range were easier to affirm than the items above the positive mean (i.e. +0.82 logit) but were harder than item below the negative mean (i.e.-0.82 logit). The items located within the range are categorised as the items with the mean level of item difficulty.

Person located below -0.82 logit have low level of person ability in teaching using science inquiry skills. This probability indicated that the items located below -0.82 logit are the easiest to affirm compared to the above items. Thus, the items below the mean sample SD at -0.82 logit are categorised as the easy items.

All the items from the three subscales progress well along the scale give reasonable evidence that the three factors have defined trait of the SETSIS measure well. There was no gap in between the items indicating that the items uniformly measure difficulty along the continuum. This means major factors that influence the underlying trait have been covered by the measure. However, there were overlapping items measuring the same difficulty level. These overlapping items seem to measure similar portions of the trait and might give the same measure information.

A detailed inspection of the item difficulty measure (see Appendix 8) reveals 11 items that measure at the same difficulty presented in Table 51 below. The table lists the overlapping items that measure at redundancy difficulties. Items K13 and K16 measure ability at 0.85 logit, explaining the same underlying trait in two different science inquiry skills. Items P7 and P23 measure ability in practicing teaching using science inquiry skills at 0.65 logit with the statements that explain the different instruction approach used in practice. Three items P1, P27 and K5 measure the trait at 0.48 difficulty but the statements expose three different strategies used for the same investigation approach. At 0.1 logit measure, items K19 and K24 measure perception of the knowledge ability in two different contexts: increasing skills and using skills to increase learning. Lastly, items B8 and B17 measure the item at -1.33 logit from information on belief of using science inquiry skills affecting learning from different perspectives: students and teachers. These items seem to measure the same difficulty; however, close analysis of the items statement shows different contexts of measure.

Table 51 Table of 11 redundancy items

Difficulty measure	Item	Statement
0.85	K13	With the SPS knowledge that I have, I can form scientific inquiries needed for students to make a study.
	K16	My experimental skills are sufficient to explain the function of experiments to students.
0.65	P7	I try to use one set of data from worksheets to assist students in the analysis process.
	P23	I can guide students to give a consistent explanation on the proofs from the observation of the experiment.
0.48	K5	I can combine SPS knowledge to the subject's content to encourage students' participation in scientific investigation activities.
	P1	When an activity of science process is challenging to implement, I will arrange every step in the activity using the investigative approach.
	P27	I am able to guide students to deliver their explanations using clear scientific terminologies.
0.10	K19	I am constantly searching for effective SPS methods to teach science.
	K24	I am able to impose an inquiry to get students' attention to solve it.
-1.33	B8	Teaching science through the investigative approach will attract students’ attention to learning science.
	B17	I am confident that teachers who understand and master SPS can teach science smoothly and efficiently.

At this stage of initial calibration, the redundancy items' character information and differences should be highlighted but the items remain through the process. Removing the individual redundancy items can increase efficiency of the measure but result in less calibration precision. In future, the benefit of calibration and the items information can be considered for shorter and effective measure of SETSIS.

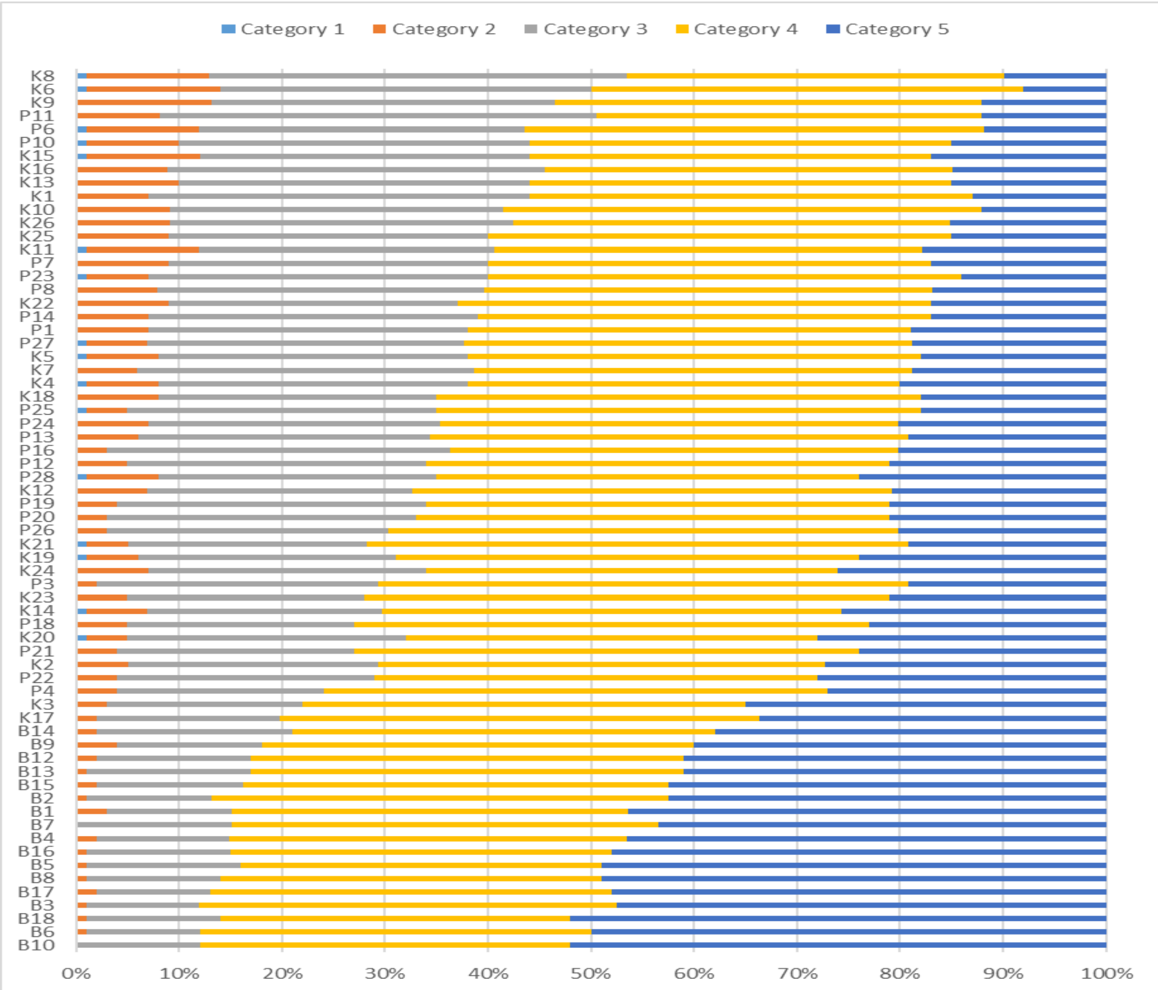
A closer look at the overall position of the two estimate parameters show that the person mean sits above the high level of item difficulty. This indicates that most items in the measure explained the lower portion of ability. Theoretically, optimal targeting measures can be obtained with the same measure of mean person ability and mean item difficulty (i.e. mean for both parameter at 0 logit): however research in psychological perspective have shown that mean item below one logit of the mean person can target a better measure (Boone, Yale and Staver, 2014) . Thus, from the measures plotted in this study, it seems that the high level of items interacts only with near-the-average person ability but not enough to explain the ability over the hardest items K8 and K6 in difficulty measure. This analysis indicates that the SETSIS measure lacks high level of items to discriminate the high ability person on top of the map. Thus, it is clearly that the measure needs more difficult items to measure the high ability hierarchy of the sample.

On the other end, further visual inspection of Figure 17 shows that the distribution of difficulty (item) and ability (person) were not evenly distributed. The model estimated more than seven items separation with the wide spread of sample's ability (in section 6.1.1). However, more than three quarters of the items sat within one SD of the mean item and at the bottom of the map. Instead, less than 10 percent of the sample were estimated as within this level of average and low ability in teaching using science inquiry skills. Even the lowest ability persons have more probability to agree with the statement in the easiest items, B10 and B6. This evidence suggested that the study needs more samples of average ability and low ability persons to distinguish the items at the level of mean item difficulty and easy item difficulty level. At this stage of study, these levels would provide information in items' level characteristics that can be used to validate the proposed construct and beneficial for future item design. The next section further analyses the characteristics in each of the item difficulty levels and the responses.

6.2.1.1 Characteristic of item hierarchy

Analysis of item hierarchy gives information to develop reasonable characteristics for the difficulty levels. The high level of item hierarchy are the most difficult items to agree with least respondents endorse in top category of rating scale. The least of item hierarchy level consists the easiest items to agree with most respondents endorse the top category. The hierarchy of items develop upon responses given by the sample. Figure 18 presents the frequency of responses in the items according to a five-point Likert scale from category 1 (not confident at all) to category 5 (definitely confident), arranged from highest hierarchy (top graph) to lowest hierarchy (bottom graph) of item measure.

Figure 18 Frequency of responses to items (in percentage) according to category



Within the item distribution in the map in Figure 17, three items' hierarchy are drawn upon marks of one sample SD above and below the upon mean item difficulty. Items with difficulty measuring above one sample SD (0.81 logit) are used to measure the highest person ability of the SETSIS label as the high level of items. Items within ±0.81 logit are categorised as the mean level of items, and the items below -0.82 logit are categorised as the low level of items.

6.2.1.1.1 High level of item difficulty

High level items consist of nine: K8, K6, K9, P11, P6, P10, K15, K16 and K13, listed inTable 52. These items contain hard statements to agree with. The frequency graph above shows only 8 percent to 12 percent of respondents chose the highest category, *definitely confident* with the item statement, but 44 to 54 percent of respondents chose the lower three categories for these items. It means that these items are associated with high difficulty in the SETSIS, whereas only respondents that are really confident in their ability teaching using science inquiry skills will agree with the statements.

Table 52 Items associated with high item hierarchy

Item	Statement	Difficulty measure
K8	I have knowledge in guiding students to plan their own problems to solve.	1.31
K6	I have knowledge in constructing scientific ideas to provide guidelines for students to explain their scientific results.	1.27
K9	I know how to provide guidance so that students can develop their own issues to solve through scientific investigation.	1.06
P11	I can guide students to ask significant scientific questions.	1.04
P6	I know how to provide suitable data to be analysed by students.	0.95
P10	I am confident of teaching through the approach of scientific investigations regardless whether the content is easy or difficult.	0.87
K15	In the absence of scientific apparatus, I am comfortable in using my own knowledge on experiments to adapt my teaching process.	0.86
K16	My experimental skills are sufficient to explain the function of experiments to students.	0.85
K13	With the SPS knowledge that I have, I can form scientific inquiries needed for students to make a study.	0.85

The three highest measure items and the three bottom items were from the KE subscale. The other three items were from the PTE subscale. Highest item K8 states about ability of sufficient knowledge to clear plan a guide (i.e. enriching integrated SPS knowledge and effectively use it) to stimulate students (i.e. plan own problems) in learning the science. Item P11 (PTE sub-scale) states capability of implementing an instruction approach (i.e. ability of giving guidance) that stimulates strategy of asking questions (i.e. significant scientific questions). The characteristics exhibited through the high items is similar those as mapped in the proposed framework of item design (see Chapter 4.3). Despite their difference in underlying factors, these item statements identify capability to enrich trait in teaching using science inquiry skills and use it to stimulate students' learning.

The observation on person location in Figure 17 shows 77 percent (157) of respondents are above the level of items K6 and K8, and thus have a higher probability to endorse more than category 4 in all the items. It reflects that most of the respondents show confidence in the overall trait. However, the discrimination of person ability in the SETSIS is not clear at levels higher than items K6 and K8. Thus, the SETSIS needs more suitable targeted items in KE to estimate the higher ability of respondents above that level.

6.2.1.1.2 Mean level of item difficulty

There are 42 items from KE, PTE and OBE located at the mean level of items. The items in this level are located within one SD from the mean item measure. The level can be separate into two parts: items above the mean measure, and items below the mean measure. The items above the mean consist of 27 items from the KE and PTE subscales, while the items at the bottom of this level consist of six items from all subscales. Nine items located near the mean location on the scale are chosen to represent overall characteristic of items at the mean level.Table 53 represents items associated with mean item hierarchy.

Table 53 Nine out of 42 items associated with mean item level

Item	Statement	Difficulty measure
K19	I am constantly searching for effective SPS methods to teach science.	0.12
K24	I am able to impose an inquiry to get students' attention to solve it.	0.12
P3	I can provide explanation to my students about the activity of science process.	0.10
K23	I know how to use information given to predict a coming observation.	0.06
K14	I am knowledgeable in implementing experiments in my teachings.	0.05
P18	I am fostering student to review and ask questions on other students' results	0.01
K20	I understand about measurement and space to help students understand the concept of length using self-measure (i.e arranging paper clips/sticks).	-0.02
P21	I ask my students to provide steps or procedures when delivering their scientific results to class.	-0.03
K2	I understand about SPS which is required to guide students towards attaining scientific evidence through scientific investigations.	-0.05

Items in this level are a mixture of two factors, but It explains the straightforward ability of using trait of teaching using science inquiry skills that interact with decisions about learning science. For example, two items – P18 and P20 – with the nearest position to the mean measure (0 logit), were constructed on different factors with the same level underneath. Item P18 states decision on using instruction strategy (i.e. review other student's result and ask questions) to enforce science inquiry skills (communication and data interpretation) in classroom learning. Item K20 states the perceived ability about knowledge of science inquiry skills (i.e. using space-time relationship) helping to explain the lesson concept. The two items, even though they are distinct from each other are both meant to measure perceived ability to interact the cognitive thought of using the trait (i.e. knowing how) of teaching science inquiry skills in learning science.

6.2.1.1.3 Easy level of item difficulty

Referring to the measure and the location, items located below -0.82 logit were categorised as the low level of item difficulty. Interestingly, all 15 items in the low level were from the OBE subscale. These items are considered as easy items with more than 80 percent of responses agreeing with the statements and endorsing categories 4 and 5 on the items.

Item B6 (*I think that teaching science through investigations is important because it stimulates the students to think*) and item B10 (*In science, I think it is important that students are involved in investigation activities*) are situated at the lowest location of the map. The two items were the easiest items to agree with across the respondents. All respondents were more likely to agree with endorsing category 4 for the items. The result suggests that OBE, as the lowest factor of the SETSIS, and item B10 were the easiest items to agree with. Table 54 shows the four items with lowest measure that associate with the low level of item hierarchy.

Table 54 Items associate with low difficulty

Item	Statement	Difficulty measure
B10	In science, I think it is important that students are involved in investigation activities.	-1.60
B6	I think that teaching science through investigations is important because it stimulates the students to think.	-1.47
B3	In science, I believe it is important for students to have problem solving and investigative skills.	-1.43
B18	I think SPS knowledge is effective in assisting teachers to successfully teach science.	-1.46

Items at the low level indicate characteristics in recognition capability of belief that the trait of teaching using science inquiry skills promote learning science. Item B10 states cognitive belief (I think) in students benefitting from learning science through involvement in the trait of teaching using science inquiry skills (investigation activities). The characteristic of the trait in OBE is located at the low level of the SETSIS scale as a complementary factor of the SETSIS (Bandura, 1993). There are only four persons measured as a person with low ability with 15 items in the easy level of item difficulty. At this level, the four persons show more than 50 percent probability of endorsing category 2, while others have shown 50 percent and greater probability of endorsing category 4 for the above item difficulty level. The probability based on responses to the easy items empirically shows that this level is the lowest level in the SETSIS across the sample taken. However, there were not enough persons to be able to distinguish ability at this level and lower. Perhaps, future samples with different area of teaching background would propagate better results at that level and below.

6.2.2 Category measure for rating scale

This analysis of category structure was empirically tested on how the respondents used the rating scale. It assessed functionality of the five categories of the rating scale used in the SETSIS relative to the trait estimation. The scale was assessed using the distribution of responses across the five-point rating structure (category structure) from category 1 to category 5 across all the items. The statistical results from category function were used to describe the items and provide reliability of trait estimation according to the responses. The information on category structure over the trait range clarified the meaning of the data collected and provided validity for the measure’s interpretation.

6.2.2.1 Category functionality in the measure

This section analysed the reliability of the category options provided in the SETSIS in estimating the person ability according to the sample distribution above. The function of the categories was examined using frequency and average measures in all five response categories. Table 55 lists the response count across the categories with a slightly skewed distribution and minimal observation count of 32 responses in category 1. The responses provide enough observation (the minimal recommended responses of 0) for stable threshold estimation in the categories (Linacre, 1999).

Table 55 Category frequency and average measure for five rating scale of the SETSIS

CATEGORY LABEL	OBSERVED COUNT	AVERAGE MEASURE
1	32	-1.35
2	646	-0.12
3	3171	1.16
4	5598	2.52
5	4010	4.12

Average measure estimates person ability based on responses. Table 55 shows that average measure increases monotonically across the five categories used in the measure. On average, persons who endorse category 1 have the lowest average ability estimate at -1.35 logit compared with a person who endorses category 5, who have the highest average ability estimate at 4.12 logit. The increment empirically suggests that respondents who perceive they have a stronger ability to execute the stated tasks (in the item statement) endorse a higher rating category while respondents that perceive they have a weaker ability to execute the stated tasks endorse the lower rating category. The result highlights that the responses to the five-rating scale design (category 1= *not confident at all*, category 2= *not confident*, category 3 = *slightly confident*, category 4 = *confident* and category 5 = *definitely confident*) in the measure works in continuum order, as expected.

6.2.2.2 Category measure to inform estimate responses

The analysis in this section provides information of the rating scale categories over the abilities measured in the SETSIS. Table 56 explains the estimates of person measure relative to the item measure according to the category measure. It lists the Rasch parameters in the five categories used in the rating scale of the measure. The responses were highest observed in category 4 with the lowest in category 1, adequate for providing category information over the estimates ability (Bond and Fox 2007). Fit statistics show well the range of the infit MNSQ and the outfit MNSQ that lie within the critical value suggested (0.5<MNSQ<1.6). These indicate that every category works productively in the measure, with all five categories providing good information into the measurement process and the items are described accordingly (Linacre and Wright 1989). Thus, the five categories of the rating scale are adequate to explain responses in the sample.

The Andrich threshold in Table 56 is a parameter to differentiate one category to the adjacent category. The threshold value reflects the estimate's ability point where there is a 50:50 chance of choosing the two adjacent categories. The increment of the threshold values (-4.04<-1.19<1.32<3.91) indicates a well-functioning five category rating scale in the SETSIS. The magnitude of distances between the adjacent thresholds (-4.04 to -1.9 = 2.14 logit, -1.19 to 1.32 =2.51 logits, 1.32 to 3.91 = 2.59 logits) indicates a distinct position for the underlying category. The gaps' magnitudes were enough (>1.4 logits, < 5.0 logits) and the increasing magnitude reflects the appropriate step of difficulty in the number of category options and the interpretation of the rating scale in the SETSIS (Linacre, 2001).

Table 56 Result of five well-functioning categories in the SETSIS

CATEGORY LABEL	OBSERVED COUNT	INFIT MNSQ	OUTFIT MNSQ	ANDRICH THRESHOLD	CATEGORY MEASURE
1	53	0.94	0.94	None	-5.18
2	1042	1.13	1.14	-4.04	-2.63
3	4813	0.99	1.00	-1.19	0.06
4	8223	0.98	1.00	1.32	2.63
5	5001	0.96	0.96	3.91	5.06

The category measure is a response structure that explains the estimation of certain abilities perceived as the highest probability of each category. It provides information on the perceived ability of the category measured. The category measure in Table 56 increases monotonically to reflect personal ability from the lowest at -5.18 for category 1 – *not confident at all* – to the highest at 5.08 for category 5 – *definitely confident*. This indicates that all categories for all items were structured in alignment of the order of person ability and function as intended. Using the same rating scale across the measure, the characteristics of the response structure can provide an indication of the trait measured in each item, as shown in Figure 19.

6.2.2.2.1 Category measure to estimate level of ability

Figure 19 illustrates the response structure in logit scale. The probability curve summarises responses to the category option of the measure. Intersections of adjacent categories were the Andrich thresholds (Table 56), which have drawn equal probability of responses between the two categories.

Figure 19 Category probability curve

```
P      -+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-
R  1.0 +                                                             +
O      |                                                             |
B      |                                                             |
A      |                                                             |
B   .8 +                                                            5+
I      |11                                                        55 |
L      |  1                                                      5   |
I      |   1        2222222                                    55    |
T   .6 +    11    22       22       333333        444444      5      +
Y      |      1  2           22   33      33    44      44   5       |
    .5 +       *2              2 3          3  4          445        +
O      |      2 1              3*            **            54        |
F   .4 +     2   1            3  2          4  3          5  44      +
       |   22     1          3    22       4    3        5     4     |
R      |  2        11      33      2     4      33    55       44    |
E      |22           1    3          2  44         3  5           4  |
S   .2 +              1133            2*            **             44+
P      |              3311           44 22         5  3              |
O      |            33    11      444     22    555    333           |
N      |       33333        11***4          ****          3333       |
S   .0 +**********************555***********1111*********************+
E      -+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-
       -5    -4    -3    -2    -1     0     1     2     3     4     5

                                ABILITY
```

The response structure shows the way in which the estimated probability in categories 1 to 5 on the SETSIS scale vary with ability. Given that, the graph can estimate the probability of selecting response, given estimated ability. Estimation probabilities for average category responses to each subscale for five ability levels are shown in Table 57 below.

Table 57 Response probability at five levels of ability

Ability estimate		Response Category				
Level	Logits	1-not confident at all	2- not confident	3- seems confident	4- confident	5- definitely confident
M+2SD	5.80	0.00	0.00	0.00	0.20	**0.80**
M+SD	4.14	0.00	0.00	0.00	0.40	**0.60**
M	2.48	0.00	0.00	0.25	**0.60**	0.15
M-SD	0.82	0.00	0.10	**0.55**	0.35	0.00
M-2SD	-0.84	0.00	0.35	**0.55**	0.10	0.00

From Table 57, on average, persons with estimated ability located above mean are expected to answer category 4 or 5. The highest person estimated ability at level M+2SD have 80 percent probability of endorsing category 5 compares to a person at the lower level of ability, M+SD, with 60 percent probability of endorsing category 5. Person with estimated ability at mean level M were expected to have most 60 percent probability endorsing category. If not, they were likely to endorse more of the lower category 3 rather than category 5 or above. Persons with ability estimated lower than mean were expected to endorse more in category 3, with 55 percent probability. Persons at level M-SD have more likelihood of endorsing category 4 with 35 percent probability than category 2 at 20 percent probability. Inversely, a person at lowest level M-2SD would have less hesitation in endorsing category 2 than category 4. This analysis of responses gives empirical evidence for category functionality and moreover assesses the reliability of the person responses measured. Interpretation of response structure suits the ability level and gives good evidence that the SETSIS is valid in measuring the sample's level, as mapped in Figure 17.

6.2.2.2.2 Category rank measure in the subscale estimation

The analysis focuses on using the probability information of the estimate average measure above to provide validity in content interpretation in the three factors of the SETSIS. Table 58 extracts the average of the estimate person measure for groups of semesters in the three-factor variables. With the available information on category threshold and response structure above, interpretation of the average ability sample with different backgrounds (i.e. group of semesters) can be provided.

On average, estimation of ability in factor KE and PTE are approximately the same but less than the average ability estimation in OBE. The average estimate ability in KE and PTE shows values that can be interpreted in the range of *slightly confident* to *confident,* while measuring in OBE can be interpreted in the range of *confident* to *definitely confident* in the SETSIS.

Table 58 Person ability according to factors

Sub-scale	Level of abilty (in logit)					
	Semester 1	Semester 3	Semester 5	Semester 6	Semester 7	Semester 8
KE	1.23	1.52	1.93	2.3	2.24	2.55
PTE	1.22	1.52	1.93	2.3	2.24	2.55
OBE	2.83	3.13	3.53	3.9	3.84	4.15

Group semester 1 shows least average estimate ability in KE and PTE that exceeds the threshold of not confident but is less than the threshold of categories 3-4 (>-1.19 logit, <1.32 logit) (see Table 56). The information explains that on average, PSTs in group semester 1 are *slightly confident* (category 3) in KE and PTE. Other groups of semesters show average ability in confidence level but do not exceed to *definitely confident* within KE and PTE.

Abilities of the sample are higher in the OBE than ability in KE and PTE. Three early groups, semester 1, semester 3 and semester 5, show more confidence in OBE.

Groups semester 6 and semester 7 show value just below the threshold of 3.91 logit. It seems that the two groups on average, share a fair level of *confident* and *definitely confident* in the factor of belief measured by OBE. The semester 8 group are way past the *confident* level, with their average abilities estimation more into *definitely confident*. The interpretation of the category rank onto the ability level provides a good baseline scale of the factors that contribute to the trait measure. The scale shows a well-functioning interpretation that measures the trait as intended.

6.2.2.2.3 Category rank measure into real score estimation

The response structure provides information to assess the validity in the measure interpretation according to the measure characteristic. Using the category threshold estimate (see Figure 19) rank of ability in the measure is used to predict real scores using complete measure characteristic curve. Figure 20 show category measure information integrated into test characteristic curve (TCC) for complete measure interpretation.

Analysis using TCC graph assist calibration of ability measures into predicted on measure score. TCC linearly predicts the test score based on estimated ability measure. Category measure information helps to interpret measure score on the same baseline scale as the ability measure. The lowest threshold measure (-4.1 logit) is calibrated at predicted score 97. The lower score than that can be interpreted as not confident at all in the SETSIS. The highest threshold (at 3.91) is calibrated at predicted score 285. Higher than that score is interpreted as definitely confident in the SETSIS. The equivalent characteristic on measure form have produce equivalent score (see Table 59 below) that useful for PST score and proficiency classification in the SETSIS.

Using rank estimation for the true score obtained in the SETSIS summarised in Table 59, the sample's performance was ranked and charted according to the semesters group, as shown in Figure 21. The pie chart represents the percentage of performance in the SETSIS according to the five-measure rank from the lowest rank – not confident at all in teaching using science inquiry skills; to the highest rank – definitely confident in teaching using science inquiry skills. It can be seen that the percentages of the lower ranks were decreasing across semesters of study while percentage for the higher ranks were increasing across semesters of study. This result seems to reflect the development in self-efficacy in teaching using science inquiry skills among pre-service science teachers in the training of BoTP.

Figure 20 **Test Characteristic Curve for the complete SETSIS measure**

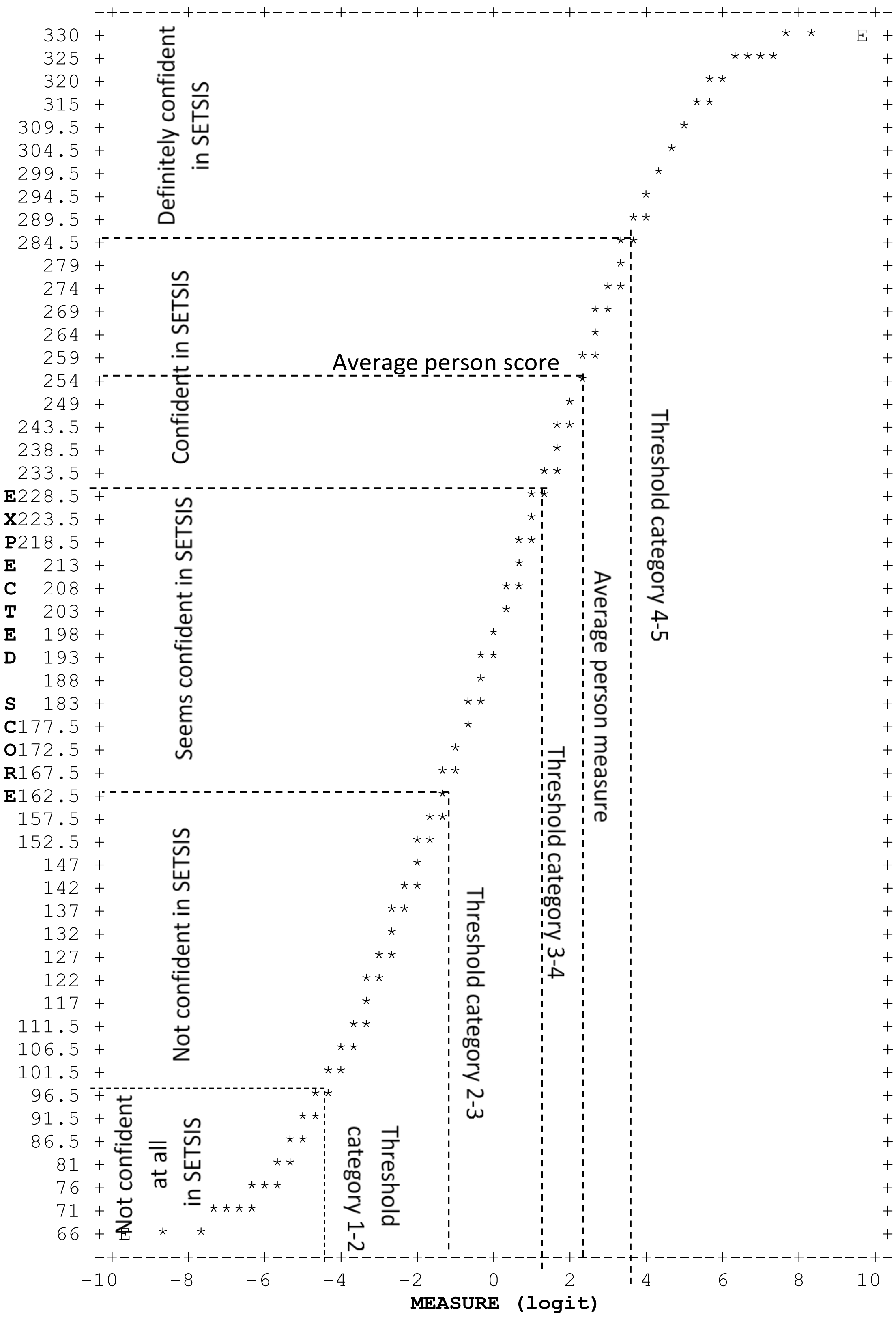
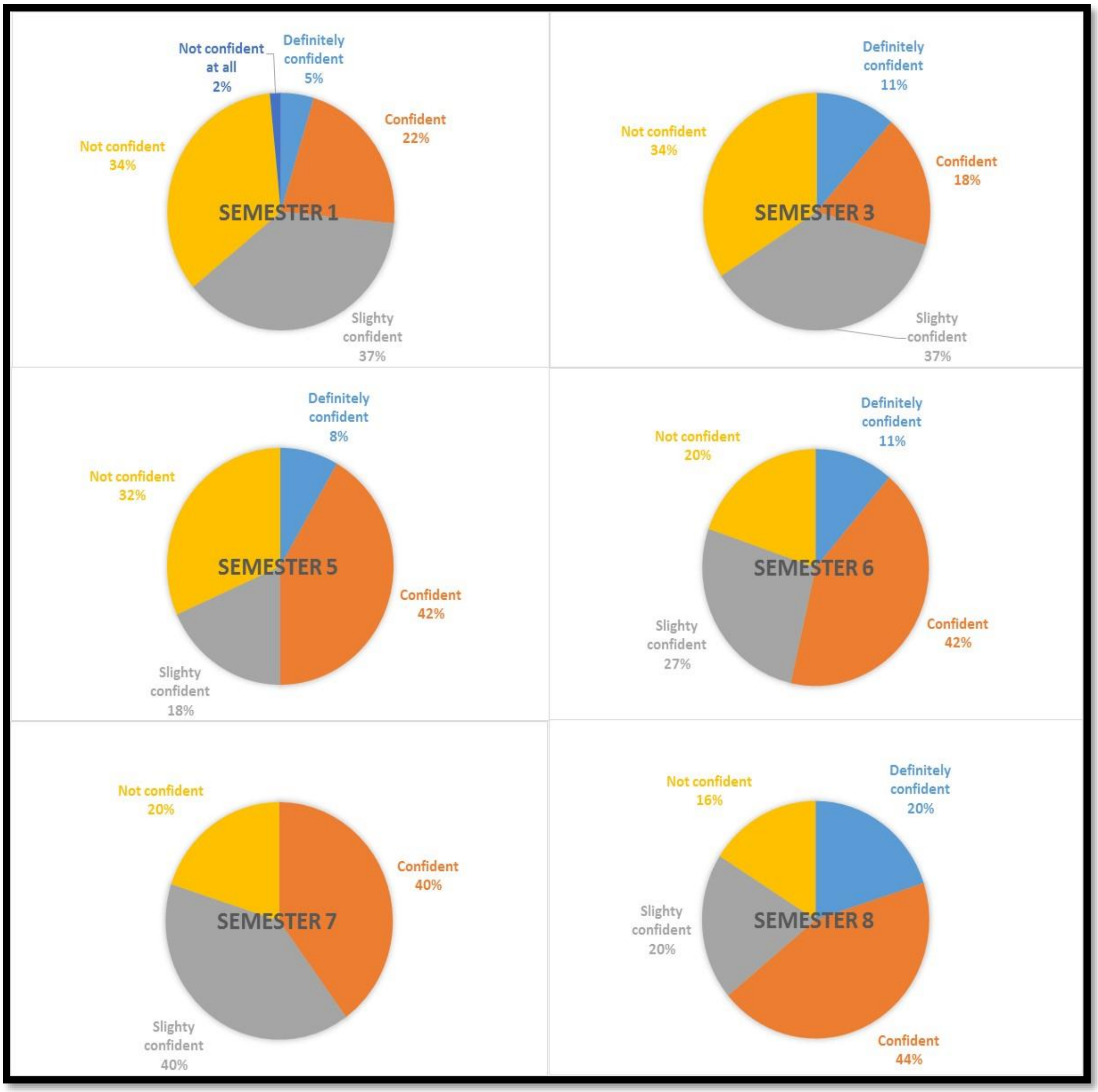


Table 59 Calibration of measure rank using the predicted score in complete measures of the SETSIS

Measure rank	Predicted true score range
Definitely confident	285 to 330
Confident	254 to 286
Slight confident	163 to 253
Not confident	97 to 162
Not confident at all	66 to 96

Figure 21 True score ranking for group of semesters



6.2.3 Summary

This chapter was intended to validate the SETSIS in the model structure. Firstly, the analysis was conducted of the structure of the level of items difficulty proposed that was used to measure level of trait in teaching using science inquiry skills. The distribution of the item difficulty–person ability map obtained from the study shows that the targeting items are not spread well across the sample traits, especially measuring the top traits of the sample. The measure lacks high level items to measure persons with high trait of ability in teaching using science inquiry skills. The current items consist most of the mean and easy level items for targeting samples with average and low trait of ability in teaching using science inquiry skills. Instead, all items function well along the measure continuum and explain the three level characteristics of difficulty measure, as proposed. The information from the characteristics of the item difficulty level has given three distinctive traits that validated the construct structure of the SETSIS in measuring the continuum trait of teaching using science inquiry skills.

Secondly, the analysis of the category measure proves that the rating scale with five category options is viable to reflect the responses structure in the measure. The five-point categories used in the measure were functioning as a mechanism of getting measurable response. All categories behave as expected and contribute information to differentiated levels of the trait of ability in teaching using science inquiry skills measured by the SETSIS. The estimation of responses from the rating scale were able to be interpreted by the score of the measure and most importantly able to classify the trait of teaching using science inquiry skills among the sample tested.

Chapter 7 Evaluation of the SETSIS

The SETSIS was modelled to measure traits of the pre-service science teachers' self-efficacy perspective in teaching using science inquiry skills. This was based on the influences related to the teacher's knowledge, practice and belief factors. It examines the relationship of performance between the SETSIS and other existing teacher knowledge assessments used in Malaysia. The relationships were examined using two sets of external assessments: i) Test of Integrated Science Process Skills (TISP), which assesses content knowledge in teaching using science inquiry skills; and ii) the assessment of Professional Practices courses that assess science teaching practice in real class situation during BoTP training. The results from this section will be used to answer my final research question.

7.1 Association of the SETSIS and the content knowledge

7.1.1 Test of Integrated Science Process Skills (TISP)

The TISP consists of 25 items that are conducted on the same 326 PSTs (N=326) that also participated in the SETSIS survey. The total score of the TISP is 25 with mean score M=21.38 (S.D. =2.96). Analysis from valid responses (N=325) show the TISP scale is consistent as a good measure (Cronbach's alpha = 0.73). As shown in Figure 22, more than 50 percent of respondents scored above mean with most responses (19.3 percent) scoring 24.00 (Mode= 24). This reflects the good knowledge of science inquiry skills among the respondents.

Table 60 reflects the descriptive statistics associated with the pre-service teachers' performance in inquiry skills knowledge during the teacher training with accordance to the semester attended. It can be seen that the highest mean (M =21.91) in inquiry skills knowledge performance was during semester 8 while the lowest mean (M=19.80) was during semester 5. However, semester 5 has the widest spread out among the group compared to the other group. This group of PSTs showed negative skewness and reflected the tendency to score more than the mean score. Therefore, the overall pattern of performance in inquiry skills knowledge was approximately the same in every group of semesters and it does not dependened on the number of semesters of training the PSTs had attended. This result seems to suggest that the knowledge might be developed or co-existed before the teachers attended the training programme.

Figure 22 Frequency distribution of the TISP achievement

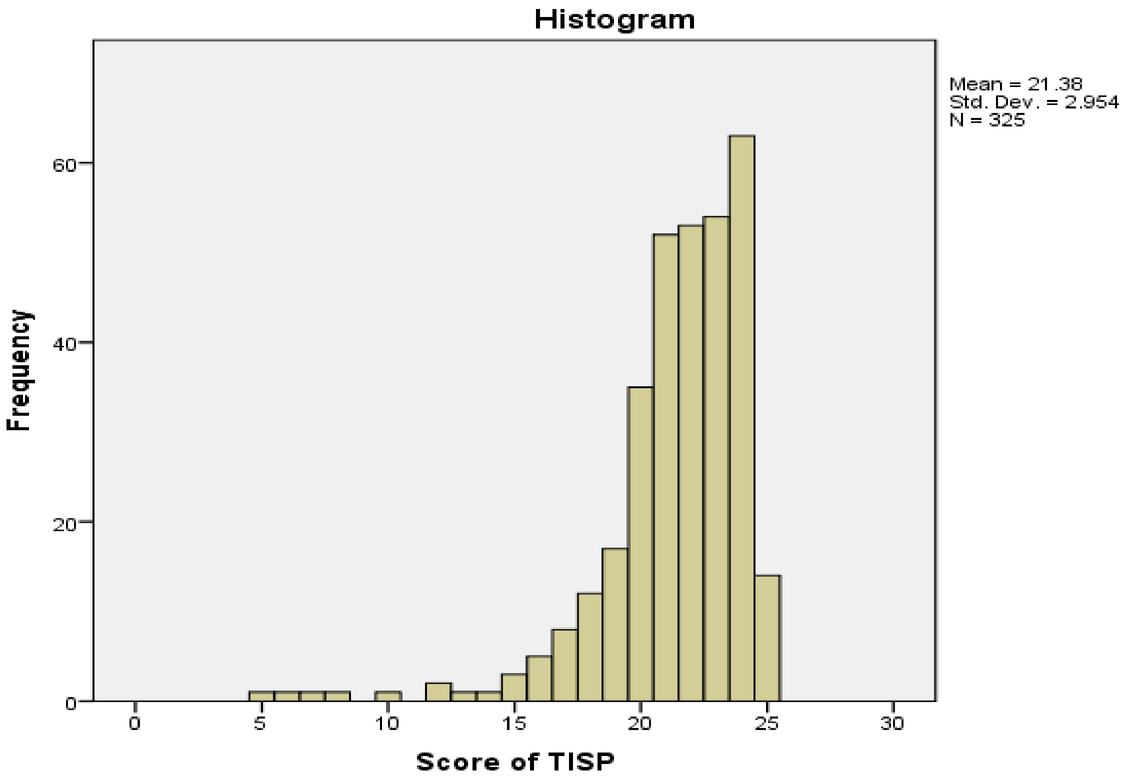


Table 60 Descriptive statistics for score performance in the TISP across cohorts

Semester group	Number of sample, N	Mean score, M	SD	Skewness	Kurtosis
1	82	21.65	2.04	-0.67	-0.13
3	28	21.89	1.95	-0.58	0.29
5	60	19.80	4.78	-1.65	2.31
6	70	21.67	2.32	-0.72	0.14
7	9	21.22	4.32	-1.65	0.69
8	75	21.91	2.11	-1.29	0.28

Analysis of mean of scores across the group of semesters in Figure 22 shows differences in the means. The histograms show achievement levels in the TISP across semesters were good. The scores distribution in all histograms were leaning towards the right where most of respondents achieved more than 20 scores in the

TISP. Despite This contradicts with Hairiah and Chin (2010) finding when they reported that the performance levels of PSTs in integrated science process skills knowledge were between moderate and low. However, the mode scores range across the semesters in this study (mode range =22 to 24) and this reflects that the knowledge possessed by the PSTs was very good.

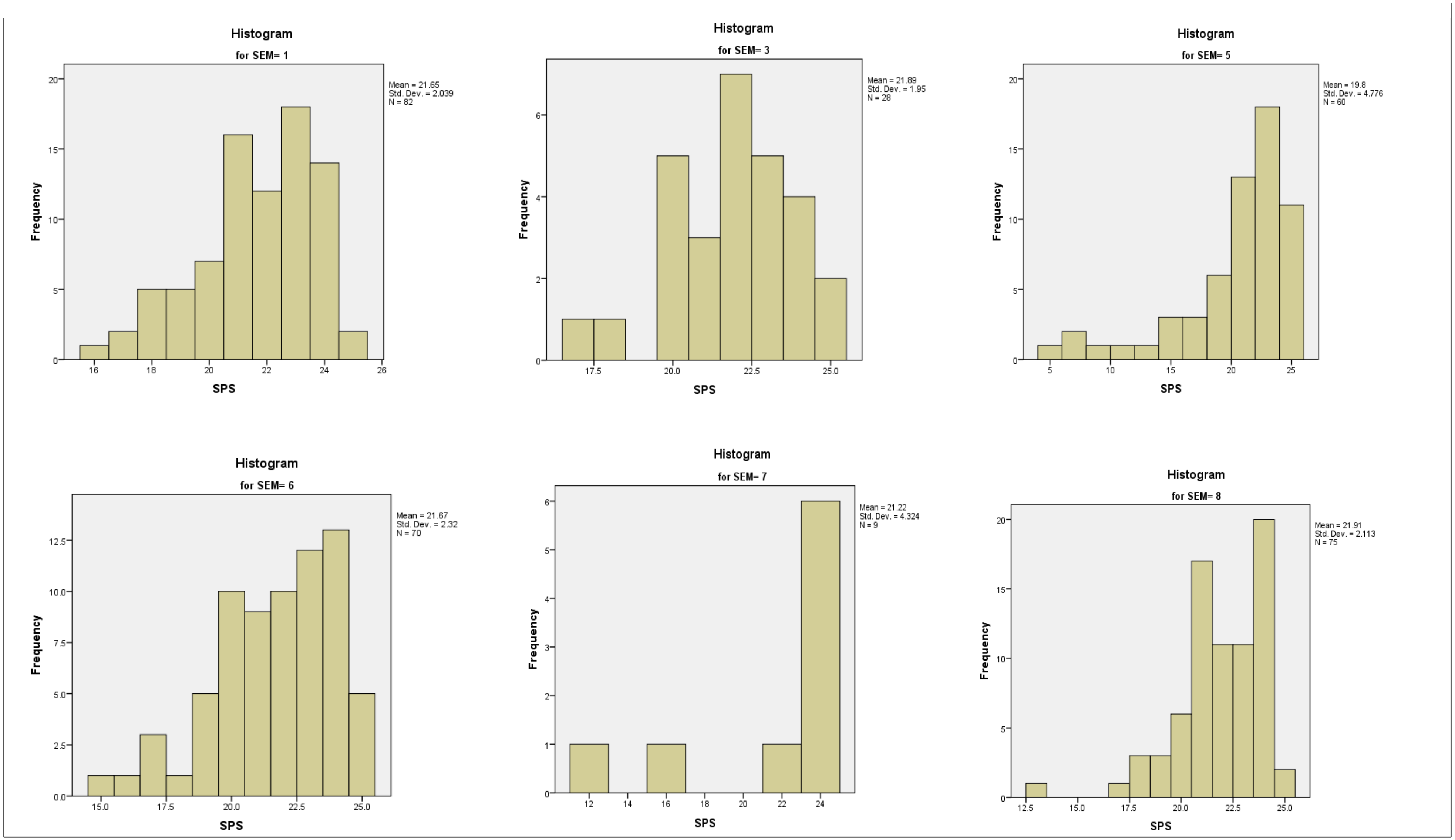
Analysis of the five subscales of the TISP revealed a pattern of scores that were contradicted by the previous findings. Table 61 of descriptive statistics indicates a good level of knowledge in controlling variables skill (mean = 4.82) and interpreting data skill (mean = 4.32). These findings were contradicted as reported in Hairiah and Chin (2010) and Tan and Chin (2001).

Thus, the analysis of the five subscales of the TISP indicates a good level of knowledge in controlling the variables skill (mean=4.82 and interpreting data skill (mean=4.32). The score percentage also indicated two other subscales: making hypotheses and defining operationally have more than 80 percent scoring above 4 with mean= 4.11 and mean =4.64, respectively. Experimenting skill, on the other hand, shows a moderate level of performance with mean = 3.49 with 45 percent of respondents scoring less than 4. The indication shows that PSTs have better knowledge in making hypotheses and defining operationally compared with experimenting skills. This results also contracdicted with respect those reported by Hairiah and Chin (2010) and Hafizan et Al. (2012).

Table 61 Descriptive statistics for score performance in the TISP

Integrated SPS	No. of Items	Minimum	Maximum	Mean	Std. Deviation
Controlling variables	5	0	5	4.82	0.62
Hypothesising	5	0	5	4.11	1.06
Define Operationally	5	1	5	4.32	0.82
Interpreting Data	5	0	5	4.64	0.72
Experimenting	5	0	5	3.49	1.07
Total	25	5	25	21.38	2.95

Figure 23 TISP score distribution across the group of semesters



7.1.1.1 Fit analysis using Rasch

Table 62 shows the summary of measure and fit statistics for 25 items of the TISP using Rasch analysis. The overall, items have good item reliability and good item separation. The item reliability in the TISP is 0.97, indicating high reliability items with seven strata groups of estimated separations (separation=5.31). It means that the TISP has high reliability in item location with a wide difficulty range.

Table 62 Summary of fit statistics for 25 items of the TISP

		INFIT		OUTFIT	
PERSON (N=311)	MEASURE	MNSQ	ZSTD	MNSQ	ZSTD
MEAN	2.56	0.99	0.10	0.86	0.10
SD	1.10	0.29	0.80	0.84	0.80
SEPARATION	1.04				
RELIABILITY	0.52				
ITEM (25 ITEMS)					
MEAN	0.00	0.96	0.20	0.86	0.00
SD	1.37	0.12	1.00	0.42	2.20
SEPARATION	5.31				
RELIABILITY	0.97				

In this study, the overall data on the items significantly fit the model. Fit analysis using MNSQ indices indicates that the data is compatible with the model. The mean measure shows a critical MNSQ value for dichotomous models in range 0.7 to 1.3 (Bond and Fox, 2007) for infit and outfit analysis. These imply that all 25 item variations are acceptable according to the model expectation.

However, reliability of person is lower than reliability of items. Person reliability of 0.52 shows poor reliability in the separation of person ability in the sample. The sample has almost the same ability when measured using the TISP. Practically, as the samples chosen were specifically training to be science teachers and have good background in sciences, it is expected that the sample persons have the same good knowledge in integrated science process skills.

The results of the the 25 items used in this study are considered acceptable and significantly compatible with the MNSQ value for dichotomus model and in line with the model range of (0.7 to 1.3) expectations as suggested in Bond and Fox (2007). In contrary, the reliability of person shows poor reliability which is lower than the reliability of items with the value of 0.52. The sample chosen in this study, has almost the same ability when measured using the TISP. Nevertheless, since the sample chosen for the study were specifiically trained to become a science subject teacher and with a good science subject knowledge and background, it is therefore expected that the samples have the same good knowledge in integrated science process skills.

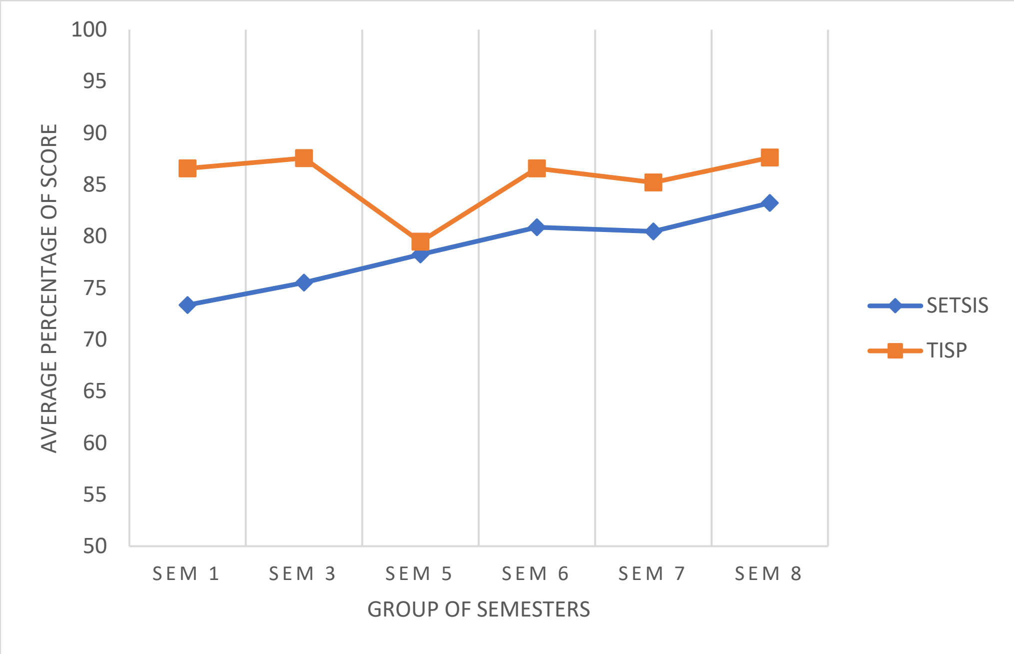
7.1.2 Correlation between the SETSIS and the TISP

Past studies have proven that content knowledge can influence the ability in practicng teaching in the classrooms (as shown in Magnusson et al. 1999; Loughran et al. 2008; Berg 2009; Park et al. 2011) thus it can affect self-efficacy development in teaching. Similarly, Guskey (1998) also believed that teacher's self-efficacy is able to infer not only the ability of teaching using science inquiry skills but also the ability to infer the teacher's content knowledge. Therefore, in this study the SETSIS was developed and used to measure the teacher's self-efficacy in using science inquiry skills. The hypothesis was tested to measure if the SETSIS is capable of predicting the confidence of the respondents' specific content knowledge of science inquiry skill using the TISP.

The SETSIS was developed to measure teacher's self-efficacy in teaching using science inquiry skills, which in theory is believed to be able to infer not only the ability of teaching using science inquiry skills but also the ability in the teacher's content knowledge (Guskey 1988). In this section tests the hypothesis that the SETSIS measurement is capable of predicting the confidence of respondents in the specific content knowledge of science inquiry skills using the score in the TISP.

Correlation and multiple regression analyses were then conducted to examine the relationship between PSTs' scores in the TISP and the potential predictors from the SETSIS measure. The overall average score percentage in the two measures, the SETSIS and the TISP, were plotted in Figure 24 . Visual inspection shows that scores in self-efficacy steadily increase across semesters while the scores in the content knowledge does not show much change across the group semesters except for group semester 5 (SEM 5). However, it can be seen that the mean percentage of the TISP was above the mean percentage of the SETSIS for all the group of semesters. Analysis of correlation and model regression next will determine the score association between the two measures.

Figure 24 Scores across group of semesters between the TISP and the SETSIS



Bivariate correlations between the five subscales of the TISP and the three subscales of the SETSIS are listed in Table 63. Pearson correlations show weak correlation between the two measures' subscales. However, there were significant correlations between all the TISP subscales with OBE except for the subscale interpreting data.

Table 63 Correlation between subscales across the TISP and the SETSIS

	KE	PTE	OBE
Controlling variables	.021	.042	.161**
Hypothesising	.083	.031	.200**
Define Operationally	.049	.046	.218**
Interpreting Data	-.022	-.024	.107
Experimenting	.042	.051	.142*

*. Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

The correlation analysis for overall scores of the TISP and the three predictors (subscales) in the SETSIS gained the same expected results as listed in Table 64. All predictors and the TISP were positively correlated with significantly weak correlation in OBE.

Table 64 Relationship of performances in the TISP with factors in the SETSIS

Correlation	KE	PTE	OBE
TISP	0.06	0.04	.24**

**. Correlation is significant at the 0.01 level (2-tailed).

The result indicates that the correlations between the traits in the SETSIS with TISP were weak. Among all the traits' correlation in the specific content knowledge of SPS, OBE shows a significant but, with a positive weak correlation. As this result might inform that the content knowledge of SPS contributes to the trait of OBE in teaching using science inquiry skills, the strength of the correlation was very weak to infer.

7.1.3 Predictive model to infer content knowledge performance

Multiple regression was used to examine the relationship between the predictors in the SETSIS and TISP scores as dependent variables for content knowledge performance. Three multiple regression models were tested. Model 1 has three possible predictors (i.e. KE, PTE and OBE), Model 2 has two possible predictors (i.e. KE and PTE) and Model 3 has only the OBE predictor. The residual plots for all the models show random patterns that indicate the line is a good fit for the data and the a regression model appropriate for the data regression models.

Table 65 lists the results of regression model summary for all the models.

Table 65 Results of regression model summary to infer content knowledge performance

Model	R	Adjusted R square	Standard Error	F-test	Significant
Model 1	0.306	0.085	3.044	11.067	0.000
Model 2	0.302	0.085	3.043	16.133	0.000
Model 3	0.241	0.055	3.093	19.974	0.000

Results show Model 1 and Model 2 have weak predictors with correlation indicating that both models explain only 9 percent variability of TISP data around its mean. In the other hand, Model 3 explain less with only 6 percent variability of the TISP data around its mean. Results of the F-test show that all models work significantly well with $p<0.001$. Adjusted R square in Table 65 were the same for Models 1 and 2 but, they decrease in Model 3. The result indicates that the model predicts better with more than one predictor. The model needs more than just OBE predictor to explain better variability of the content knowledge.

According to the result above, Model 1 was tested as a working model of the SETSIS in predicting the content knowledge score among respondents. Looking at model contributors inTable 66, KE did not contribute to the regression model. Thus, Model 2 was then tested without KE. The result for Model 2 in Table 66 shows the two predictors, PTE and OBE, have significant regression coefficient. The PTE subscale has a negative coefficient. The negative regression coefficient indicates respondents with higher scores in the PTE subscale are expected to have lower scores in TISP after controlling OBE. One unit of increase in the PTE score decreases 0.05 unit of score in TISP. After accounting for PTE scores, respondents with higher OBE scores are expected to have higher scores in TISP. Increasing a unit of OBE score will predict a 0.12 unit increase of score in TISP.

Table 66 Multiple regression predictors of the working model to infer content knowledge performance

Model 1	Coefficients	Standard Error	P-value
Intercept	16.404	1.256	0.000
KE	0.017	0.018	0.333
PTE	-0.059	0.019	0.002
OBE	0.123	0.022	0.000
Model 2			
Intercept	16.640	1.233	0.000
PTE	-0.045	0.013	0.000
OBE	0.123	0.022	0.000

7.1.4 Applying the predictive model

Multiple regression analysis shows that model of the SETSIS with PTE factor and OBE factor were contributing significantly in predicting score of the content knowledge among respondents. The coefficient results were used in the working model as follows.

$$TISP = 16.64 + 0.12OBE - 0.05\ PTE$$

This model works but only estimates about 9 percent of variability with the TISP score. Checking on the validity of the model with the observed data, the predictive model was used with the TISP data of the two groups: the group of semester 5 with the lowest mean score in the TISP, and the group of semester 8 with the highest mean score in the TISP. The predictive scores of the model were plotted against the observed scores of the two groups.

Figure 25 Model prediction of science inquiry skills knowledge for semester 5

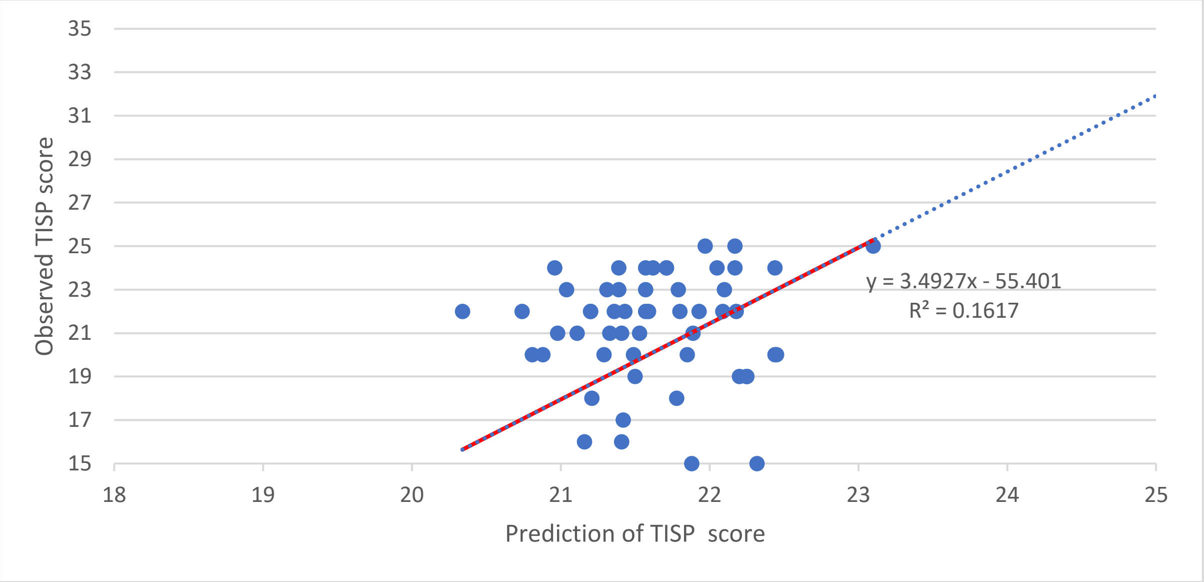


Figure 25 shows the model was applied to 60 respondents of semester 5. The predictive score of the TISP then plotted with the observed score of the TISP. The scattered plot shows positive correlation with low variance. A visual inspection shows that the model apparently has a good correlation with plotted points scattered near the best fit line. However, the R square value shows a low variability of 2 percent indicating that there is too much low variance in predicting the content knowledge.

Figure 26 Model prediction of science inquiry skills knowledge for semester 8

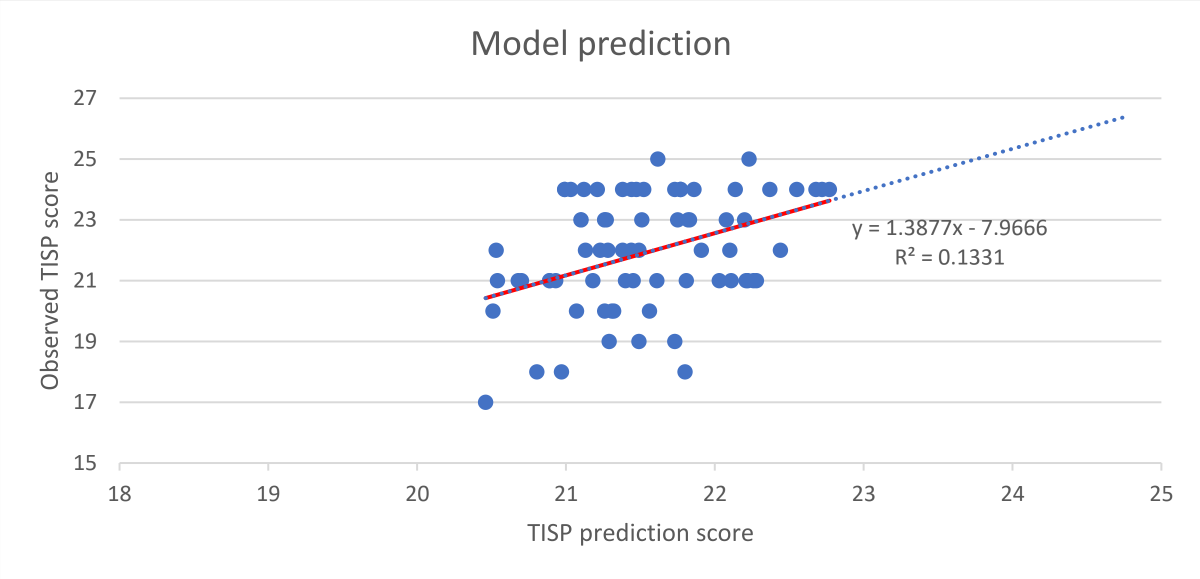


Figure 26 shows the model applied to 74 respondents from the semester 8 group. The predictive score of the TISP is then plotted with the observed score of the TISP. The scattered plot shows positive correlation with variances approximately the same with the group above. Visual inspection shows the model apparently has a good correlation with plotted points scattered near the best fit line. The R square value shows variability at 2 percent, which is too low to indicate the content knowledge performance.

7.2 Association of the SETSIS and science teaching practice

7.2.1 Professional Teaching Practice Assessment

In the BoTP curriculum, Professional Practice comprises formal modules for PSTs practicing their teaching in real situation. These modules are conducted in real primary science classes during the final four semesters of the BoTP programme. These modules are part of the ITE curriculum used to assess in-site practices. PSTs need to undergo three phases of modules of Practicum in semesters 5, 6 and 7, and a module of Internship in semester 8 at designated schools.

During the practicum, a PST needs to teach for at least eight periods in science classes every week. Teacher trainers and guidance teachers from the schools observe the teaching sessions in real classes and conduct supervision of nine times in every phase. Joint assessments on teaching performances are based on institutional criteria assessment at the end of every phase (Institute of Teacher Education, 2016).

During the Internships, PSTs need to teach about four periods of science subject classes, plan and implement activities related to science learning for the schools. PSTs receive guidance from their mentor (e.g. existing in-teachers) and from their teacher trainers during their time in the schools. A joint formative assessment from the mentor and the trainers was conducted based on institutional criteria assessment at the end of the module.

Figure 27 Frequency of score of Professional Practices for Practicum phase II (above) and Internship (below)

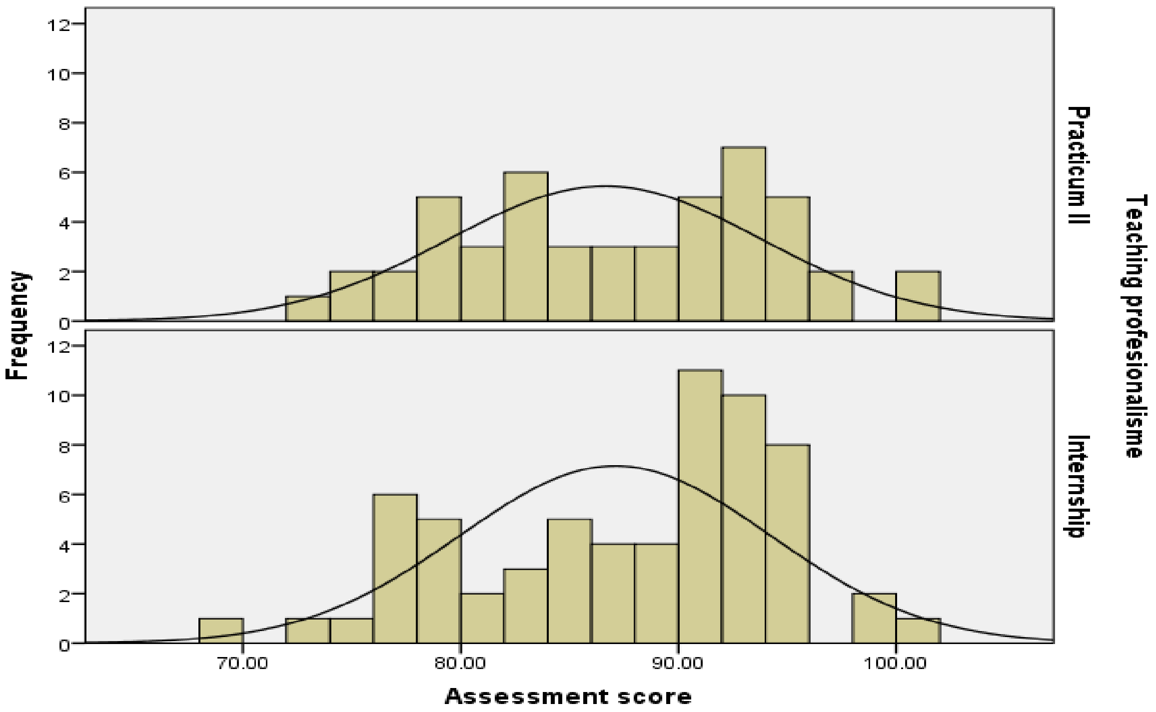


Figure 27 shows the frequency of score of assessments of Professional Practices received from ITE's Department of Exam and Senate. The results of this section are bound to caveat from the usefulness of data received from the institutions. The following data present two out of the four formal modules conducted at ITE. The histogram of the Practicum II module assessment shows 49 scores distributed in the range 72 to 100. The histogram of Internship module assessment shows 64 scores distributed in the range 69 to 100.

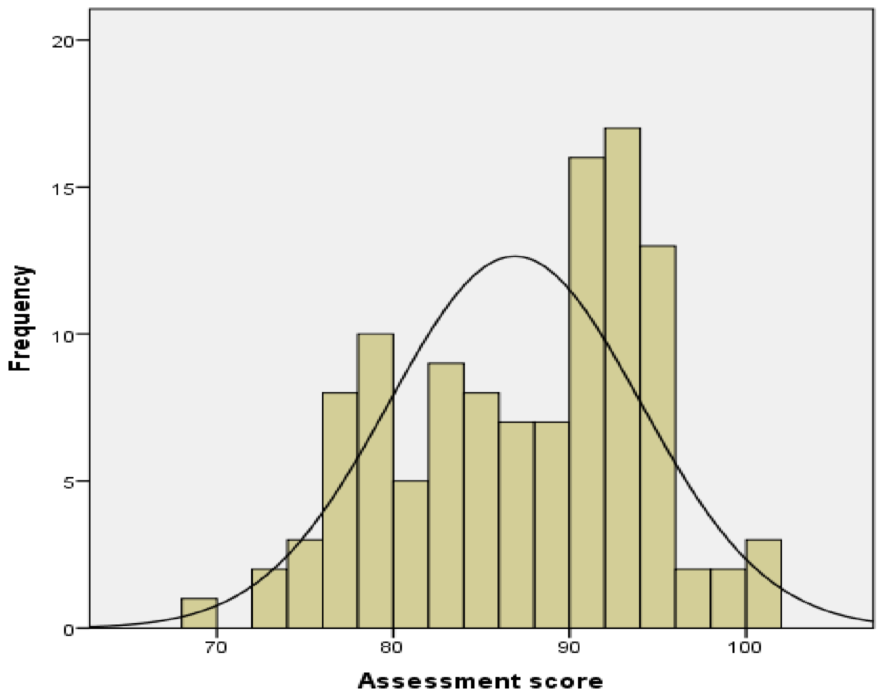
Table 67lists the descriptive table of assessment scores in Practicum II and Internship. The mean scores reflect that both modules have approximately the same performance with an Internship mean score at 87.09 (SD=7.14) and Practicum II mean score just slightly below at 86.63 (SD=7.18). The scores of the Internship module have a slightly wider range with significantly normal distribution compared to the Practicum II module, which were not significantly normal.

Table 67 Descriptive table for Practicum II and Internship

	N	Mean	SD	Std. Error	Minimum score	Maximum score	Shapiro-Wilk		
							Statistic	df	Sig.
Practicum II	49	86.63	7.18	1.03	72.00	100.00	0.97	49.00	0.21
Internship	64	87.09	7.14	0.89	69.00	100.00	0.95	64.00	0.01

Due to the following analysis of multiple regression, the scores for Practicum II and Internship were combined and label as Professional Practice. Figure 28 shows the histogram of the combined scores of the two assessments called Professional Practice. Visual inspection shows good distribution of the sample in the assessment score.

Figure 28 Performance in Professional Practice



The combination of 113 samples from the two module assessments were used for this analysis. Descriptive analysis in Table 68 shows the result of mean performance in Professional Practice within the range of the SD of the two mean scores from Table 67. A normality test shows a significant result (p<0.01). The result concludes that the combination data was appropriate to represent the performance of the two modules using Professional Practice.

Table 68 Descriptive analysis of Professional Practice score

	N	Mean	SD	Minimum score	Maximum score	Shapiro-Wilk Statistic	df	Sig.
Professional Practice	113.00	86.89	7.13	69.00	100.00	0.96	113.00	0.00

7.2.2 Correlation between the SETSIS and teaching practice assessment

The SETSIS measurement model were developed theoretically using the concept of self-efficacy believe to predict capability in performing the task of teaching science using science inquiry skills. Using the concept in the model, this section tests the hypothesis that the SETSIS measure is capable in predicting the performance of respondents in the practice of teaching science (i.e. the assessment score of Professional Practice).

Correlation and multiple regression analyses were conducted to examine the relationship between PSTs' assessment scores of Professional Practice and potential predictors from the SETSIS measure. The results are used to discuss potential utilisation of the SETSIS model in the area of science teaching practice.

Bivariate correlation between performances in professional teaching practice with the three theoretical factors model of the SETSIS are listed in Table 69. Pearson correlations show non-significant correlation between the practice and any components of the SETSIS. However, it can be seen that each of the practice scores correlate very weakly with the predictors. All predictors were positively correlated except PTE, indicating higher traits in predictors tending to have higher performance in practice except for the PTE trait.

Table 69 Correlation of Professional Practice with the SETSIS model

	KE	PTE	OBE
Professional Practice	0.104	-0.018	0.009

Two multiple regression models were tested. Model 1 has three possible predictors (i.e. KE, PTE and OBE) and Model 2 has two possible predictors (i.e. KE and PTE).

Checking on residual plots of both models show random patterns that indicate that the data can be used with the regression models. Table 70 lists the results of regression model summary for Models 1 and 2. Results show both models have weak predictor correlation indicating that both models explain only 5 percent of the variability of the performance data around its mean.

Table 70 Results of regression model summary to infer Professional Practice

Model	R	Adjusted R square	Standard Error	F-test	Significant
Model 1	0.225	0.015	7.077	1.434	0.228
Model 2	0.226	0.034	7.010	2.969	0.055

Results of adjusted R square in Table 70 increase in Model 2 instead of Model 1. The result indicates that the model predicting better without OBE. F-test shows that Model 1 does not significantly work, $F(3,109) = 1.43$, $p>0.05$. Model 2 shows a better working model with F-test result is just slightly over significant $F(2,110) = 2.97$, $p=0.055$.

7.2.3 Predictive model to infer practice performance

Multiple regression was used to examine the relationship between a predictor and dependent variable (i.e. Practice Performance) after controlling the other variable in the model. According to the result in the above section, Model 2 is considered as a working model of the SETSIS in predicting practice scores among respondents. Looking at model contributors inTable 71, KE has a significant positive regression coefficient, indicating respondents with higher scores in the KE subscale are expected to have higher performance scores in professional practice after controlling PTE. One unit of increase in KE score increase 0.22 unit of performance of professional practice. On the other hand, the PTE subscale has a negative coefficient as suggested from its correlation. This indicates that after accounting for KE scores, respondents with higher PTE scores are expected to have lower scores in professional performance. Increasing a unit of PTE scores will predict 0.22 unit decrease of score in Professional Practice.

Table 71 Multiple regression predictors of the working model to infer professional practice

Model 2	Coefficients	Standard Error	Significant
Intercept	83.550	4.880	0.001
KE	0.220	0.090	0.020
PTE	-0.220	0.100	0.030

7.2.4 Applying the predictive model

Multiple regression analysis shows that models of the SETSIS with KE factor and PTE factor contribute significantly in predicting scores of professional practice among respondents. The coefficient results are used in the working model as follows:

$$Practice = 83.55 + 0.22\ KE - 0.22\ PTE$$

This model seems to work but only estimates about 5 percent of variability of professional practice. Checking on the validity of the model with the observed data, the predictive model was used with the data of the two group assessments: Practicum II and Internship. The predictive scores of the model were plotted against the observed scores of the two groups.

Figure 29 shows the model applied to 49 respondents (see Practicum II in **Error! Reference source not found.**) in semester 6 group. The predictive score is then plotted with the observed scores of Practicum II. The scattered plot shows positive correlation with low variance. Visual inspection shows that the model apparently has a good correlation with the plotted points that were scattered near the best fit line. However, the R square value shows low variability of 3 percent, indicating that it has too much low variance in the model.

Figure 30 shows the model applied to 64 respondents (see Internship in Table 67) in semester 8 group. The predictive score then plotted with the observed score of Internship. The scattered plot shows positive correlation with variance slightly higher than the group above. Visual inspection shows that the plotted points are closer at higher observed score but scattered further at the lower observed score. The R square value shows higher variability at 5% but considering too low in indicating practice.

Figure 29 Model prediction in Practicum II (semester 6)

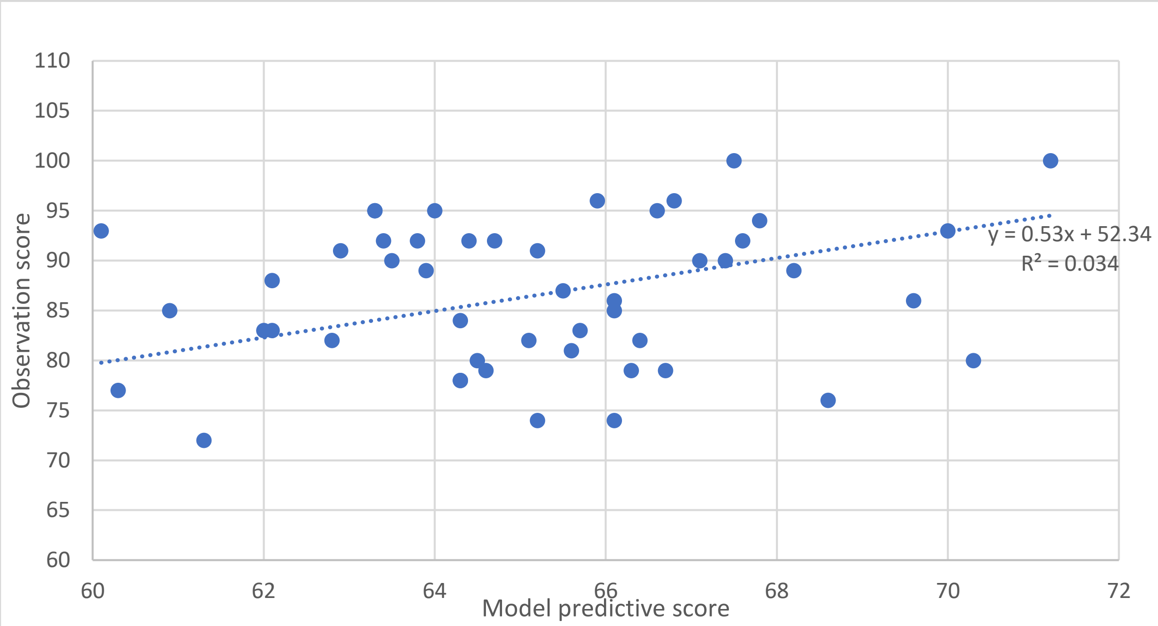
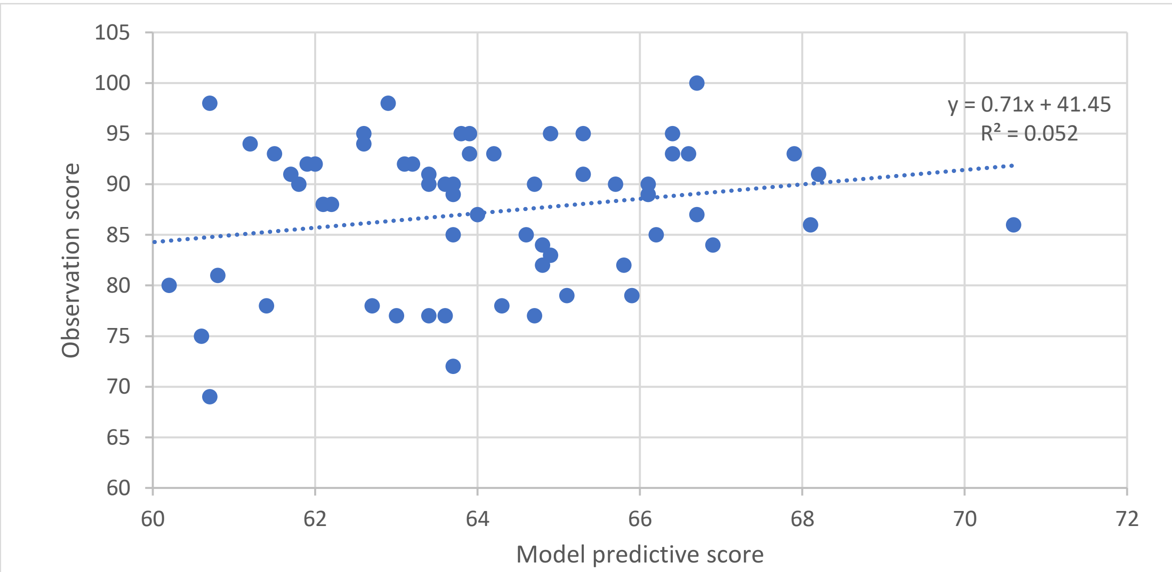


Figure 30 Model prediction in Internship (semester 8)



7.3 Summary findings of the chapter

The findings demonstrated that there are weak correlations between the SETSIS and the two measures. In the measure of content knowledge, the score of the TISP has low but significant correlation with the OBE. Although the correlation might not establish a strong association, it does inform a tendency of performance in the content knowledge test (i.e. the TISP) influencing the belief about the outcomes of using science inquiry skills in science learning.

The predictive model of the SETSIS also significantly shows contribution of OBE, together with PTE in inferring the content knowledge. However, the model shows contrast contribution of the two traits. While OBE have a positive contribution, PTE have a negative contribution that infer the content knowledge. Even though the working model shows low variability in inferring the content knowledge within the two groups' score, the analysis revealed that the OBE and PTE have the possibility to infer the content knowledge of PST.

Furthermore, KE interstingly was foundnot to contribute to the teacher's content knowledge performance. This may be due to the fact that PSTs develop their knowledge in teaching using their own sets of experiences from their own everyday practices in the classroom and not only from their existing content knowledge (van Driel, Verloop and de Vos, 1998). The PSTs have to cope with the requirements to teach the science subject using science inquiry skills regardless of their level of understanding of the content knowledge. Thus, they might also be performing in the classroom without a full understanding of the content knowledge of the science subject (Harlen and Holroyd, 2007; Hafizan, Halim and Meerah, 2012)

The findings revealed the association between the SETSIS and teaching practice were low between the three predictors of the SETSIS with the score in Professional Practice. The score of Professional Practice correlated negatively with PTE. The model predicts practice with two contributing factors; KE and PTE. It seems that OBE has no contribution in predicting practice.

This model identifies efficacy in knowledge of teaching (KE) and efficacy in personal teaching capability (PTE) ; two efficacy element of underpinning PCK contribute to PSTs' professional practice (Seidel and Sturmer, 2014) . Uniquely, the model infers positiive contribution of KE instead negatively contribution of PTE. Shulman (1986) in his explanation of strategic knowledge in the teaching practice field, describes *"it is in the very nature of the practical or policy fields that individual principles (knowledge of teaching) are fated to clash on particular occasion (in practice)"*(p.13).

The silent resistance which was portrayed through the contradict contributors in the practice indicated that Professional Practice courses offer chances for PSTs to develop their teacher knowledge. However, the factor of belief in the output of using science inquiry skills as suggested in the reform policy was still lacking. As a result, even though PSTs posed the ‘theory’ of teaching using science inquiry skills in training, that might not be enough to expect inculcation of science inquiry skills during classroom teaching practices.

Chapter 8 Discussion and conclusion

8.1 Introduction

In this chapter, I discuss the main findings from my study related to the development and validation of the SETSIS, which emphasise the study's contribution to theory and practice. The first section discusses the contribution of the study findings in the area of instrument design and development, and the substantive findings in order to achieve the objectives of the study. The second section discusses the significance of the findings related to PST education, especially for the Institute of Teacher Education (ITE) in Malaysia. The third section discusses the limitations of the study with suggestions for future research using its findings. Finally, this chapter concludes with a personal reflection on the study.

8.2 Contribution of my study

This study aimed to develop a theory-driven, valid and reliable instrument that allows the measuring of self-efficacy for the specific task of teaching using science inquiry skills in the specific specifically in the context of the PST education field. The SETSIS is an attempt to develop a TSE tool with a theoretical concept that has emerged from recent literature. It is defined by the three subscales, KE, PTE and OBE in the particular task of using science inquiry skills. Previous chapters (Chapters 4, 5, 6 and 7) were dedicated to answering the RQs of the study, and this chapter will further discuss the findings' contribution to the study objectives accordingly.

8.2.1 Overview on contribution of the findings

The SETSIS is developed extensively from the teacher efficacy model (Tschannen-Moran, Hoy and Hoy, 1998), and this study initiates integration between the teacher efficacy model and the substantive teacher efficacy measure within the challenges and issues of TSE measures in teaching development (Wyatt, 2014) and knowledge for teachers (Roberts and Henson 2000). Within the three factors of self-efficacy, this study proposes the SETSIS as a viable model for TSE measurement within the particular task and domain. As this study aims at exploring the combination of the three subscales in the model, it also discusses the validity of the SETSIS measurement in aligning along with the concept of PST development in teaching science.

The discussions of the findings are presented according to the objectives of the study. The finding stated in section 8.2.2 emphasises the concept of the three factors developed from the literature and applied in the SETSIS. The concept is able to define the TSE measure in alignment with teacher development in the context of teacher education. The discussion provides the conceptual insights that the SETSIS can work as a model for TSE measures in the specific task of teaching science using science inquiry skills.

Next, section 8.2.3 discusses the statistical evidence that emphasises the reliability and validity of the proposed SETSIS. The findings are used to clarify the construct validation of the SETSIS, especially in the three factors and their contributions in the refinement of TSE model literature. Then, section 8.2.4 discusses the SETSIS as a statistically acceptable model of measurement. The findings provide empirical evidence that the SETSIS has improved the operationalisation of teacher knowledge in models of TSE measurement (Roberts and Henson 2000; Pruski et al. 2013).

Lastly, section 8.2.5 discusses the substantive findings that emphasise the relation of the SETSIS measures with the existing teacher knowledge assessments consisting of a subject knowledge test and the institutional practice assessments. It suggests that the SETSIS might contribute to evidence of an early concept of belief assessment that can infer the PSTs development in teaching.

8.2.2 Objective one: To define and conceptualise the SETSIS construct based on the concept of TSE in a PST education context

Research in TSE measures development and provides ambiguous concepts on the specificity of task and context measures. Prominently, the model of TSE quantitative measures emphasises the role of agent-end rather than the concept of agent-means (Bandura 1986; Tschannen-Moran and Hoy 2001; Wyatt 2014). This study improves the concept of TSE by developing a quantitative tool that assesses belief in the ability to take action in teaching using science inquiry skills rather than a belief in ability to bring out the outcomes of science inquiry skills. The study of the SETSIS has demonstrated work to establish a TSE concept that assesses the specific task of teaching using science inquiry skills in the specific context of PST development. This study has enabled the underlying principle to be identified more clearly in the specific task that aligns with the context of teachers' knowledge development of PSTs (Veal, 2012; Juttner *et al.*, 2013) in the construct framework of the SETSIS presented in Chapter 4. Generally, the SETSIS is developed using the three representatives of subscales, as noted below.

- The belief that I know what I need to know to teach using science inquiry skills: *KE* represents belief in possession of the science inquiry skills knowledge by an individual PST.
- The belief that I can effectively use science inquiry skills in teaching classroom science: *PTE* represents belief in personal capability in translating the knowledge into action.
- The belief that using science inquiry skills can improve students learning in science: *OBE* represents belief in the values of science inquiry skills teaching in science learning.

The items constructed for the SETSIS in this study demonstrate good content validity from the consensus of ten experts in the area. The items have high recognition from the experts for all the three subscales (see section 4.5.1). The consensus supports the containing construct and gains the experts' recognition about the importance of the interaction of the three self-efficacy factors in the context of the PSTs' education development.

The three subscales represent the knowledge from both theoretical and practical perspectives that are inextricably linked to the belief of PSTs while teaching. PSTs believed in developing their knowledge of teaching not only from the successful outcomes but also in the classroom teaching process (Abd-el-khalick, Bell and Lederman, 1997; Van Driel, De Jong and Verloop, 2002; Kind, 2009). With the attempt to explore PSTs beliefs concerning agent-means beliefs as they interact with agent-ends beliefs (Wyatt 2014), this study has applied the teacher knowledge perspective to the three factors of the SETSIS. The experts' finding has given the positive consensus to the further possibility of KE as one of the factors in TSE (Wheatley 2012; Wyatt 2010), in addition to PTE and OBE, which have been highlighted in models commonly used in TSE measuring (Kleinsasser, 2014).

Further, in the findings of section 4.5.2, the pre-test survey empirically confirmed the constructed instrument at the item-level. Statistical evidences of item polarity and item fit demonstrate the combination of items in the construct which was measured in the same direction and, as expected in the responses, determined using parameters of the Rasch model analysis. That means all the result items were checked to ensure they were working well together in measuring one underlying variable, which is self-efficacy in teaching using science inquiry skills.

8.2.3 Objective two: To determine the psychometric qualities of a measure of self-efficacy in teaching science using science inquiry skills

The SETSIS shows high reliability in the responses gained. Early descriptive findings in the average mean scores of normality distribution (z-score) are closely matched to the mean scores of self-efficacy in five components of essential elements of inquiry (Smolleck, Zembal-Saul and Yoder, 2006). In the context of the specific task in using science inquiry skills, this in part reflects close similarity to the self-efficacy judgement about science inquiry skills with PST samples from Smolleck‘s research in the US.

Furthermore, this study provides significant findings in differences for mean scores across the subscales of KE, PTE and OBE. Comparatively, the mean score shows proximity to the previous research into self-efficacy in teaching using inquiry (Smolleck, Zembal-Saul and Yoder, 2006). However, respondents have differences in judgement of self-efficacy across the three factors proposed in this current study, perhaps this is because in this study it emphasises more on self-efficacy in the action of teaching using science inquiry skills rather than self-efficacy in making learning engagements using science inquiry. The features in the three factors seem important for exploration in the context of PST development with the task of using science inquiry skills as a teaching method (Wheatley, 2005). Thus, the SETSIS seems to be able to provide reliable information with regards to self-efficacy as the outcomes of the three important factors.

The next findings will examine the main features of the three theoretical factors developed together to measure the self-efficacy construct. Exploratory factor analysis (EFA) is used to empirically examine the existence of the factors in the SETSIS's structure. The analysis supports the contributions of the 66 items, clustered together to form three factors with good inter-correlation. The three contributed factors explained a total of 54.70 percent variance of the measure, which implies better indication of factorial validity instead of the two-factor measure consisting of PTE and OBE that is commonly used in science teacher efficacy (Gibson and Dembo 1984). Additionally, the reliability results in the SETSIS demonstrate a strong construct validity at > 0.90, which is far better for general reliability than the two factors of the Teacher Efficacy Scale of Gibson and Dembo (1984) (Henson, 2001). The results of the SETSIS also point out the highest factor, which based on the contributed items is interpreted as KE and explains 45.26 percent of response variance. This finding clearly supports the idea that the KE factor has an intriguing role of self-efficacy in the subject knowledge (Wheatley, 2005; Palmer, 2011), adding a significant factor into the existing TSE model. In the sense of factorial study, the SETSIS provides empirical validation to explain a better refinement of the three-factor validity sample.

8.2.4 Objective three: To operationalised and develop a psychometrically defensible measurement model of the SETSIS

In this section, I will discuss the establishment of the SETSIS as a valid measurement model based on the findings using the Rasch model analysis. Given that the SETSIS response data were proven reliable and fit to the Rasch model, the results of the analysis are discussed as evidences to a working model of the SETSIS.

At the item level, the results of person reliability at 0.98 with six persons separation and the items reliability at 0.98 with seven item separations indicated that the SETSIS has valid items to measure self-efficacy in teaching using science inquiry skills among the sample respondents. The results provide evidences of an ability of the SETSIS to discriminate a respondent's level of self-efficacy based on responses given to the items. The operationalisation of the level of self-efficacy discrimination is now explained.

The analysis in the relationship between respondents and the items responded to using the Wright map (Figure 17) has discriminated three levels of self-efficacy based on the items' level to the relative position of respondents.The respondents located at the bottom position relative to the easy item level are described as having low level of self-efficacy. The respondents located at the level of the mean items are described as at the average level of self-efficacy, while respondents at the level of the high items and above are described as respondents with high levels of self-efficacy. The level discrimination on the map reports the level of self-efficacy based on probability responses to the items level measure. Although the result acknowledges more items are needed to measure and discriminate the responses at the top position of the map, it discerns the three levels of items that are characterised to measure each level of self-efficacy in teaching using science inquiry skills.This structure analysis at the item level has empirically proven that the SETSIS is a functional tool to assess and discriminate self-efficacy in PST education.Thus, the patterns that emerged can be generalised to describe levels of self-efficacy in teaching using science inquiry skills in the targeted population.

Additionally, the five-points rating scale is used also to contribute to the operationalisation of the measurement model. The findings in section 6.2.2 provide evidence that the constructed model can facilitate the interpretation validity using the rating scale model. The finding empirically shows that the same five-points rating scale used across the SETSIS was able to function as expected and explained all the responses well in every category. Results provide tentative evidence that PSTs' responses to the SETSIS are best matched using five-point category descriptors (Bandura 2006; Toland and Usher 2015).The study also demonstrates utilisation of the rating scale model and traces the interpretation of the model-based level into the real score estimation (Irribarra *et al.*, 2015). The finding is able to identify empirical boundaries between the model-based level and estimates ranks for the true score. The result indicates in the true scores of five ranks able to identify generally increase of self-efficacy level across semesters. Empirically, the true score ranking result visualised in Figure 21 shows the top ranks comprising the majority of the higher groups of semesters while lower ranks consist of relatively low groups of semesters. It explains that high self- efficacy during the programme influences PSTs' characteristics in developing a sense of efficacy in teaching skills (Deehan, Danaia and McKinnon, 2017). This suggests that the present study has managed to assess the personal responses and empirically validate and operationalised the SETSIS to measure self-efficacy in teaching using science inquiry skills over the course of the PSTs education programme.

Subsequently, the SETSIS is developed to support teaching development in PST education that is conducted parallel to the model introduced in SETAKIST (Roberts and Henson 2000). Though SETAKIST provides the direction of the concept of self-efficacy assessing specialisation in teacher knowledge, the work provided little concrete direction in the operationalisation of the concept, especially in the construction of items and the scaling (Pruski *et al.*, 2013). This study, on the other hand, was able to provide confidence for the validity of the items and the scaling to be used as a personal belief component in assessing the PSTs' teacher knowledge development. The findings empirically synchronise the items tasks, score scale and the measurement model across the three factors of KE, PTE and OBE (Brown and Wilson 2011), thus validating the SETSIS as a working model of TSE measure.

8.2.5 Objective four: To infer PSTs development using the measurement model of the SETSIS

This study has provided the evidence that the subject knowledge for teaching is interconnected with the views reflected in KE, PTE and OBE. In the concurrent validity test for specific subject knowledge of science inquiry skills (i.e. the TISP) , the SETSIS revealed positive but very weak relationships between self-efficacy in teaching using SIS and the subject knowledge tested. The findings also provided a significant emphasis on expectancy of belief in teaching outcomes (i.e. OBE) being weak which is related to the subject knowledge possessed. The findings reveal the important role of belief in developing teacher's specific owned knowledge (i.e. in teaching using science inquiry skills), a similar discovery found in Pajares (1992).

The predictive model infers performance of content knowledge with a linear trend and significant to two predictive factors. It explains for the small variability of the response data but indicates that the predictor factors (i.e. PTE and OBE) can provide information on the predictive variable. This information suggests PTE and OBE are among the contributing factors to infer the content knowledge performance with contradicting contribution.The predictive model informs that the content knowledge increased expectancy belief in teaching outcomes but decreased their personal teaching practice.

In the context of the performance of PST's content knowledge, this predictive model infers that the subject knowledge can increase the belief in outcomes of using science inquiry skills, but this is not reflected in PST's belief about their personal capability of teaching using the skills in classroom. This finding addressed that the existing assessments of content knowledge used in the current programme, seem to well reflect the belief on the outcomes of teaching but are not enough to reflect the personal belief in teaching capability. It suggests the content knowledge is able to develop belief in good outcomes by using the skills but at the same time increases doubt in personal capability of using the skills in the science classrooms.

This study further investigated the contribution of the SETSIS components in relation to science teaching performance using data of teaching practice assessment provided by the ITE. The findings reveal there is no significant correlations between the teaching practice in all the factors. The correlations were positive except for PTE. Subsequently, it provided further evidence in the context of the teaching practices in Malaysia by the multiple regressions model. The predictive model suggests that the PSTs' performance in teaching practices is dependent on a positive factor of KE. However, after considering the contribution of the KE, PTE contributes negatively to the practice performance.

The predictive model explains the observed issues in the context of the performance of Malaysian pre-service and novice teachers' performance in using science inquiries in the classrooms. Thus, PSTs were able to state the importance of using science inquiry skills in the classroom but not incoporating them during classroom teaching a similar outcome were found in the studies of Hairiah and Keong (2011) and Rauf (2013). It seems that PSTs and novice teachers failed to implement the planned science inquiry skills task in the classroom because they personally did not have the belief and self-confidence to use the task (i.e. negative contributor of PTE) even though they have the belief that they had the knowledge about it (i.e. positive contributor of KE). Thus, this study seems to inform the lack of factors for the unsuccessful implementation of PST knowledge in the teaching practice of using science inquiry skills in the classroom.

The findings from this current study have drawn attention to the extent that subject knowledge and practice knowledge growth in PSTs mirrors their growth of self-efficacy. This study has highlighted differences and similarity in results which from previous literature related to self-efficacy and the relationship of the subject knowledge and practice knowledge of teachers. Thomson et al. (2017) for instance found that there are a strong link between self-efficacy in teaching science to subject knowledge, and instructional knowledge in PSTs' education; yet the practice performance is a better predictor of future self-efficacy. In the other hand, Wyatt (2010) found that they are unevenly developed growth of teacher knowledge and TSE in a PST partly because of the constraints imposed by the curriculum and its context.

In the context of the new curriculum implementation in Malaysia, the findings call for some explanations about belief in personal teaching capability in using science inquiry skills. PSTs' perceived belief in the knowledge possession and belief in the value of the outcomes of using inquiry skills in teaching science.This is well reflected with their growth in the teaching task and the subject knowledge, but it is not the same direction as their growth of belief in their personal capability of teaching. It seems that the two types of assessments used by ITE enable to develop the growth of the teacher's belief in knowledge efficacy and their belief in outcomes efficacy, nevertheless shows negative results on the belief of the their personal efficacy.

The findings in the predictive of the SETSIS reveal that the SETSIS model in this study is able to predict the content knowledge performance (i.e. the TISP) and the teaching practice assessments of pre-service teachers. However, the results in this study has a weak association with the findings Bandura (1977) had conceptualised. Bandura discovered the association between PTE and OBE as the predictive factors to explain the specific performance. Nevertheless, the models developed in this study had significant information in the contribution of perceived personal teaching capability (i.e. PTE) and the belief in the outcomes (i.e. OBE) to infer the content knowledge performance in difference directions.

Even though Bandura (1977) has conceptualised the role of self-efficacy within the two factors (i.e. PTE and OBE) to infer future behaviour, noticeable results found in the predictive models using multiple regression model were only able to explain the association of PTE and OBE in the specific content knowledge performance. There were weak association but, the models have given significant information in the contribution of perceived personal teaching capability (i.e. PTE) and the belief in the outcomes (i.e. OBE) to infer the content knowledge performance in different directions.

This results may support the findings of in Riggs & Jesunathadas (1993) and Riggs et al. (1994), where they uncovered PTE contributed with the higher performances and OBE reacted only with the weak believe. In this study, the content knowledge tested (i.e. knowledge of SPS in teaching science) were fundamentally knowledge learned during school days and not during the programme. The PSTs might performed in the fundamental knowledge of SPS but still develop their belief of the outcomes of the teaching science using the knowledge.Thus, in order to infer content knowledge of the teaching programme, this study suggests PTE and OBE to be used as a measure factors in TSE.

In the other hand, the model revealed that the two factors of self-efficacy, KE and PTE significantly inferred teaching practice performance. This supports the idea suggested in Robert & Henson (2000) to measure TSE based on the concept of PCK. Likely that the two factors of KE and PTE are consistent with the teacher knowledge model used in the teacher training programme. KE and PTE are able to infer the teaching performance among PSTs. Nevertheless, the findings were unable to explain the significant contribution of OBE and inferred the teaching practice performance. Since the teaching performance were assessed towards the end of BoTP, the OBE might have been self-developed and too strong to be considered in the model. Thus, in order to infer teaching practice performance, this study suggests KE and PTE to be used as a measure factors of TSE.

To conclude, this study presented valid evidence of the three factors as the general construct of the SETSIS instrument. Through a rigorous process, the construct framework of the measure was validated with the main pilot study. It has explained the SETSIS as a measurement model that seeks to explain three factors (knowledge, belief and practice) underpinning self-efficacy in teaching using science inquiry skills. This study was able to provide validity for the SETSIS through evaluation of the psychometric properties of the instrument. The findings acknowledged that the three factors extend the model of teacher efficacy, which informs the self-efficacy in teaching using science inquiry skills but the models utilise different sets of factors to infer performance in context of knowledge and practice of teaching. However, the limit has been set, based on the interpretation of theory and findings in the context of PST education in Malaysia. The validation of the score interpretation was based on the context rather than the usage of the score in general.

8.3 The study implications

The construction of the SETSIS aims to support the effective transformation of the new science primary curriculum. The SETSIS is designed to be able to identify levels of self-efficacy in teaching using science inquiry skills among PSTs. The result can provide an initial description of PSTs' future capabilities in implementing the curriculum in classrooms.

8.3.1 Implication for teacher educators

Firstly, the study was able to establish a valid and reliable TSE tool to measure self-efficacy in specific context of task. In working towards preparing PSTs to implement the reform-based strategies in the classroom, the SETSIS helps teacher educators to identify the level of self-efficacy in the subject knowledge (KE) in the individual PST, and in advance identify the perceived capability in teaching practice (PTE) of using science inquiry skills. The additional information of OBE can also be used to assess PSTs' ground beliefs and perceptions about the teaching task given in the training duration. Teacher educators can easily get straight-forward information about the PSTs belief from the SETSIS throughout the training programme. Having the assessment information in the level of self-efficacy can create awareness about the PSTs' personal beliefs in the reform strategies. It is important to acknowledge the PSTs' beliefs (self-efficacy) as it brings about necessary reform-based pedagogy strategies (Lumpe *et al.*, 2012). PSTs need to feel that they are capable of implementing reform strategies successfully. With information at hand, and one way to make PSTs feel capable to implement the strategies is to promote adequate training in the reform strategies.

Secondly, the predictive models of the SETSIS suggests negative impact on the confidence of personal teaching practice to PSTs' knowledge of science inquiry skills and PSTs' teaching practice. The correlation models (section 7.1.1.3 and section 7.1.2.3) from the substantive findings reflect belief of PSTs in teacher knowledge of teaching science using science inquiry skills. It explains about contrary belief factors that may not be detected from the cognitive test (Hafizan, Halim and Meerah, 2012) or practice assessment (Hairiah and Keong 2011).

The direct-measure of the self-efficacy in teaching using science inquiry skills seems to provide an alternative measure for the constraint of contrary outcomes between PSTs' belief position with their knowledge possession, and with their teaching practice performance. The contrary direction of contributed self-efficacy factors in inferring ITE teaching practices in the findings of this study should be checked. It informs teacher educators of the lack of factors in belief for the unsuccessful implementation of PSTs knowledge in teaching practice of using science inquiry skills in the classroom. As Wheatley (2002, p.9) asserts '*disequilibrium inherently causes and involves uncertainty*', that means concern about reforms that require teacher educators to make fundamental changes to practice that do not align with the curriculum will not make the implementation successful. Therefore, teacher educators should be concerned whether reform-teaching strategies learned during training match PSTs' beliefs in their capability to implement the knowledge. Having the access to find out the level of the PSTs' self-efficacy can help teacher educators to identify cases and provide support to challenge the existence beliefs and strengthen the source of self-efficacy, which may result in positive development in implementing policy practice.

Information gathered from the three components of the measure can may be able to facilitate teacher educators to infer future potential implementation of the teaching knowledge learned in the science inquiry classroom. For instance, if the outcomes show high efficacy in OBE but not with KE and PTE, teacher educators may develop a strategy to help provide confidence in using science inquiry skills in their classroom teaching while strengthening the subject knowledge and the teaching practice mastery. On the contrary outcomes, teacher educators may provide open discussions to challenge their outcome expectancy belief and develop positive belief persuasion in using science inquiry skills rather than focusing solely on the cognitive development in the training provided. It is important to maintain positive levels of self-efficacy belief as it is essential to make PST less likely to give up when encountering difficulty to deliver science using science inquiry skills in their future teaching career (Pajares, 1992; Bandura, 1994; Zimmerman, 2000) and at once, give them the positive impact to their development in the teaching of science. Thus, it is recommended for the teacher educators to assess the affective component along with training assessment for personal evaluation, which is important for PSTs' education development (Darling-Hammond, 2006).

Lastly, the study argues that the SETSIS promotes links to PSTs development in teacher's knowledge. It shows general positive increment in self-efficacy during training; yet, it is also able to identify evidence of doubt caused by the "reality shock" of teaching experiences indicated by decreasing self-efficacy beliefs (Ruys, Van Keer Hilde and Aelterman Antonia, 2011). Teacher educators should be aware of the present efficacy doubts because it may lead to less effort and giving up more easily in the reform-base strategies (Tschannen-Moran, Hoy and Hoy, 1998). Teacher educators could help with effort of activities that can encourage reflective thinking (Henson, 2001). Through reflection, PSTs can use various of self-efficacy sources (Bandura, 1986) to build experiences to succeed in the reform-task.

8.3.2 Implication for policy-makers in PST education

The findings from this study indicated that self-efficacy in teaching using science inquiry skills varies from *not confident*, *slightly confident*, and *confident* to *definitely confident*. In addition, the evidence shows that the PSTs' self-efficacy has increased significantly by the end of their training. With regards to the context of PST education in Malaysia, PSTs are required to complete 24 weeks of in-site classroom teaching practice and a four-week internship towards the end of the BoTP programme. During this, the PSTs develop conscious awareness in their teaching decisions as they are expected to depend on the in-site school guidance and are accountable for their own learning process during the classroom practice. They therefore increase self-efficacy towards the end of the programme as a result of this awareness and the requirements of the specific curriculum unit (Darling-Hammond, Newton and Wei, 2013). Through the self-efficacy information, the importance of teaching practice experiences among PSTs should be emphasised in the curriculum along with the subject knowledge learned.

Instead Despite of the setback after the experience with the classroom teaching practices, PSTs are able to strengthen their perceived ability in teacher knowledge. It shows the importance of classroom teaching experiences in creating awareness of their potential in using the teacher knowledge and the importance of a well-supported training programme to strengthen their self-efficacy in teaching (van Driel, Beijaard and Verloop, 2001; Darling-Hammond, 2006). It was encouraging to see PSTs becoming aware of their self-efficacy doubt (Wheatley, 2002) as soon as they entered the programme. They can get the support needed from the training programmes earlier and learn to handle their doubts during the training rather than when they becoming novices. Thus, it is important to expose teaching practice experiences in the teacher education curriculum at the early stage of training.

Moreover, policy-makers may consider using a tool such as the SETSIS to measure the belief component of teacher knowledge in the BoTP assessment curriculum. The self-efficacy level can infer the teachers' resilience towards implementing the transformed curriculum in Malaysia. PSTs' positive self-efficacy combines with doubt in their capability to often foster great effort, motivation and achievement (Wheatley, 2002); thus, introducing the assessment into the curriculum may help to create awareness of self-efficacy and gain effort in getting the best help during the training programme. The information about the level of self-efficacy can contribute to developing the future confidence in implementing science inquiry skills in the science classroom for PSTs' future teaching careers, personally, and the reform of science learning, generally.

8.4 Limitations of my study

8.4.1 Limitations and future suggestions of the study

As promising as the SETSIS appears, it has some potential limitations. In this study, the pilot data were collected from a sample studying a major course of primary science education, planning to become primary science teachers in ITE across Malaysia. Thus, the findings are true in the context of the applied study programme. A more heterogeneous sample consisting of diverse PST teaching options is needed if the SETSIS finding needs to be applied to a larger population of PSTs.

The study has shown that the items have given reliable, excellent internal consistency and validity with the numerous items constructed. However, analysis of the main pilot study also suggests that the items were not well-targeted in measuring the perceived ability of teaching science using science inquiry skills, especially in the higher level of self-efficacy. When using the SETSIS to evaluate the level of self-efficacy in teaching using science inquiry skills, the findings have proximity in discriminating the lower to average level of samples than the samples with the higher level of self-efficacy.

Nevertheless, the SETSIS generalisation was limited by the specific task of teaching using science inquiry skills in the self-efficacy model suggested. When applying this instrument and the findings, users should be aware of these caveats. The result of the main pilot study has generated a massive amount of rich data, which have been selected to present the contribution of self-efficacy in the factors underlying the particular task for the study purpose. In regard to generalising the use of the measure, future research may use the finding of the model to construct a wider science teaching task.

Another limitation is caused by the cross-sectional design of the study. At the same time, limited access to institutional professional teaching practice attainment may limit the role of the self-efficacy factors as the predictive contributors of the implementation of PST education at a low variance rate. Tests of the reciprocal effects model must be based on longitudinal data with repeated measures of performance attainments in the subject knowledge and the teaching practices. The question whether the PSTs' achievements cause their self-efficacy factors, or whether it is their self-efficacy factors that cause their achievements (Marsh & Craven, 2006), cannot be answered with the data obtained from the study.

8.4.2 Future suggestions

To further validate this instrument, a more heterogeneous sample consisting of diverse PST teaching options is needed. This way, the sample represents the population that the items are intended to measure, especially at the lower level of self-efficacy of OBE, which would be wider as their sources of self-efficacy in belief would be different, so that the instruments can be used in a broader context of teachers with other option backgrounds in PST education but who still need to teach science.

The findings in this study have shown early evidence that the measurement model suggested in the study can be developed further to assess development in teacher's knowledge, especially in the subject and instructional knowledge. The result in Figure 21 shows a relative growth of self-efficacy across the group of semesters across the programme. The related evidence can be a proxy that self-efficacy can infer growth of a teacher's knowledge gained during the teacher training programme. Further research should consider studying the different points of time in the growth of the SETSIS and their relation to the teacher knowledge assessment. The comprehensive model that includes the three areas of self-efficacy relevant to the elements in teacher development can be further constructed and validated to identify the longitudinal growth of these factors in individual PSTs throughout the programme. Besides this, the model could investigate and identify the level of self-efficacy in particular factors that might influence the growth of teacher's knowledge for individual PSTs.

8.5 Concluding thoughts

This thesis had initially been proposed as a result of my experiences as a science subject teacher. Instead of learning to teach using science inquiry skills for science learning during my training, I had seldom used the approach in my teaching. I stressed the content more than the process when practicing teaching science. At that time, I believed it is the best and easiest way to teach science as it was what I had learned from my school experiences and what was practiced by most of the senior peer science subject teachers. However, when I started to work for ITE and followed senior science teacher trainers and attended seminars about the role of science inquiry skills in science literacy, I realised that I had been teaching the students to learn for the assessment, as I had been taught in my school days.

Now, with the transformation in the primary science curriculum, I felt that it is important to identify future potential ability of PSTs for implementing the approach in the science classroom accordingly. It has been proven that acquisition in the cognitive component of teacher knowledge does not necessarily translate into inculcating that knowledge in the real classroom (Hairiah and Keong 2011; Rauf et al. 2013). Thus, implementing such a measurement instrument, one that measures future teachers' potential ability in delivering the tasks and also identifies their perception of capability in specific teacher knowledge would be a huge help. The self-perception result can inform stakeholders of ITE of how to form the necessary strategies to produce future teachers that can resiliently support the transformation of the science curriculum in primary schools all over Malaysia.

Having realised how the role of belief could have changed my past teaching practices, I try to find a concept that can assess the affective component at the level of PST education. Rather than a complex and multidimensional construct, literature has offered robust validity and reliable arguments for measuring self-efficacy in PSTs and teachers, and the relationship to infer perseverance in the teaching career (Maddux 2009; Williams 2010; Kleinsasser 2014; Menon and Sadler 2016; Thomson et al. 2017). For instance, the teacher efficacy model (Tschannen-Moran and Hoy 2001) demonstrated the capacity to assess science teacher knowledge at various levels of their teaching career (Pruski et al. 2013; Smolleck et al. 2006; Bleicher 2004; Roberts and Henson 2000; Riggs and Enochs 1990). Thus, I took the challenge to develop the instrument and psychometrically defend the construct's validity using the extensive methods.

The process of developing the instrument was challenging, especially in communicating the elusive construct of the SETSIS. I have learned a lot throughout the study, especially about finding the suitable method to incorporate the multidimensional variables into a construct of the SETSIS. Throughout the study, I found that construct modelling in Wilson (2005) was very helpful for embodying the variables in the measuring construct of the SETSIS. The Rasch model used was a derivative model but it gave adequate evidence to challenge the concept of the model proposed and at the same time suggested an alternative model solution for the unidimensionality of the construct. I recommend the method for instrument developers as the approach used was convenient and flexible for constructing a defensible measure.

Additionally, the validity evidence of the measure produced substantive findings in regard of PSTs' perceptions of teacher knowledge. Results showed that perceived belief about the value of the knowledge has a positive relationship to PSTs' knowledge performance but does not contribute to the assessment of the curriculum of ITE. It indicated the role of belief in the cognitive component of PST but their practices of teacher knowledge have ignored this aspect. Thus, it is suggested that ITE should include assessment of belief/affective components like the one uncovered in this study for constructive and comprehensive information of teacher knowledge development.

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Appendix A Experts Information Sheet

UNIVERSITY OF LEEDS

Experts Survey Information Sheet

Developing and Validating a Measure of Self-Efficacy in Teaching Science Using Science Inquiry Skills

My name is Syakima Ilyana Ibrahim. I am a PhD student from University of Leeds, United Kingdom. Before you decide to take part or not it is important for you to understand why the research is being done and how it is developed. Please take time to read the following information. Ask me if there is anything that is not clear or if you would like more information. Thank you for reading this.

The purpose of the research

In 2011, a new science curriculum for primary school in Malaysia is transformed to upgrade the scientific literacy in school children. To date, science process skills (SPS) has become an important component in the new science curriculum and become one of the skills needed to teach science in a more effective and meaningful way (Malaysia Ministry of Education 2014). SPS are the science inquiry skills that are used to teach science content using process-based approaches. The aim of this research is to develop a valid instrument (i.e. questionnaire) to seek insights from individual pre-service teachers (PST) about their self-efficacy in using SPS to teach science, and to measure how this develops during teacher training. This research intends to infer competency of PST in teaching science through measuring their self-efficacy (i.e. belief about self-capability) in this.

The definition of construct

This project aims to develop and validate a measure to infer competence of pre-service teachers (PST) in teaching science. The measure intends to assess PST perceived capability in using science inquiry skills in classroom teaching by using three key aspects or domains; knowledge, practice and belief named as Knowledge Efficacy (KE), Personal Teaching Efficacy (PTE) and Outcome Belief Efficacy (OBE). This inter-correlated measure will be used to rate self-efficacy in teaching science using science inquiry skills among PST.

Knowledge Efficacy (KE)

Knowledge efficacy measures the degree to which pre-service teachers (PST) believe that they have knowledge of science inquiry skills including twelve SPS (observation, classification, measurement and using number, inference, communication, predicting, using space-time relationship, interpreting data, define operationally, controlling variables, hypothesizing and experimenting (Malaysia Ministry of Education 2013) that enables them to organise and conduct science inquiry strategies in the classroom. The table below shows exemplar KE items.

Item type	Example of item	Comment
A good KE item	I possess understanding about operationally define variables for guiding my students towards explanation that are consistent with experimental and observation evidence	This item reflects knowledge of define operationally in assist students in science inquiry method.
A poor KE item	I know how to use SPS well in teaching science	This item refer to self-efficacy in using SPS in teaching and better in PTE section.

Personal Teaching Efficacy (PTE)

Personal teaching efficacy (PTE) refer to self-efficacy in the domain of personal teaching practice. PTE reflects judgement of pre-service teacher (PST) that they are confident with their own ability in practice teaching science using science inquiry strategy.

Item type	Example of item	Comment
Good PTE item	I am confident that I have the necessary skills of scientific process to teach science inquiry in classroom	This item reflects personal confident in capability of teaching science inquiry by using the skills needed.
Poor PTE item	I am confident that SPS can be used to teach science	This item did not reflect personal preference in using

		SPS during teaching practices.

Outcome Belief Efficacy (OBE)

Outcome belief Efficacy (OBE) refer to PST belief in the usage of SPS in science inquiry strategies that lead to effective teaching and learning of science. It concerns about the general belief based on PST experiences rather than personal belief in ability of producing the experiences. Table below shows stems use to describe the definition of OBE.

Item type	Example of item	Comment
Good OBE item (in learning)	I believe that SPS create opportunity to satisfy children curiosity when learning science	This item intends to assess belief in **value of SPS** that can satisfy curiosity in learning.
Poor OBE item (in learning)	In science, I think it is important for children to learn SPS. (The fit stem would be - I think it is important for children to use SPS during inquiry activities so that they can learn science effectively)	This item intends to assess belief but in the important of learning SPS.
Fit stem to describe OBE (in teaching)	I am confident that using SPS in inquiry strategies can improve the effectiveness of my teaching practices in science class.	This item intends to assess belief that **effective teaching can be produced** by using SPS. It's refer to preference to use it due to PST general belief that it is good practicing.

Unfit stem to describe OBE (in teaching)	Even when I try very hard to use SPS, I do not teach science as well as I would like. (The fit stem would be - I want to use SPS to improve my science teaching practice)	This item reflects practice domain in ability of producing good teaching by using SPS

Summary

To establish a set of valid instrument in measuring what it intended to measure, a general perspective of content validation on items must be gained first. A questionnaire survey consist all the item pool will be sent out to experts and academicians in different field. The goal of the expert questionnaire survey is to gain expert consensus on items that reflect KE, PTE and OTE in measuring self-efficacy in using science inquiry skills to teach science.

In the survey, you need to rate to what extent each item measured one of the three domains using a 5-point scale (with 1 point being entirely disagree and 5 point being entirely agree). The experts also will be encouraged to provide comments and suggestions for each item or offer your own lists of possible item for each domain.

Your responses will be used to inform fieldwork instruments, a PhD thesis, future reports, conference presentations and/or poster presentations but your work will be anonymous in any reporting. Your expertise, dedication and time is most appreciated.

Thank you very much for taking your time reading this information sheet and taking part in the study. For any inquiries do contact me at edsii@leeds.ac.uk or +447542817270.

This PhD study is being supervised by Dr Matt Homer (M.S.Homer@education.leeds.ac.uk) and Professor Jim Ryder (J.Ryder@education.leeds.ac.uk).

Appendix B Ethics Approval

Performance, Governance and Operations
Research & Innovation Service
Charles Thackrah Building
101 Clarendon Road
Leeds LS2 9LJ Tel: 0113 343 4873
Email: ResearchEthics@leeds.ac.uk

UNIVERSITY OF LEEDS

Syakima Ibrahim
PhD candidate
School of Education
University of Leeds
Leeds, LS2 9JT

ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee
University of Leeds

20 October 2015

Dear Syakima

Title of study: **Developing and Validating A Measure of Self-Efficacy in Teaching Science Process Skills**
Ethics reference: **AREA 15-023**

I am pleased to inform you that the above research application has been reviewed by the ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee and following receipt of your response to the Committee's initial comments, I can confirm a favourable ethical opinion as of the date of this letter. The following documentation was considered:

Document	Version	Date
AREA 15-023 SII_Ethical_Review_Form_V3 (amended).doc	2	19/10/15
AREA 15-023 Appendix 1 Information Sheet.docx	2	19/10/15
AREA 15-023 Appendix 2-consent form.doc	2	19/10/15
AREA 15-023 SII_ FIELDWORK ASSESSMENT.docx	1	24/09/15

Please notify the committee if you intend to make any amendments to the original research as submitted at date of this approval, including changes to recruitment methodology. All changes must receive ethical approval prior to implementation. The amendment form is available at http://ris.leeds.ac.uk/EthicsAmendment.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://ris.leeds.ac.uk/EthicsAudits.

We welcome feedback on your experience of the ethical review process and suggestions for improvement. Please email any comments to ResearchEthics@leeds.ac.uk.

Yours sincerely

JBlaikie

Jennifer Blaikie
Senior Research Ethics Administrator, Research & Innovation Service
On behalf of Dr Andrew Evans, Chair, AREA Faculty Research Ethics Committee
CC: Student's supervisor(s)

Appendix C Participant Consent Form and Information Sheet

UNIVERSITY OF LEEDS

CONSENT FORM

Title of research project:

Developing and Validating A Measure of Self-Efficacy in Teaching Science Using Science Process Skills

Name of researcher:
Syakima Ilyana Ibrahim

	Please write your initials next to the statement you agree with
I confirm that I have read and understand the information sheet dated (date) explaining the above research project and I have had the opportunity to ask questions about the project. I agree to take part in the project.	
I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.	
I give permission for my score in Practicum, Practicum II or Practicum II (whichever is the latest) to be used (by the permission of ITE's Examination and Senate Department) in the research.	
I understand that my responses will be kept strictly confidential. (I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.)	
I agree for the data collected to be used in the researcher's PhD thesis, future reports, conference presentations and/or poster presentations.	
I agree to take part in the above research project.	

Name of participant	
Participant's signature	
Date	

UNIVERSITY OF LEEDS

Information Sheet

Developing and Validating a Measure of Self-Efficacy in Teaching Science using Science Process Skills

My name is Syakima Ilyana Ibrahim. I am a PhD student from University of Leeds, United Kingdom. Before you decide to take part or not it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask me if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

The purpose of the research

This research intended to develop an instrument to seek insights from individual pre-service teachers about their self-efficacy (i.e. belief about self-capability) in teaching science process skills (SPS) and how it develops during teacher training. The aim of this research is to explore the pre-service teachers' self-efficacy in teaching SPS by measuring three different traits, which are knowledge, belief and practice. The result of this study will be very useful not only to the policy makers and teacher educators but also to the pre-service teachers as well for the success of the professional training and development of teacher training programme in Malaysia. Thus, I would like to invite the science pre-service teachers to participate by completing the two sets of surveys as listed below based on the experiences during teacher training programme;

i) *The Measure of Self-efficacy in Teaching Science Process Skills (SETSPS)*

I would very much like this to be a positive experience for you and hope that you may want to complete the survey provided to the end. In the first phase of the study, you will need to complete a questionnaire about your self-efficacy in teaching SPS which contains two parts; questions section with five scale response and demographic and information section. This may take 15-20 minutes to complete.

ii) *The Test of Basic and Integrated Science Process Skills*

The second survey of the study will be a test of your knowledge in basic and integrated SPS, which may take about 30 minutes to one hour. This will in NO WAY be associated to your grade in your teacher training courses. The score in this test, will be used to part of validating your response in above measure.

In additional to these, the data of score from the Practicum courses (subject to the approval of Department of Exams and Senate of ITE) will be used for the purpose of validating these three dimensions. The score of the Practicum assessment, together with score from the test in (ii) will be used to validate the measure in (i). The participant who volunteered may withdraw at any phase of the study. All the data gathered in this research will only be used for the research purposes and will be kept strictly confidential.

The duration of the study

This study will take place from March until July 2016 and I will be inviting all science pre-service teachers in Malaysian Institute of Teacher Education to take part.

Your rights

If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. You can still withdraw at any time without it affecting any benefits that you are entitled to in any way. You do not have to give a reason. If there are any questions or topics which you feel uncomfortable, then you can choose to end the survey. Whilst there are no immediate benefits for those people participating in this study, it is hoped that this study will give an opportunity to you to help to improve the learning experiences in teacher training programme by sharing your belief, knowledge and practice experience regarding teaching SPS. All the information that are collected during this study will be kept strictly confidential. The result will be published however you will not be identified in any report or publication. You will be given a copy of this information sheet and a signed consent form to keep.

Thank you very much for taking your time reading this information sheet and taking part in the study. For any inquiries do contact me at edsii@leeds.ac.uk or 01123804470.

Appendix D Instrument the SETSIS (fieldwork version)

Primary School Pre-Service Teachers' Self-Efficacy in Teaching Science Using Investigation Skills

SELF-EFFICACY IN TEACHING SCIENCE USING INVESTIGATION SKILLS (SETSIS)
Efikasi Kendiri Mengajar Sains Menggunakan Kemahiran Penyiasatan

Soal-selidik ini direka bagi meneroka konsep dan kompetensi guru pelatih dalam menggunakan kemahiran penyiasatan semasa mengajar sains. Kemahiran penyiasatan dalam kajian ini merangkumi 12 kemahiran proses sains (KPS) berikut ;

KPS 1 : Memerhati
KPS 2 : Mengelas
KPS 3 : Mengukur dan menggunakan nombor
KPS 4 : Membuat inferens
KPS 5 : Meramal
KPS 6 : Berkomunikasi
KPS 7 : Menggunakan perhubungan ruang dan masa
KPS 8 : Mentafsir maklumat
KPS 9 : Mengawal pembolehubah
KPS 10: Mendefinisi secara operasi
KPS 11: Membuat hipotesis
KPS 12: Mengeksperimen

Soal-selidik ini mengandungi 4 bahagian yang perlu dilengkapkan.

Arahan:

Dalam skala yang sama (1 (langsung tidak yakin) hingga 5 (sangat yakin)), sila nilai sejauh mana keyakinan anda terhadap keupayaan diri anda terhadap penyataan-penyataan di Bahagian I, Bahagian II dan Bahagian III.

Sila legkapkan Bahagian IV dengan maklumat demografik anda.

	ARAHAN: Dalam skala 1 (langsung tidak yakin) hingga 5 (sangat yakin), sila nilai dan tandakan sejauh mana keyakinan terhadap keupayaan anda dalam penyataan-penyataan berikut.					
Bahagian I - Efikasi Pengetahuan						
	Bahagian ini mengukur sejauh mana keyakinan anda terhadap pengetahuan kemahiran penyiasatan sains yang dimiliki cukup untuk merancang dan melaksanakan proses sains dalam pengajaran.			**Skala**		
No.	Item	Langsung tidak yakin		Agak yakin		Sangat yakin
K1	Saya rasa pengetahuan kemahiran proses sains (KPS) saya mencukupi bagi membimbing murid membentuk kefahaman yang lebih bermakna tentang sains.	1	2	3	4	5
K2	Saya faham tentang KPS yang diperlukan bagi membimbing murid memperoleh bukti saintifik melalui penyiasatan sains.	1	2	3	4	5
K3	Saya faham KPS asas untuk membantu murid mengumpulkan data yang diperlukan untuk menjawab persoalan mereka.	1	2	3	4	5
K4	Saya tahu cara merancang aktiviti penyiasatan sains yang menarik perhatian murid mempelajari sains.	1	2	3	4	5
K5	Saya boleh menggabungkan pengetahuan KPS dengan isi kandungan subjek bagi mendorong murid terlibat dalam aktiviti penyiasatan sains.	1	2	3	4	5
K6	Saya mempunyai pengetahuan merangka idea saintifik bagi menyediakan garis panduan kepada murid menerangkan keputusan sains mereka.	1	2	3	4	5
K7	Saya mempunyai kemahiran membuat hipotesis yang cukup bagi memainkan peranan utama dalam membimbing murid mengenalpasti pembolehubah yang terlibat dalam persoalan saintifik yang dikemukakan.	1	2	3	4	5
K8	Saya mempunyai pengetahuan membimbing murid merancang masalah sendiri untuk disiasat.	1	2	3	4	5
K9	Saya tahu bagaimana memberi tunjuk cara agar murid boleh membina persoalan kajian mereka untuk dijawab melalui penyiasatan.	1	2	3	4	5
K10	Saya mempunyai pengetahuan berunding dengan murid berkenaan perhubungan yang mungkin di antara penerangan.	1	2	3	4	5
K11	Saya tahu yang saya memiliki pengetahuan KPS yang cukup untuk mengajar sains secara penyiasatan kepada murid-murid sekolah rendah.	1	2	3	4	5
K12	Saya mempunyai pengetahuan isi kandungan yang diperlukan untuk mengajar sains kepada murid-murid sekolah rendah.	1	2	3	4	5
K13	Dengan pengetahuan KPS yang ada, saya boleh membentuk persoalan saintifik yang diperlukan untuk murid membuat kajian.	1	2	3	4	5
K14	Saya berpengetahuan melaksanakan aktiviti eksperimen dalam pengajaran saya.	1	2	3	4	5
K15	Apabila apparatus sains tidak ada, saya selesa menggunakan pengetahuan eksperimen saya untuk mengubahsuai aktiviti P&P sains.	1	2	3	4	5

K16	Kemahiran eksperimen saya cukup bagi menerangkan **fungsi** eksperimen kepada murid.	1	2	3	4	5
K17	Saya yakin untuk mengajar sesuatu konsep sains yang pernah saya faham melalui eksperimen.	1	2	3	4	5
K18	Apabila murid sukar memahami sesuatu konsep sains, saya yakin pengetahuan saya dalam KPS dapat membantu mereka memahami konsep tersebut.	1	2	3	4	5
K19	Saya berterusan mencari cara penggunaan KPS yang berkesan bagi mengajar sains.	1	2	3	4	5
K20	Saya faham tentang pengukuran dan ruang bagi membantu murid memahami konsep panjang menggunakan model pengukuran sendiri (i.e. mengatur klip kertas / lidi).	1	2	3	4	5
K21	Saya berupaya menghuraikan pemerhatian saya dengan pernyataan kuantitatif	1	2	3	4	5
K22	Saya boleh menghuraikan pemerhatian saya dalam pelbagai bentuk penerangan bermakna.	1	2	3	4	5
K23	Saya tahu menggunakan maklumat diperoleh untuk meramal pemerhatian yang akan datang.	1	2	3	4	5
K24	Saya boleh mengemukakan soalan/ masalah bagi menimbulkan minat murid untuk menyelesaikannya.	1	2	3	4	5
K25	Saya yakin mempunyai kemahiran penyiasatan yang cukup bagi mengajar konsep sains penting dengan berkesan.	1	2	3	4	5
K26	Saya sentiasa boleh menjawab soalan sains murid menggunakan kefahaman saya dalam proses sains.	1	2	3	4	5
Bahagian II - Efikasi Pengajaran Kendiri						
	Bahagian ini mengukur sejauh mana anda yakin dengan keupayaan sendiri untuk mengamalkan pendekatan penyiasatan sains dalam					
P1	Apabila aktiviti proses sains sukar untuk dilaksanakan, saya akan menyusun setiap langkah aktiviti menggunakan pendekatan penyiasatan.	1	2	3	4	5
P2	Apabila aktiviti proses sains sukar diterangkan, saya menggunakan pendekatan penyiasatan untuk membantu murid memahaminya.	1	2	3	4	5
P3	Saya boleh memberikan penerangan kepada murid saya tentang aktiviti berkaitan proses sains.	1	2	3	4	5
P4	Saya berupaya merancang aktiviti proses sains dengan menggunakan modul yang disediakan.	1	2	3	4	5
P5	Saya memilih menyediakan data daripada eksperimen sebenar sebagai bahan instruksional berbanding menggunakan data daripada buku kerja.	1	2	3	4	5
P6	Saya tahu cara menyediakan data sesuai untuk dianalisis murid.	1	2	3	4	5
P7	Saya berupaya untuk menggunakan satu set data daripada lembaran kerja bagi membantu murid dalam proses analisis.	1	2	3	4	5
P8	Saya berupaya untuk membimbing murid memberikan pelbagai cadangan bagi membentuk penerangan daripada data.	1	2	3	4	5

P9	Saya boleh menyediakan bukti yang diperlukan untuk menyokong sesuatu penyiasatan murid.	1	2	3	4	5
P10	Sama ada kandungan sains itu susah atau tidak, saya pasti dapat mengajarnya dengan menggunakan pendekatan penyiasatan sains.	1	2	3	4	5
P11	Saya boleh membimbing murid dalam bertanyakan soalan saintifik yang bermakna.	1	2	3	4	5
P12	Saya yakin boleh mengaplikasikan kemahiran penyiasatan sains semasa pengajaran saya.	1	2	3	4	5
P13	Saya berupaya membimbing murid ke arah penyiasatan yang sesuai berdasarkan soalan-soalan yang cuba untuk dijawab.	1	2	3	4	5
P14	Saya berupaya membantu murid mendalami soalan yang dikemukakan, supaya mereka dapat mengalami penyiasatan yang menarik dan berhasil.	1	2	3	4	5
P15	Saya percaya saya mampu mengajar konsep sains dengan mudah menggunakan pendekatan penyiasatan sains.	1	2	3	4	5
P16	Dalam penyiasatan sains, saya cuba menggalakkan murid mengkaji sendiri sumber-sumber dalam percubaan untuk menghubungkait penerangan mereka dengan pengetahuan saintifik.	1	2	3	4	5
P17	Saya percaya saya mampu mendorong murid melibatkan diri semasa aktiviti penyiasatan sains dalam kelas.	1	2	3	4	5
P18	Saya perlu menggalakkan murid mengkaji semula dan bertanyakan soalan tentang keputusan hasil kerja murid lain.	1	2	3	4	5
P19	Saya berupaya untuk menunjukkan kepada murid saya garis panduan yang mesti diikuti apabila berkongsi dan mengkritik penerangan.	1	2	3	4	5
P20	Saya boleh memberi peluang kepada murid membuat keputusan penting dalam menilai kesahan sesuatu penerangan sains.	1	2	3	4	5
P21	Saya membimbing murid saya menyediakan langkah-langkah atau prosedur yang ditetapkan untuk menyampaikan keputusan saintifik kepada kelas.	1	2	3	4	5
P22	Jika ada peluang saya akan menggalakkan murid bagi membuat penerangan yang pelbagai melalui pemerhatian yang sama.	1	2	3	4	5
P23	Saya boleh membimbing murid membuat penerangan konsisten antara bukti daripada pemerhatian dengan eksperimen yang dijalankan.	1	2	3	4	5
P24	Melalui proses berkongsi penerangan, saya akan cuba memberi peluang murid untuk mengkritik kaedah penerangan dan penyiasatan.	1	2	3	4	5
P25	Saya mahu membimbing murid menilai sendiri ketekalan di antara penerangan mereka dengan idea saintifik yang diterima.	1	2	3	4	5
P26	Saya cuba merancang masa bagi memberi peluang murid untuk menerangkan penyiasatan dan penemuan mereka semasa pengajaran dan pembelajaran di kelas.	1	2	3	4	5
P27	Saya pasti boleh membimbing murid dalam mengucapkan penerangan menggunakan istilah sains yang jelas.	1	2	3	4	5
P28	Saya memilih menunjukkan cara pengajaran sains yang menepati kehendak kurikulum terkini kepada guru besar.	1	2	3	4	5

Bahagian III - Efikasi Kepercayaan Hasil						
	Bahagian ini mengukur mengetahui sejauh mana anda yakin dengan pengaruh kemahiran penyiasatan terhadap keberkesanan pengajaran dan pembelajaran sains.					
B1	Saya fikir bahawa penggunaan Kemahiran proses sains (KPS) penting dalam penyiasatan sains kerana murid-murid boleh mempelajari dan memahami konsep sains dengan lebih baik di dalam kelas.	1	2	3	4	5
B2	Penggunaan KPS dalam penyiasatan sains dapat membantu pembelajaran sains seperti yang kehendaki.	1	2	3	4	5
B3	Dalam sains , saya fikir adalah penting bagi murid belajar kemahiran menyiasat masalah.	1	2	3	4	5
B4	Saya yakin aktiviti melibatkan proses sains boleh mendorong murid untuk berminat dalam matapelajaran sains.	1	2	3	4	5
B5	Saya percaya bahawa kemahiran penyiasatan diperlukan untuk murid berjaya dalam pembelajaran sains pada peringkat yang lebih tinggi.	1	2	3	4	5
B6	Saya fikir bahawa pengajaran sains dengan menggunakan penyiasatan penting kerana ia boleh merangsang murid berfikir	1	2	3	4	5
B7	Saya percaya bahawa aktiviti penyiasatan sains membantu murid untuk memahami konsep abstrak dalam sains.	1	2	3	4	5
B8	Pengajaran sains melalui pendekatan penyiasatan akan menarik minat murid terhadap pembelajaran sains.	1	2	3	4	5
B9	Saya percaya kumpulan murid berkeupayaan rendah berminat untuk mempelajari sains dengan aktiviti penyiasatan	1	2	3	4	5
B10	Dalam sains , saya fikir adalah penting bagi murid untuk terlibat dalam aktiviti penyiasatan.	1	2	3	4	5
B11	Saya percaya bahawa pendekatan penyiasatan sains merupakan strategi pengajaran yang mudah dilaksanakan.	1	2	3	4	5
B12	Saya percaya bahawa pendekatan penyiasatan sains ialah cara yang lebih baik untuk mengajar sains.	1	2	3	4	5
B13	Saya rasa guru yang mengunakan penyiasatan sains dalam strategi pengajaran boleh meningkatkan pencapaian murid dalam sains.	1	2	3	4	5
B14	Pengajaran sains dengan menggunakan pendekatan penyiasatan akan membolehkan konsep sains dapat dipelajari oleh semua murid.	1	2	3	4	5
B15	Saya yakin bahawa strategi pendekatan penyiasatan sains dapat memperbaiki keberkesanan pengajaran sains dalam kelas.	1	2	3	4	5
B16	Saya percaya penguasaan KPS membantu guru mengajar menggunakan pendekatan penyiasatan sains.	1	2	3	4	5
B17	Saya yakin bahawa guru yang memahami dan menguasai KPS dapat mengajar sains dengan lancar dan berkesan.	1	2	3	4	5
B18	Saya rasa pengetahuan KPS berkesan membantu kejayaan guru mengajar sains	1	2	3	4	5

BAHAGIAN IV MAKLUMAT DEMOGRAFIK

Lengkapkan maklumat di bawah.

NO	ITEM	INFORMATION
1	No pelajar	
2	IPG Kampus	
2	Semester PISMP	
3	Jantina	[ ] Lelaki [ ] Perempuan
4	Kaum	[ ] Melayu [ ] Cina [ ] India [ ] Lain-lain (nyatakan)____________
5	Keputusan subjek sains SPM	_______(Biologi) ________ (Kimia) __________ (Fizik) _________ (matapelajaran sains selain dinyatakan)
6	Jenis sekolah menengah yang anda hadiri.	[ ] Sekolah menengah berasrama penuh [ ] Sekolah menengah kebangsaan [ ] Sekolah menengah jenis kebangsaan [ ] Lain-lain ………………………………………………….. (nyatakan)
7	Adakah anda berpengalaman mengajar sebelum ini?	[ ] Ya [ ] Tidak

Appendix E Expert's Survey of the SETSIS

Expert Survey of

Self-Efficacy in Teaching Using Science Inquiry Skills Instrument (SETSIS)

This questionnaire is designed to gain expert perspectives on the content and need of items in domains to measure primary school pre-service teachers' self-efficacy in teaching using science inquiry skills

PART 1: Demographic Information of Experts

Please fill in the information

NO	ITEM	INFORMATION
1	Institution	
2	Gender	[ ] Male [ ] Female
3	Specialization	
4	Level of professional experience	

PART II: SETSIS Item Pool Survey

Instructions:

Please evaluate each of the item that have been listed under the three domains.

On a scale from **1 (*entirely disagree*)** to **5 (*entirely agree*)**, *please rate to what extent* each item measured the domain functioning**.**

1	2	3	4	5
entirely disagree	**somewhat disagree**	**neither agree nor disagree**	**somewhat agree**	**entirely agree**

You are encourage to provide comments and suggestions for each item or offer your own lists of possible item for each domain.

ARAHAN : Berikan pendapat anda merujuk kepada kesesuaian item K1 hingga K39 berdasarkan definisi dimensi *Knowledge Efficacy (KE)*.
Sila tandakan (/) pendapat anda dalam skala 1 hingga 5 di ruangan yang disediakan.
Anda digalakkan memberi pandangan dan cadangan terhadap setiap item atau mencadangkan item baru yang sesuai untuk setiap dimensi/ domain.

DOMAIN KNOWLEDGE: KNOWLEDGE EFFICACY (KE)

Skala KE diperkenalkan bagi mengukur efikasi kendiri dalam pengetahuan isi kandungan pengajaran KPS.
Definisi dimensi KE mengambil kira keyakinan guru pelatih dalam menjelmakan pemahaman kerja sains dalam aktiviti menggunakan pengetahuan KPS.
Ianya merujuk kepada pengetahuan kemahiran sains inkuiri termasuk 12 KPS (memerhati, mengelas, mengukur dan menggunakan nombor, membuat inferens, meramal, berkomunikasi, menggunakan perhubungan ruang dan masa, mentafsirkan maklumat, mendefinisi secara operasi, mengawal pemboleh ubah, membuat hipotesis, mengeksperimen (Malaysia Ministry of Education 2013)) yang diperlukan untuk merancang dan melaksanakan strategi inkuiri sains.
Pengetahuan kemahiran sains inkuiri juga ditakrifkan sebagai kemahiran yang membolehkan guru pelatih merangka dan menjawab soalan saintifik dan masalah saintifik secara sistematik.

Item Number	Item	Skala					Comment/ suggestion
		1	2	3	4	5	
		Sangat tidak setuju	Tidak setuju	Tidak pasti	Setuju	Sangat setuju	
K1	Saya mempunyai pengetahuan yang diperlukan untuk memberi respon kepada soalan daripada murid tentang sains sekolah rendah I *have knowledge needed to respond questions from pupils about primary science*						
K2	Saya memiliki pengetahuan membuat inferens yang diperlukan untuk memberikan murid hubung kait yang mungkin di antara pemerhatian sains dengan kesimpulan mereka. *I possess necessary knowledge of inference to provide pupils with the possible connections between science observation and their conclusion.*						

	K3	Saya yakin pengetahuan kemahiran proses sains saya mencukupi bagi membimbing murid ke arah idea yang diterima secara saintifik yang membolehkan mereka membentuk kefahaman yang lebih bermakna tentang sains. *I am confident in my knowledge of SPS to guide pupils toward scientifically accepted ideas upon which they can develop more meaningful understanding of science.*							
	K4	Saya berasa selesa dengan pengetahuan mengeksperimen saya bagi mengubahsuai pendekatan pengajaran sekiranya peralatan sainstifik yang diperlukan tidak disediakan. *I feel comfortable with my experimenting knowledge in order to improvise if scientific apparatus needed are not available.*							
	K5	Apabila murid menghadapi kesukaran memahami sesuatu konsep sains, saya berasa yakin mempunyai pengetahuan KPS bagi membantu mereka untuk memahaminya menggunakan pendekatan inkuiri saintifik. *When pupils has trouble understanding a science concept, I am confident in my knowledge of SPS to help them to better understand it by using science inquiry approach*							
	K6	Saya mempunyai kefahaman dalam KPS yang diperlukan bagi menentukan cara terbaik untuk kanak –kanak boleh memeperolehi bukti saintifik.*I have the necessary understanding of SPS to determine the best manner through which children can obtain scientific evidence.*							
	K7	Saya memahami asas KPS untuk dapat membantu murid mengumpulkan data berkenaan yang diperlukan untuk menjawab persoalan mereka. I understand the basic of SPS *to help pupils to gather the appropriate data necessary for answering their questions*							
	K8	Saya mempunyai kefahaman KPS bagi menyediakan sendiri kebanyakan daripada persoalan saintifik yang diperlukan untuk penyiasatan pelajar. *I have knowledge in SPS to create the majority of the scientific questions needed for students to investigate.*							

	K9	Saya yakin mempunyai pengetahuan KPS yang cukup bagi mengajar konsep sains yang penting dengan berkesan. *I have knowledge of SPS in order to teach important science concepts effectively*						
	K10	Saya sentiasa berusaha mencari cara penggunaan KPS yang lebih baik bagi mengajar sains. *I am continually finding better way to use SPS in teaching science*						
	K11	Saya lazimnya berupaya menjawab soalan sains pelajar menggunakan pemahaman saya dalam proses sains.*I am typically able to answer pupils' science questions using my undersanding in scientific process.*						
	K12	Saya tahu cara merancang aktiviti penyiasatan sains menjadikan murid berminat dengan pembelajaran sains. *I know how to plan science invastigation activity to make students interested in scienc learning*						
	K13	Saya tahu mengintegrasikan pengetahuan isi kandungan topik saya dengan KPS bagi mendorong murid terlibat dalam aktiviti inkuiri sains. *I know how to join my subject matter knowledge with SPS to motivate students into scientific proceess activities.*						
	K14	Saya mempunyai pengetahuan untuk merangka idea saintifik bagi menyediakan garis panduan kepada murid menyampaikan keputusan dan penerangan mereka. *I have necessary knowledge to formulate scientific ideas to help pupils with the guidelines for communicating their results and explanations.*						
	K15	Saya yakin berpengetahuan dalam membuat inferensi, meramal dan berkomunikasi untuk menawarkan/menunjukkan pendekatan bagi menghasilkan penerangan daripada bukti. *I have knowledge of inference, predicting and communication to be able to offer/show approaches for generating explanations from evidence.*						

	K16	Saya mempunyai kemahiran membuat hipotesis yang cukup bagi memainkan peranan utama dalam membimbing pelajar mengenalpasti soalan saintifik.*I have necessary skills in hypothesising to able to play the primary role in guiding pupils identify scientific questions.*							
	K17	Saya yakin untuk mengajar sesuatu konsep sains yang pernah saya belajar melalui pengetahuan eksperimen saya. *A I feel confident in teaching science concept that I have learn through my knowledge of experimenting.*							
	K18	Saya mempunyai pengetahuan isi kandungan dan pengetahuan KPS bagi membenarkan murid meransang sendiri masalah untuk disiasat dalam aktiviti saintifik. *I possess the knowledge of content and SPS to allow students to devise their own problems to investigate.*							
	K19	Saya berpengetahuan memberikan tunjuk cara agar para pelajar boleh menumpukan persoalan mereka kepada soalan yang boleh dikendalikan untuk kajian. *I have knowledge to provide demonstrations through which students can focus their queries into manageable questions for investigation.*							
	K20	Saya tidak yakin berupaya untuk menggunakan pengetahuan KPS apabila mengajar pelajaran sains kepada pelajar saya I do not feel capable to use knowledge of SPS when I teach scince lesson to my students.(-)							
	K21	Saya berupaya meramal dengan mengaitkan pemerhatian saya dengan pengalaman sebelumnya.I am able to make prediction by link my observation with my previous experiences.							

	K22	Saya berpengetahuan untuk memberikan pelajar saya hubung kait yang ada antara proses dan pengetahuan saintifik di mana melaluinya mereka boleh mengaitkan penerangan mereka. *I have knowledge to provide my students with possible connections to scientific knowledge through which they can relate their explanations.*							
	K23	Saya mempunyai pengetahuan eksperimen tetapi merasa sukar menerangkan kepada para pelajar cara eksperimen sains berfungsi *I have knowledge in experimenting but encounter difficulties in explaining to students how the science experiments work.*							
	K24	Saya memahami konsep proses saintifik dengan cukup baik untuk mengajar inkuiri sains dengan berkesan. *I understand scientific process concept well enough to teach science inquiry effectively*							
	K25	Apabila mengajar sains, saya biasanya mengetahui persolan/masalah pelajar *When teaching science, I usually knows student questions/ problems*							
	K26	Saya berharap mempunyai kefahaman yang lebih baik tentang konsep sains yang saya ajar.*I wish I had a better understanding of the science concept I teach.*							
	K27	Saya yakin mempunyai pengetahuan KPS yang lebih baik berbanding pengetahuan konsep sains untuk mengajar sains sekolah rendah. I have better knowledge of SPS compare to knowledge of science concept that enable me to teach science in primary school.							
	K28	Saya tahu yang saya memiliki pengetahuan KPS yang cukup untuk mengajar secarainkuiri sains kepada murid-murid sekolah rendah. *I know that I possess the necessary knowledge of SPS to teach science inquiry to primary pupils*.							

	K29	Saya mempunyai pengetahuan isi kandungan yang diperlukan untuk mengajar sains kepada murid-murid sekolah rendah. *I possess the necessary subject matter knowledge to teach science to primary pupils.*						
	K30	Saya berpengetahuan melaksanakan aktiviti eksperimen dalam pengajaran saya. *I knowledgable in implementing experimental activities in my teaching*						
	K31	Saya berupaya menghuraikan pemerhatian saya dengan pernyataan kuantitatif *I am able to describe my observation with quantitative statement*						
	K32	Saya berupaya menghuraikan pemerhatian saya dalam pelbagai bentuk penerangan bermakna. *I am able to describe my observation using various meaningful presentation..*						
	K33	Saya berupaya menetapkan aturan berdasarkan kepada persamaan, perbezaan dan saling berhubungan. *I am able to imposing order based on similarities, differences and interrelationship*						
	K34	Saya berupaya menghasilkan sistem pengelasan berdasarkan kepada perbandingan dan perbezaan sifat. *I am able to develop a classification system based on compare and contrast attribute.*						
	K35	Saya mempunyai keupayaan pengetahuan untuk berunding dengan pelajar berkenaan perhubungan yang mungkin di antara penerangan. *I am able in regards of knowledge to negotiate with students possible connections between/among explanations.*						
	K36	Saya tahu menggunakan maklumat untuk meramal pemerhatian yang akan datang. *I do know to use information to forecast future observation*						

	K37	Saya mempunyai kefahaman dalam pengukuran untuk membantu murid memahami konsep panjang menggunakan model pengukuran sendiri (i.e. mengatur klip kertas / lidi). I have understanding in measurement to help pupils learn the concept of length through creating model of measurement (i.e. line up paper clips/ tooth picks).							
	K38	Saya tahu mengemukakan soalan/ masalah bagi menimbulkan minat murid untuk menyelesaiakannya. I knowl how to confront pupils with questions/ problems that they want to resolve.							
	K39	Saya tahu cara merancang aktiviti pemerhatian dengan bantuan peralatan dan lima deria. *I know how plan observation activity with the aid of instruments and five senses.*							

ARAHAN : Berikan pendapat anda merujuk kepada kesesuaian item P1 hingga P36 berdasarkan definisi dimensi *personal teaching efficacy* (PTE).
Sila tandakan (/) pendapat anda dalam skala 1 hingga 5 di ruangan yang disediakan.
Anda digalakkan memberi pandangan dan cadangan terhadap setiap item atau mencadangkan item baru yang sesuai untuk setiap dimensi/ domain.

DOMAIN PRACTICE: PERSONAL TEACHING EFFICACY (PTE)

Dimensi personal teaching efficacy (PTE) merujuk kepada efikasi kendiri dalam domain praktis.
PSE didefinisi sebagai pertimbangan individu guru pelatih dalam keyakinan diri terhadap kebolehan mereka menggunakan pendekatan KPS dalam pengajaran sains.
Setiap item dimensi adalah mengikut tahap kesukaran yang dibangunkan melalui hipotesis pencapaian responden berdasarkan PCK taxonomy (Veal & MaKinster 1999).

	Item Number	Item	Skala					Comment/ suggestion
			1	2	3	4	x	
			Sangat tidak	Tidak setuju	Tidak pasti	Setuju		
	P1	Saya yakin berupaya menggunakan KPS dengan baik semasa mengajar sains. *I am sure that I able to use SPS well in teaching science*						
	P2	Apabila mendapati kandungan sains itu susah, saya lebih suka menggunakan pendekatan proses sains untuk murid memahaminya dengan lebih baik. *When I find the science content difficult, I prefer to use science process approach to make students understand it better.*						

	P3	Saya yakin yang saya mempunyai kemahiran yang diperlukan untuk mengajar proses saintifik. *I am confident that I have the necessary skills to teach scientific process*						
	P4	Melalui syarahan dan penggunaan buku teks, saya berupaya untuk menyediakan bukti yang diperlukan untuk murid membentuk penerangan saintifik . *Using the lecture and textbook, I am able to provide my students with all evidence required to form scientific explanations.*						
	P5	Saya berupaya untuk merancang aktiviti kemahiran proses dengan menggunakan lembaran kerja yang sedia ada. *I am able to plan process skills activity by using the existing worksheet.*						
	P6	Saya berupaya untuk menyediakan para pelajar saya data yang diperlukan untuk menyokong sesuatu penyiasatan.*I am able to provide my students with the data needed to support an investigation.*						
	P7	Saya berupaya untuk menyediakan para pelajar saya bukti untuk dianalisis. *I am able to provide my students with evidence to be analyzed.*						
	P8	Saya berupaya untuk menggunakan lembaran kerja sebagai bahan instruksional bagi menyediakan satu set data di dalam kelas. *I am able to utilize worksheets as an instructional tool for providing a data set*						

	P9	Saya berupaya untuk menggunakan satu set data daripada lembaran kerja bagi membantu pelajar dalam proses analisis. *I am able to utilize the data set in worksheets to walk students through the analysis process.*						
	P10	Saya berupaya untuk membimbing murid menilai sendiri ketekalan di antara penerangan mereka dengan idea saintifik yang diterima. *I am able to guide students to independently evaluate the consistency between their own explanations and scientifically accepted ideas.*						
	P11	Apabila aktiviti saintifik sukar untuk dilaksanakan, saya lebih suka menyusun langkah-langkah aktiviti dengan terperinci. *When science activities are difficult to execute, I prefer to organise the activities in detail steps.*						
	P12	Apabila aktiviti proses saintifik sukar dilaksanakan, saya suka menjelaskan konsep sains terus kepada pelajar.*When science activities are difficult to execute, I prefer to explain the science concept straight away to students.*						
	P13	Saya berupaya untuk merancang masa bagi para pelajar saya untuk menerangkan penyiasatan dan penemuan mereka semasa pengajaran dan pembelajaran di kelas. *I am able to plan time for my students to describe their investigations and findings to others during classroom teaching and learning.*						

	P14	Apabila pelajar menghadapi masalah memahami sesuatu konsep sains, saya lebih suka menggunakan pendekatan proses saintifik untuk membantunya memahami dengan lebih baik. *When a student has trouble understanding a science concept, I prefer to use scientific process approach to help him/her to better understand it .*						
	P15	Sekiranya diberi pilihan, saya tidak akan mengundang guru besar untuk menilai cara pengajaran sains saya. *Given a choice, I would not invite the principle to evaluate my science teaching practice(-)*						
	P16	Sama ada kandungan sains itu susah atau tidak, saya pasti dapat mengajarnya dengan menggunakan pendekatan proses sains. *Whether the science content is difficult or not, I can teach it using science process approach*						
	P17	Saya berupaya memberi peluang kepada murid membuat keputusan kritikal melalui penilaian kesahan penerangan saintifik.*I am able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations.*						
	P18	Melalui proses berkongsi penerangan, saya berupaya untuk menyediakan para pelajar dengan peluang untuk mengkritik kaedah penerangan dan penyiasatan. *Through the process of sharing explanations, I am able to provide students with the opportunity to critique explanations and investigation methods.*						
	P19	Saya berupaya membimbing para pelajar dalam bertanyakan soalan saintifik yang bermakna. *I am able to guide students in asking scientific questions that are meaningful.*						

	P20	Saya berupaya untuk membimbing para pelajar ke arah penyiasatan yang sesuai berdasarkan soalan-soalan yang cuba untuk dijawab. *I am able to guide students toward appropriate investigations depending on the questions they are attempting to answer.*						
	P21	Saya berupaya membantu para pelajar mendalami soalan yang dikemukakan oleh guru atau daripada bahan pengajaran, supaya mereka dapat mengalami penyiasatan yang menarik dan berhasil. *I am able to help students refine questions posed by the teacher or from instructional materials, so they can experience interesting and productive investigations.*						
	P22	Saya berupaya untuk membimbing para pelajar dalam mengucapkan penerangan menggunakan istilah yang jelas.*I am able to coach students in the articulation of explanations using clear terms.*						
	P23	Saya berupaya untuk menunjukkan kepada pelajar saya langkah-langkah atau prosedur yang ditetapkan untuk menyampaikan keputusan saintifik kepada kelas. *I am able to model for my students prescribed steps or procedures for communicating scientific results to the class.*						
	P24	Saya berupaya untuk menunjukkan kepada pelajar saya garis panduan yang mesti diikuti apabila berkongsi dan mengkritik penerangan. *I am able to model for my students the guidelines to be followed when sharing and critiquing explanations.*						
	P25	Saya berupaya untuk memudahkan penyiasatan respon terbuka dan berjangka panjang, dalam usaha untuk memberikan peluang kepada pelajar mengumpulkan bukti. *I am able to facilitate open-ended, long-term student investigations in an attempt to provide opportunities for students to gather evidence.*						

	P26	Semasa merancang aktiviti sains, saya lebih suka menggunakan modul kemahiran proses sains yang sedia ada berbanding memikirkannya sendiri. *During planning science activities, I prefer to use the existing science process skills modul rather than think for myself.*						
	P27	Saya berupaya untuk membimbing murid memberikan pelbagai cadangan bagi membentuk penerangan daripada data.. *I am able guide pupils to offer multiple suggestions for creating explanations from data.*						
	P28	Saya berupaya memberikan peluang kepada para pelajar bagi membuat penerangan yang pelbagai melalui pemerhatian yang sama.*I am able to provide students with the opportunity to construct alternative explanations for the same observations.*						
	P29	Saya berupaya menggalakkan para pelajar saya mengkaji sendiri sumber-sumber dalam percubaan untuk menghubung kait penerangan mereka dengan pengetahuan saintifik. *I am able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.*						
	P30	Saya berupaya membimbing para pelajar untuk mewajarkan kaedah dan penerangan mereka berdasarkan bukti yang diperoleh. *I am able to guide the students justify their method and explanation based on their own evidence.*						
	P31	Saya yakin berupaya mendorong pelajar saya melibatkan diri semasa aktiviti inkuiri sains dalam kelas. *I am able to motivate my students to participate during inquiry activities in class*						

	P32	Saya berkeupayaaan untuk menggalakkan para pelajar mengkaji semula dan bertanyakan soalan tentang keputusan hasil kerja pelajar lain. *I encompass the ability to encourage students to review and ask questions about the results of other students' work.*						
	P33	Saya mempunyai keupayaan untuk meramal persoalan saintifik murid melalui *pengalaman bermakna* yang saya kongsikan .*I possess the ability to predict pupils' scientific questions from meaningful common experiences provided .*						
	P34	Saya tidak begitu efektif dalam membuat aktiviti proses saintifik. *I am not very effective in developing scientific process activities.*						
	P35	Saya berupaya memberikan penerangan kepada pelajar saya tentang aktiviti proses saintifik. *I am able to provide my students with explanations in scientific process activities*						
	P36	Saya sukar untuk menerangkan kepada pelajar sebab ujikaji sains berfungsi. *I find it difficult to explain to students why science experiments work*						

ARAHAN : Berikan pendapat anda merujuk kepada kesesuaian item B1 hingga B23 berdasarkan definisi dimensi *outcome belief efficacy (OBE)*.
Sila tandakan (/) pendapat anda dalam skala 1 hingga 5 di ruangan yang disediakan.
Anda digalakkan memberi pandangan dan cadangan terhadap setiap item atau mencadangkan item baru yang sesuai untuk setiap dimensi/ domain.

Domain Belief: Outcome belief efficacy (OBE)

Definisi-Outcome belief efficacy (OBE) dibangunkan untuk mengukur domain kepercayaan terhadap pengaruh kemahiran proses sains (KPS) dalam hasil pengajaran dan pembelajaran sains.
OBE merujuk kepada penilaian guru pelatih terhadap kepercayaan mereka menghasilkan pengajaran sains yang baik menggunakan KPS.
OBE juga merujuk kepada kepercayaan terhadap KPS dapat membantu hasil pembelajaran melalui pendekatan proses sains.
Setiap item dibangunkan mengikut tiga tahap pencapaian melalui hipotesis pencapaian responden berdasarkan PCK taxonomy (Veal & MaKinster 1999)

Item Number	Item	Skala					Comment/ suggestion
		1	2	3	4	5	
		Sangat tidak setuju	Tidak setuju	Tidak pasti	Setuju	Sangat setuju	
B1	Saya percaya bahawa penguasaan KPS mewujudkan peluang untuk memenuhi sifat ingin tahu kanak-kanak apabila mempelajari sains. *I believe that mastery of SPS create oppurtunity to satisfy children curiousity when learning science.*						
B2	Saya percaya bahawa kemahiran penyiasatan diperlukan untuk murid berjaya dalam pembelajaran sains pada peringkat yang lebih tinggi. I believe investigative skills are needed for pupils to success in their higher level science learning						

B3	Pengalaman murid dalam sains berkaitan langsung dengan keberkesanan guru mereka menggunakan pendekatan inkuiri dalam pengajaran sains. The pupils experience in science is directly related to the effectiveness of their teacher in using inquiri approach in teaching science.						
B4	Saya fikir bahawa pengajaran sains dengan menggunakan inkuiri penting kerana ia boleh merangsang kanak-kanak untuk berfikir *I think that teaching science by using inquiry is important because it can stimulate children to think*						
B5	Aktiviti proses sains melalui pendekatan inkuiri boleh memperkayakan pengalaman murid dalam memmuridi sains. Science process activities through inquiry approach can enriching pupils' experience in learning science						
B6	Guru yang mengunakan inkuiri sains dalam strategi pengajaran boleh meningkatkan pencapaian murid dalam sains. Teacher who used science inquiy in teaching strategies can improve student's achievement in science.						
B7	Aktiviti inkuiri sains boleh mendorong murid untuk memmuridi konsep sains.Science inquiry activities can motivate pupils to learn science concept.						
B8	Para pelajar dalam kumpulan berkeupayaan rendah tidak akan berminat untuk mempelajari sains dengan aktiviti sains inkuiri pupils in low ability group will not be interested in learning science with science inquiry activities						

B9	Pengajaran sains dengan menggunakan pendekatan sians inkuiri akan membolehkan konsep sains dapat dipelajari oleh semua murid. By teaching science using scientific process approach, science concepts are accessible for all pupils						
B10	Saya fikir bahawa penggunaan KPS dalam inkuiri sains penting kerana kanak-kanak boleh mempelajari dan memahami konsep sains dengan lebih baik di dalam kelas. *I think that by using SPS in inquiry approach is important because children can learn and understand science concept better in class.*						
B11	Usaha penting seseorang guru menggunakan pendekatan inkuiri dalam mengajar sains akan menghasilkan perubahan kecil dalam pencapaian murid. A teacher s significant effort to use inquiry approach in teach science will produces little change in pupils performance.						
B12	Saya yakin bahawa strategi pendekatan inkuiri sains dapat memperbaiki keberkesanan pengajaran sains dalam kelas. *I am confident that science inquiry approach strategies can improve the effectiveness of teaching science in class*.						
B13	Saya percaya kaedah pengajaran menggunakan inkuiri sains membantu penguasaan KPS*I believe that teaching science by using science inquiry helps to master SPS.*						

B14	Saya yakin bahawa guru yang memahami dan menguasai KPS dapat mengajar sains dengan lancar dan berkesan. *I am confident that teachers who understand and master SPS can teach science smoothly and effectively.*						
B15	Tidak kira seberapa banyak usaha yang saya lakukan, saya tidak akan berjaya mengunakan pendekatan inkuiri sains disebabkan kurang penguasaan KPS. *No matter how much effort I put in, I will not success in using science inquiry approach because of poor ability in SPS.*						
B16	Saya percaya bahawa pendekatan inkuiri sains merupakan strategi pengajaran yang sukar untuk digunakan. *I believe that science inquiry approach is a difficult teaching strategies to use.(-)*						
B17	Saya percaya bahawa pendekatan inkuiri sains ialah cara yang lebih baik untuk mengajar sains. *I believe that science inquiry approach is a better way to teach science.*						
B18	Penggunaan KPS dalam inkuiri sains tidak dapat membantu saya mengajar konsep sains sebaik yang saya kehendaki. The usage of *SPS in science inquiry will not help me to teach science as well as I would like*						
B19	Saya tidak yakin bahawa pendekatan inkuiri sains merupakan strategi yang baik dalam mengajar konsep sains yang rumit. *I am not confident that science inquiry approach are good strategies in teaching difficult science concept.*						

B20	Saya percaya bahawa aktiviti inkuiri sains membantu murid untuk memahami konsep abstrak dalam sains. I believe that science inquiry activities help pupils to understand abstract concepts in science.						
B21	Pengajaran sains melalui pendekatan inkuiri sains akan menarik minat murid terhadap pembelajaran sains.. *Teaching science by using science inquiry approach will attract pupils in learning science.*						
B22	Dalam sains , saya fikir adalah penting bagi kanak-kanak untuk terlibat dalam aktiviti inkuiri sains. *In science, I think it is important for children to participate in inquiry activities.*						
B23	Dalam sains , saya fikir adalah penting bagi kanak-kanak untuk belajar kemahiran menyiasat masalah. *In science, I think it is important for children learn skills to investigate problem.*						

Appendix F 72 items of the SETSIS

Code	Item	Code	Item	Code	Item
K1	I feel my knowledge in SPS is sufficient to guide my students to form a more meaningful understanding of science.	K25	I am confident I have sufficient investigation skills to teach important scientific concepts effectively.	P23	I can guide students to give a consistent explanation on the proofs from the observation of the experiment.
K2	I understand about SPS which is required to guide students towards attaining scientific evidence through scientific investigations.	K26	I can always answer scientific enquiries from students using my understanding of the science process.	P24	Through explanation, I will try to offer opportunities for students to criticize the methods of explanation and investigation.
K3	I understand SPS is a basis to assist students in collecting data to answer their questions.	P1	When an activity of science process is challenging to implement, I will arrange every step in the activity using the investigative approach.	P25	I want to guide the students to self-evaluate the consistency between their explanation and the scientific ideas given to them.
K4	I know how to plan interesting scientific investigations to attract the students to learn science.	P2	When a science process is difficult to explain, I will use the investigative approach to assist the students' understanding.	P26	I plan time to give students a chance to explain their investigations and discovery in class.
K5	I can combine SPS knowledge to the subject's content to encourage students' participation in scientific investigation activities.	P3	I can provide explanation to my students about the activity of the science process.	P27	I am able to guide students to deliver their explanations using clear scientific terminologies.
K6	I have knowledge in constructing scientific ideas to provide guidelines for students to explain their scientific results.	P4	I am able to plan science process activities with provided modules.	P28	I choose to show the best method of teaching science according to the latest curriculum to the headmaster.
K7	I have sufficient skills to create a hypothesis to play the main role in guiding students to identify variables involved in the scientific issues.	P5	I choose to provide data from real experiments as instructional materials rather than data from workbooks.	B1	I think that the use of Science Process Skills (SPS) is important in science investigations because students can learn and understand science concepts better in class.
K8	I have knowledge in guiding students to plan their own problems to solve.	P6	I know how to provide suitable data to be analysed by students.	B2	The use of SPS in science investigations is able to assist the learning of science as desired.
K9	I know how to provide guidance so that students can develop their own issues to solve through scientific investigation.	P7	I try to use one set of data from worksheets to assist students in the analysis process.	B3	In science, I believe it is important for students to have problem solving and investigative skills.
K10	I know to deal with students on the possible relations through explanations.	P8	I am able to guide students to give various suggestions to form explanation from the data.	B4	I am confident that activities involving science processes nurture students to be more interested in science.
K11	I know I possess sufficient SPS knowledge to teach science through scientific investigations to primary school students.	P9	I can provide proof needed to support an investigation by students.	B5	I believe that investigative skills are needed for students to be successful in learning science on higher levels.
K12	I have sufficient knowledge on the content needed to teach science to primary school students.	P10	I am confident of teaching through the approach of scientific investigations regardless whether the content is easy or difficult.	B6	I think that teaching science through investigations is important because it stimulates the students to think.
K13	With the SPS knowledge that I have, I can form scientific inquiries needed for students to make a study.	P11	I can guide students to ask significant scientific questions.	B7	I believe that investigative science activities assist students to understand abstract concepts in science.
K14	I am knowledgeable in implementing experiments in my teachings.	P12	I am confident I can apply science investigation skills in my teaching.	B8	Teaching science through the investigative approach will attract students' attention to learning science.
K15	In absence of scientific apparatus, I am comfortable in using my own knowledge on experiments to adapt my teaching process.	P13	I am able to guide and direct students to appropriate investigations based on the questions that they try to answer.	B9	I believe that low ability students will be more interested and curious in learning science with the investigation activities.
K16	My experimental skills are sufficient to explain the function of experiments to students.	P14	I am able to help students to study in depth on questions given, so that they can experience a great and successful investigation.	B10	In science, I think it is important that students are involved in investigation activities.
K17	I am confident to teach a scientific concept which I understand through experiments.	P15	I believe I can teach science concepts easily using the science investigation approach.	B11	I believe that the science investigation approach is an applicable teaching strategy.
K18	When students struggle with understanding scientific concepts, I am confident my knowledge of SPS is able to assist with their understanding.	P16	In a science investigation, I try to encourage students to study the sources themselves to relate their explanation to their scientific knowledge.	B12	I believe that science investigation is a better method in teaching science.
K19	I am constantly searching for effective SPS methods to teach science.	P17	I believe I can encourage students to get involved during science investigation activities in class.	B13	I think that teachers who employ science investigations as a teaching strategy are able to increase the achievements of students in science.
K20	I understand about measurement and space to help students understand the concept of length using self-measure (i.e arranging paper clips/sticks).	P18	I am fostering students to review and ask questions on other students' results	B14	Teaching science using the investigative approach enables all students to learn science concepts.
K21	I am able to explain my observations with a quantitative statement.	P19	I am able to show my students the guidelines to be followed when sharing and criticizing explanation.	B15	I am confident that this science investigation approach can improve the efficiency of teaching and learning science in class.
K22	I am able to explain my observations in a variety of significant explanation methods.	P20	I can give chances to students to make important decisions in verifying a scientific explanation.	B16	I believe that mastering the SPS will help teachers to teach using science investigation approach.
K23	I know how to use information given to predict a coming observation.	P21	I ask my students to provide steps or procedures when delivering their scientific results to class.	B17	I am confident that teachers who understand and master SPS can teach science smoothly and efficiently.
K24	I am able to impose an enquiry to get students' attention to solve it.	P22	If given opportunity, I will encourage students to give various explanations from the same observation.	B18	I think SPS knowledge is effective in assisting teachers to successfully teach science.

Appendix G Factor Loading using Promax Rotation

Item Label	Loading			Action
	Factor 1	Factor 2	Factor 3	
K11	0.91	0.00	-0.16	Retain in Factor 1
K12	0.81	0.00	-0.12	Retain in Factor 1
K22	0.77	-0.04	0.03	Retain in Factor 1
K21	0.75	0.06	-0.10	Retain in Factor 1
K6	0.75	-0.16	0.09	Retain in Factor 1
K23	0.73	0.05	-0.07	Retain in Factor 1
K1	0.71	0.11	-0.10	Retain in Factor 1
K16	0.70	-0.03	0.05	Retain in Factor 1
K7	0.69	0.08	-0.10	Retain in Factor 1
K13	0.69	-0.06	0.13	Retain in Factor 1
K5	0.68	0.08	0.03	Retain in Factor 1
K14	0.66	0.00	0.11	Retain in Factor 1
K10	0.66	-0.04	0.03	Retain in Factor 1
K18	0.65	0.06	0.08	Retain in Factor 1
K8	0.63	-0.17	0.20	Retain in Factor 1
K2	0.62	0.26	-0.14	Retain in Factor 1
K25	0.62	-0.11	0.24	Retain in Factor 1

K24	0.61	-0.02	0.15	Retain in Factor 1
K26	0.60	-0.06	0.22	Retain in Factor 1
K4	0.60	-0.03	0.12	Retain in Factor 1
K17	0.59	0.14	0.02	Retain in Factor 1
K3	0.56	0.32	-0.14	Retain in Factor 1
P3	0.56	0.12	0.14	Retain in Factor 1
K9	0.53	-0.09	0.30	Retain in Factor 1
K20	0.53	0.04	0.12	Retain in Factor 1
K15	0.49	-0.07	0.29	Retain in Factor 1
P4	0.46	0.17	0.14	Retain in Factor 1
K19	0.45	0.05	0.23	Retain in Factor 1
P9	0.43	0.02	0.34	slightly to significant cross loading (oblimin).Omitted
P15	0.41	0.13	0.31	Retain in Factor 1
B10	-0.18	0.84	0.06	Ratain in Factor 2
B4	0.01	0.82	-0.06	Ratain in Factor 2
B6	0.07	0.82	-0.09	Ratain in Factor 2
B16	0.15	0.80	-0.12	Ratain in Factor 2
B1	0.03	0.79	-0.07	Ratain in Factor 2
B8	0.00	0.78	-0.01	Ratain in Factor 2
B2	0.07	0.76	-0.05	Ratain in Factor 2
B18	0.00	0.75	0.07	Ratain in Factor 2
B3	0.06	0.75	-0.05	Ratain in Factor 2
B5	0.04	0.74	0.02	Ratain in Factor 2
B17	0.08	0.74	-0.08	Ratain in Factor 2
B7	0.03	0.74	0.01	Ratain in Factor 2

B12	-0.08	0.68	0.17	Ratain in Factor 2
B9	0.01	0.68	0.03	Ratain in Factor 2
B13	-0.09	0.64	0.23	Ratain in Factor 2
B15	-0.09	0.62	0.28	Ratain in Factor 2
B14	-0.16	0.60	0.30	Ratain in Factor 2
B11	-0.03	0.39	0.35	cross loading. Omitted
P24	-0.05	-0.02	0.80	Retain in Factor 3
P25	-0.14	0.14	0.74	Retain in Factor 3
P28	0.09	0.05	0.65	Retain in Factor 3
P26	-0.03	0.18	0.64	Retain in Factor 3
P11	0.27	-0.12	0.64	Retain in Factor 3
P19	0.13	-0.06	0.64	Retain in Factor 3
P18	0.13	0.03	0.62	Retain in Factor 3
P23	0.13	0.03	0.62	Retain in Factor 3
P22	0.04	0.14	0.62	Retain in Factor 3
P27	0.14	0.07	0.60	Retain in Factor 3
P20	0.08	0.08	0.59	Retain in Factor 3
P8	0.31	-0.10	0.56	Retain in Factor 3
P10	0.30	-0.09	0.54	Retain in Factor 3
P14	0.24	0.03	0.51	Retain in Factor 3
P21	0.14	0.10	0.51	Retain in Factor 3
P16	0.17	0.05	0.50	Retain in Factor 3
P1	0.29	0.01	0.49	Retain in Factor 3
P12	0.22	0.14	0.49	Retain in Factor 3

P7	0.33	-0.05	0.48	Retain in Factor 3
P6	0.31	-0.04	0.46	Retain in Factor 3
P13	0.33	0.07	0.43	Retain in Factor 3
P2	0.34	0.07	0.36	slightly to significant cross loading(Oblimin).Omitted
P17	0.22	0.22	0.34	Not significant. Omitted
P5	0.28	0.10	0.31	Not significant. Ommited

Appendix H Result of Item Difficulty Measure

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEA CORR.	ITEM
6	1104	324	1.17	0.08	0.96	-0.5	0.95	-0.6	0.67	K6
8	1104	324	1.17	0.08	1.01	0.2	1	0.1	0.66	K8
9	1138	324	0.92	0.09	0.93	-0.9	0.91	-1.2	0.7	K9
30	1141	324	0.9	0.09	1	0.1	1.01	0.2	0.68	P6
34	1143	324	0.89	0.09	0.83	-2.4	0.82	-2.4	0.74	P11
1	1152	323	0.8	0.09	0.96	-0.5	0.96	-0.4	0.65	K1
33	1157	324	0.78	0.09	1.06	0.8	1.06	0.8	0.7	P10
16	1159	324	0.77	0.09	0.98	-0.2	0.99	-0.1	0.67	K16
10	1162	324	0.75	0.09	1.08	1.1	1.1	1.3	0.62	K10
13	1163	323	0.72	0.09	0.88	-1.6	0.89	-1.4	0.71	K13
15	1163	323	0.72	0.09	1.15	1.9	1.13	1.7	0.67	K15
11	1167	324	0.71	0.09	1.03	0.5	1.03	0.4	0.71	K11
25	1179	324	0.62	0.09	0.9	-1.3	0.9	-1.4	0.7	K25
26	1180	324	0.62	0.09	0.89	-1.4	0.89	-1.5	0.71	K26
44	1184	324	0.59	0.09	0.82	-2.5	0.82	-2.4	0.71	P23
31	1188	324	0.56	0.09	0.97	-0.4	1	0.1	0.69	P7
32	1184	323	0.56	0.09	0.89	-1.5	0.88	-1.5	0.73	P8
22	1189	324	0.55	0.09	0.96	-0.4	0.95	-0.6	0.72	K22
5	1191	321	0.44	0.09	0.82	-2.5	0.82	-2.5	0.73	K5
18	1203	324	0.44	0.09	0.89	-1.4	0.91	-1.2	0.72	K18
27	1204	324	0.44	0.09	0.81	-2.6	0.84	-2.2	0.73	P1
37	1204	324	0.44	0.09	0.85	-2.1	0.86	-1.8	0.72	P14

7	1206	324	0.42	0.09	1.07	0.9	1.06	0.8	0.64	K7
4	1210	324	0.39	0.09	1.14	1.7	1.18	2.2	0.65	K4
48	1210	324	0.39	0.09	0.82	-2.5	0.81	-2.6	0.74	P27
36	1213	324	0.37	0.09	0.75	-3.6	0.75	-3.6	0.76	P13
12	1221	324	0.31	0.09	1.09	1.2	1.07	0.9	0.65	K12
45	1225	324	0.28	0.09	1.03	0.4	1	0.1	0.68	P24
46	1226	324	0.27	0.09	0.99	-0.1	0.99	-0.1	0.66	P25
38	1228	324	0.26	0.09	1.02	0.3	1.06	0.7	0.65	P16
35	1229	324	0.25	0.09	0.81	-2.7	0.81	-2.6	0.75	P12
40	1234	324	0.21	0.09	1	0	1.01	0.2	0.66	P19
49	1235	324	0.2	0.09	1.07	1	1.05	0.7	0.72	P28
41	1238	324	0.18	0.09	0.9	-1.4	0.9	-1.3	0.68	P20
19	1241	324	0.16	0.09	1.09	1.1	1.14	1.8	0.67	K19
21	1243	324	0.14	0.09	0.95	-0.6	0.96	-0.5	0.66	K21
14	1248	324	0.1	0.09	1.03	0.4	1	0.1	0.71	K14
24	1245	323	0.09	0.09	1.06	0.8	1.06	0.7	0.68	K24
28	1250	324	0.09	0.09	0.68	-4.7	0.76	-3.4	0.73	P3
47	1250	324	0.09	0.09	0.84	-2.1	0.82	-2.4	0.71	P26
23	1251	324	0.08	0.09	0.98	-0.2	0.97	-0.3	0.66	K23
42	1255	324	0.05	0.09	0.99	-0.1	0.99	-0.1	0.67	P21
20	1258	324	0.02	0.09	1.25	3	1.25	2.9	0.63	K20
39	1260	324	0.01	0.09	0.84	-2.2	0.85	-1.9	0.71	P18
2	1269	324	-0.06	0.09	1.14	1.8	1.15	1.8	0.65	K2
29	1282	324	-0.17	0.09	0.93	-0.9	1.01	0.1	0.68	P4
43	1283	324	-0.17	0.09	0.94	-0.8	0.9	-1.2	0.71	P22
3	1321	323	-0.52	0.09	1.08	1	1.13	1.5	0.64	K3
62	1328	324	-0.55	0.09	1.23	2.7	1.17	1.9	0.61	B14
17	1331	324	-0.57	0.09	0.96	-0.5	0.99	-0.1	0.67	K17
58	1351	324	-0.74	0.09	1.28	3.4	1.26	2.8	0.58	B9

60	1354	324	-0.77	0.09	1.16	2	1.11	1.3	0.61	B12
61	1358	324	-0.81	0.09	1.13	1.6	1.07	0.8	0.62	B13
63	1372	324	-0.93	0.1	0.98	-0.3	0.95	-0.6	0.65	B15
51	1386	324	-1.06	0.1	0.99	-0.1	1.07	0.8	0.61	B2
56	1389	324	-1.09	0.1	1.01	0.2	1.19	1.9	0.6	B7
53	1390	324	-1.1	0.1	1.19	2.3	1.11	1.1	0.6	B4
50	1393	324	-1.13	0.1	1.33	3.8	1.23	2.3	0.58	B1
64	1396	324	-1.16	0.1	0.97	-0.3	0.92	-0.7	0.66	B16
65	1397	324	-1.17	0.1	1.2	2.4	1.28	2.6	0.57	B17
57	1403	324	-1.23	0.1	1.09	1.1	1.11	1.1	0.6	B8
66	1408	324	-1.28	0.1	1.07	0.8	1.03	0.3	0.65	B18
52	1410	324	-1.3	0.1	1.03	0.4	1.02	0.2	0.6	B3
54	1412	324	-1.32	0.1	1.04	0.5	1.01	0.1	0.63	B5
55	1413	324	-1.33	0.1	1.04	0.5	1	0	0.62	B6
59	1422	324	-1.42	0.1	1.32	3.6	1.27	2.3	0.55	B10
MEAN	1256.1	323.9	0	0.09	1	0	1	-0.1		
P.SD	89.1	0.5	0.72	0	0.13	1.7	0.13	1.5		