PHYSICS INSTRUCTIONAL CONTEXT AND LEARNERS' EPISTEMOLOGICAL BELIEFS

LEE WEEN SHIN

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To my beloved family

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ABSTRACT

This study focuses on the physics epistemological beliefs of physics learners in one of the universities located in Malaysia on instruction in physics education. Sophisticated physics epistemological beliefs learners perceive physics knowledge as dynamic, tentative, and evolving with highly interrelated concepts, and are able to see themselves as the knowers who can construct and evaluate knowledge through interaction with others. On the other hand, naive physics epistemological beliefs learners view physics knowledge as fixed and absolute as well as truth and fact accumulating knowledge that is transmitted and received from authorities. Research shows that physics learners adopt different learning strategies according to their physics epistemological beliefs. Learners with sophisticated physics epistemological beliefs tend to use deep learning approach while their counterparts are likely to adopt rote learning strategies. Hypothesis shows that instructional context exerts strong impact on learners' physics epistemological beliefs. However, many research have not provided detailed explanation on how instructional context practices influence learners' epistemological beliefs. Thus, the objectives of this research study are to investigate learners' physics epistemological beliefs towards instructional context and to develop a framework outlining the instructional context that causes sophisticated and naive physics epistemological beliefs. Phenomenological research design was used and the data was collected from four respondents for a semester through interviews and observations. Constant comparative method was used to analyse the collected qualitative data. As a result, a framework with six categories and 36 sub-categories of instructional context was generated which explain the development of learners' physics epistemological beliefs. The framework serves as the basic guideline for physics educators to better design instructional context which will enhance the development of sophisticated physics epistemological beliefs among learners to improve their learning strategies and physics conceptual understanding.

ABSTRAK

Kajian ini memberi tumpuan kepada kepercayaan epistemologi pelajar-pelajar fizik di salah sebuah universiti di Malaysia terhadap cara pengajaran pendidikan fizik. Pelajar dengan kepercayaan epistemologi fizik yang canggih melihat pengetahuan fizik sebagai dinamik, tentatif, dan berkembang dengan konsep-konsep yang saling berkaitan serta menganggap diri mereka berupaya membina dan menilai pengetahuan melalui interaksi dengan orang lain. Sebaliknya, pelajar dengan kepercayaan epistemologi fizik yang naif melihat pengetahuan fizik sebagai tetap dan mutlak, serta terdiri daripada kebenaran dan fakta yang boleh dikumpul dan diterima daripada pihak lain. Penyelidikan menunjukkan bahawa pelajar fizik menggunapakai strategi pembelajaran yang berbeza menurut kepercayaan epistemology mereka. Pelajar dengan kepercayaan epistemology canggih lebih cenderung untuk menggunakan pendekatan pembelajaran yang mendalam manakala golongan naif bercenderung menggunakan strategi pembelajaran yang mengutamakan hafalan. Hipotesis menunjukkan bahawa konteks pengajaran mempunyai kesan yang mendalam terhadap kepercayaan epistemologi pelajar. Walau bagaimanapun, kebanyakan penyelidikan tidak memberi penjelasan terperinci tentang bagaimana kesan ini terjadi. Oleh itu, objektif kajian ini adalah untuk menyiasat kerpercayaan epistemology pelajar fizik terhadap konteks pengajaran serta membangunkan satu kerangka kerja untuk mengenalpasti cara-cara pengajaran yang menyumbang kepada kepercayaan epistemologi yang canggih dan naif. Penyelidikan kualitatif fenomenologi dengan kaedah temu bual dan pemerhatian digunakan untuk mengumpulkan data daripada empat orang pelajar sepanjang satu semester. Kaedah perbandingan berterusan telah digunakan untuk menganalisis data kualitatif. Satu kerangka kerja telah dihasilkan dengan enam kategori dan 36 sub-kategori konteks pengajaran yang menjelaskan pembentukan kepercayaan epistemologi fizik dalam kalangan pelajar. Kerangka kerja ini memberikan satu garis panduan asas bagi pendidik untuk merangka konteks pengajaran yang akan meningkatkan pembangunan kepercayaan epistemologi fizik dalam kalangan pelajar serta memperbaiki strategi pembelajaran dan pemahaman mereka tentang fizik.

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LIST OF ABBREVIATIONS

CLASS	-	Colorado Learning Attitudes about Science Survey
CGPA	-	Cumulative Grade Point Average
DSBQ	-	Domain Specific Beliefs Questionnaire
EBAPS	-	Epistemological Beliefs Assessment for Physical Science
FMCE	-	Force and Motion Conceptual Evaluation
LAL	-	Learning about Learning
MI	-	Modeling Instruction
MPEX	-	Maryland Physics Expectations
PEB	-	Physics Epistemological Beliefs
PET	-	Physics and Everyday Thinking
PbI	-	Physics by Inquiry
PSET	-	Physical Science and Everyday Thinking
SPM	-	Sijil Pelajaran Malaysia
STPM	-	Sijil Tinggi Persekolahan Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Traditionally, three topics are grouped under the study of philosophy, namely knowledge, reality, and value. For philosophers, these three topics are termed as epistemology, metaphysics, and ethics. Epistemology is a philosophical branch which studies the nature, sources, limitations, and validity of knowledge (Velasquez, 2005). According to Pritchard (2006), epistemology or knowledge can be divided into propositional knowledge and ability knowledge. Propositional knowledge refered to knowledge asserted information in sentences or says something in a case while ability knowledge refered to know-how knowledge (Pritchard, 2006). However, only propositional knowledged will be the focus of this study. It is believed that a person's epistemological belief plays an important role in his or her journey of knowledge acquisition. For example, if a physics learner believes that the nature of physics knowledge is about applying physics formula to solve physics problems, his or her knowledge acquiring process maybe different from a learner who believes that physics learning involves relating fundamental concepts to problem solving technique.

As a science subject, physics is developed from the effort of study about the physical environment (Cutnell & Johnson, 1998). The law and theories of physics have contributed so much to human civilization in which it helps to explain how aeroplane flies, why a thousand tonne ship does not sink in the sea, and so on. Physics is also used to predict how nature will behave based on experiments. The use of mathematics has distinguished physics from other science disciplines such as chemistry and biology. However, mathematics is not physics and vice versa; mathematics is used to relate and interconnect physics concepts (Sands, 2004). The falsifiability in science indicates that some physics theories may be able to explain a phenomenon, but not all. As such, we cannot identify any theory as absolute right because it is right within a certain context nor can we prove a theory right, but we can prove it false (Sands, 2004).

In order to produce professional graduates, it is essential to prepare students with the epistemological beliefs of professionals (Biggs & Tang, 2007). Thus, it has now become a common objective among physics educational institutions to educate physics learners to think and act like physicists. Align with this, the major objective of Physics program in Malaysia university is to educate and train learners to become a capable physicist and to contribute their work force in the field of research and industrial development institutions (FS, 2010). For instance, physicists have learnt from experiments that physics is not simple; certain knowledge and process of physics knowing have to be associated with evidence justification and low authorities dependency (Adams et al., 2007; Hammer, 1994; Redish, Saul, & Steinberg, 1998; Stathopoulou & Vasniadou, 2007a).

Furthemore, the significant relationship discovered between learners' epistemological beliefs and conceptual learning have motivated educators to instil appropriate physics epistemological beliefs within their learners (Buehl & Alexander, 2006; Hammer, 1994; Hofer, 2000; Sahin, 2009; Stathopoulou & Vosniadou, 2007a). Thus, various instruction practices have been introduced to improve learners' physics epistemological beliefs, learning strategies, and conceptual understanding. From past research results, it has been found that instructional practices that address physics epistemology either implicitly or explicitly are able to improve learners' physics epistemological beliefs (Elby 2000; Otero & Gray, 2008; Brewe et al., 2009; Lindsey et al., 2012) while traditional lectures are less effective (Redish et al. 1997).

1.2 Background of the Problem

Although physics is a familiar subject to most learners who take science or engineering courses in universities, many perceive physics as the toughest subject (Sands, 2004) because of the numerous theories, laws, and formulae (Ornek et al., 2008). According to research, there are learners who believe that physics consists of symbols, purely algorithm, absolute truth, and unrelated pieces of information. This type of learners also sees the learning and justification of physics as highly depended on authorities such as lecturers and books. Therefore, they often neglect themselves as the knower or learner who have the abilities to construct physics knowledge (Hammer, 1994; Redish et al., 1998; Elby, 1999; Elby, 2001; Lising & Elby, 2005; Adam et al., 2006; Gray et al., 2008).

On the other hand, learners tend to adopt different learning strategies in physics learning, though these learning strategies are attached from the beliefs a learner holds about knowledge and knowing (Lising & Elby, 2005; Dahl et al., 2005; Richter & Schmid, 2009). For learners who believe that physics knowledge is about symbols and is purely algorithms, they tend to learn and solve physics problems by manipulating mathematics equations as well as plug and chug algorithm to appropriate formula. As for learners who believe that physics knowledge is made up of concepts which are represented by symbols and algorithms, they prefer learning and solving physics problems through conceptual understanding (Hammer, 1994). In addition, for those who believe that physics is about absolute truth and unrelated pieces of information, they see physics as a subject that requires intense memorization instead of a deep understanding on key basic ideas (Elby, 2001).

1.2.1 Physics Epistemological Beliefs and Physics Instruction

As mentioned earlier in this chapter, physics is a subject of an academic domain that has been developed from the study of the physical world through scientific processes. Physics is also known as a set of concepts and ideas that can be segregated into hierarchies, but are linked by common ideas (Sands, 2004). Usually, physics is taught in schools as a series of discrete topics such as motion, heat, and light, and so on. In universities, physics is divided into mechanics, thermodynamics, optics, and etc. Learners' beliefs on knowledge may largely be affected by the distinction of the subject taught in schools and universities since formal education has major influence on learners' epistemological beliefs (Buehl et al., 2002). Limited discussion on the interrelationship between physics concepts may lead learners to regard physics as a set of weakly connected collection of academic domain knowledge (Hammer, 1994).

According to Sand (2004), mathematics is the language used to describe, relate, and interconnect physics concepts. On the contrary, some studies have shown that not all learners are able to grasp the deeper concepts that are presented in symbols and formulas (Redish et al., 1998). Many see physics concepts as independent from mathematics and tend to solve physics problem using formula, algebra manipulation, and arithmetic only instead of understand the conceptualization of symbols and formula to understand and explain the relative problems in qualitative terms (Hammer, 1994). Therefore, it is clear that teaching of solely problem solving steps and recipes during schools and universities may not necessary encourage the development of physics epistemological beliefs among learners (Sin, 2014).

Learning physics is an active process where efforts are needed to gain deeper and conceptual understanding to nurture meaningful physics learning. Laboratory activities conducted by learners in schools and univertisities that emphasize on a single and common conclusion do not value effort and engage learners in actively construct their own knowledge (Sin, 2014). In addition, we are nurtured and taught by parents, teachers, elders, and etc. who seem to impose innate habits on us to follow and accept the information from authorities without questining and doubt. In addition to this, there is also the digital age where learners are capable of completing homework, assignments, and coursework merely by collecting and gathering information from internet without the need to fully understand the subject matter.

The factual nature of the teaching approach and the assessment methods used such as written tests and assignments has led to superficial understanding rather than meaningful learning (Elby, 1999) where discussion on the nature of the physics knowledge is limited. In addition, such teaching approach contradicts with the epistemological belief which classifies knowledge as subjective and that there is no simply right or wrong physics theory, but theories that are suitable to answer certain context and yet may change due to advance development.

In regard to traditional lecture, Hammer (1994) found that such method is less effective in developing sophisticated physics epistemological beliefs compared to workshop instruction. Elby (2001) also discovered that epistemological focus instruction practices are able to enhance learners' physics epistemological beliefs better. In addition, Otera and Gray (2008), Brewe et al. (2009), and Lindsey et al. (2012) discovered that both PET (Physics and Everyday Thinking) and PSET (Physical Science and Everyday Thinking) as well as MI (Modelling Instruction) and PbI (Physics by Inquiry) instructional practices are effective in developing sophisticated physics epistemological beliefs among learners.

Although various instructional context have been designed to help learners in developing physics conceptual understanding coupled with sophisticated Physics epistemological beliefs, most instruction practices focus on singular and accepted version of physics knowledge (Sin, 2014). For example, laboratories work and report are always guided with a set of procedures and expected results, thus learners are only involved in verifying that their own experimental results correspond to the expected outcome, not in constructing their own understanding on the concepts learnt.

Besides that, educators often try to design and frame learning objectives based on the important information of the subject as well as effective teaching and learning theories with necessary learning material to help learners in acquiring knowledge. However, while due negligence on learners' epistemological beliefs in the formulation of instruction, educators are discouraged from becoming effective in the teaching and learning process (Murphy & Alexander, 2006). In fact, many have the main control over the teaching context, and this actually promotes dependency epistemological beliefs among learners.

Furthermore, it has been repeatedly emphasized that instructional practices should be aligned with proper assessment strategies (Dick & Casey, 1996; Bloom et al., 1971). Similarly, Biggs (1996) has stated that the key components of teaching and learning are the instructional and assessment practices and they should be aligned with the intended learning objectives. These, on the other hand, have to adopt higher cognitive learning so that learners can acquire such skill after the completion of their study. Ironically, the current widespread misalignment between learning objectives and instructional and assessment practices does not promote this. Also, if learners were exposed to practices that promote higher order cognitive learning, but are assessed with lower order cognitive assessments, then it is expected that the learners' cognitive level will be negatively influenced as well to fit in the expected mode of assessment (Frederiksen & Collins, 1989).

In addition, Knight (2002) has highlighted 25 reasons of the insufficient use of summative assessment in higher education. One of his concerns is the epistemological assumption behind the measurement. Learners who are exposed to instruction practices that emphasize on sophisticated physics epistemological beliefs development but are required to answer multiple choice examination with a particular true answer or examination that assess the retrieval of information and/or purely mathematics calculation will cause conflicts between the nature of physics knowledge and knowing (Palmer & Marra, 2008).

According to Shay (2008), assessment is essential in supporting teaching and learning, such as provide support for future learning, information about performance, qualification selective information, and information for stakeholders in judging the effectiveness of teaching and learning system (Hornby, 2003). Learners learn what they think will be assessed, which means the kind of assessment drives how they learn (Brown & Knight, 1994). If they were only required to recall, apply, describe, and compare, then they will not unable to effectively engage themselves in learning.

Over concentration or dependence on assessment and guidance does not warrant beneficial learning experience.

Last but not least, the message that highlights the importance of assessment results only is believed to have direct influence on learners' epistemological beliefs. The examination-oriented teaching and learning practices have, sadly, shifted the learning objective from conceptual understanding to merely passing examinations with flying colours (Sharifah Maimunah, 2003). Tests that emphasize on speed, efficiency, persistence, and memory retention are, frankly speaking, not recommended for science learning (Confrey, 2006)because it hinders learners' critical and reflective thinking and gives a false impression that the ability to conquer test items is all that required to master physics knowledge.

In short, factual teaching and learning process is a common method for acquiring physics knowledge during the early years of physics learning. More often than not, physics is taught as a series of discrete topics such as motion, heat, optics, thermodynamics, and so on in schools and universities. In these early years of physics learning, learners are rewarded for their ability to memorize the learning content and manipulating mathematical equations. With these skills, they can obtain similar results irrespective of their ability to be self-reliant and justify the knowledge (Elby, 1999). Such nurturing of factual and discrete physics teaching and learning as well as the assessment methods that reward rote learning have, in fact, misshaped many learners' epistemological beliefs on physics knowledge. This has caused learners to see physics as a factual knowledge domain built up of pure mathematics manipulations together with discrete and unrelated ideas that does not require self-reliance and justification. Therefore, it can be said that the existing teaching method has produced learners who enter universities with high certainty, high simplicity, and low justification in regard to physics epistemological beliefs (Hammer, 1994; Redish et al., 1998; Buehl et al., 2002; Sin, 2014). Consequently, such tencency can lead learners to adopt surface learning strategy, perceiving learning was solely accumulating factual knowledge from authorities, and resulting in poor academic performance (Bing & Redish, 2012; Elby, 2001; Hammer, 1994; Habsah Ismail et al., 2013; Richter & Schmid, 2010; Schommer-Aikins, 2008; Stathopoulou & Vosniadou, 2007b).

1.2.2 Social Constructivist Epistemological Beliefs

In order to understand how learners' physics epistemological beliefs were constructed, social constructivist framework suggested that learners' epistemological beliefs are formed through social interactions (Brownlee & Berthelsen, 2008). Epistemological beliefs influence is in turn dependent on learning contexts, which include instruction practices (Palmer & Marra, 2008). This means that learners attend to knowledge and learning with certain existing epistemological beliefs which are then influenced by the learning contexts and calibrated with the learning approaches.Study on social culture learning has demonstrated that, to understand a person's social culture learning, his or her intellectual development has to be understood beforehand (Slavin, 2003).

Moreover, constructivists believe that, theoretically, a learner constructs his or her own knowledge based on his or her previous experiences and social interaction with others. According to Sackney and Mergel (2007), the constructivist theory has made five claims, which are: (1) there is no absolutely true and objective sense to understand the world (certainty of knowledge); (2) knowledge is continuously evolving; (3) prior knowledge has effect on a new learning experience because of the interconnection between information (simplicity of knowledge); (4) learning is an active process where knowledge is constructed rather than passively received (source of knowledge); and (5) knowledge is justified through continuous reflection and resolution of divergence (justification of knowledge). Thus, with consideration on the social and cultural perspectives in knowledge creation, social constructivist believes that learning occurs via the construction of meaning in social interaction (Provenzo, 2009).

Published works (Perry, 1970; Belenky et al., 1986; Kuhn, 1991; Baxter Magolda, 1992; King and Kitchener, 1994) which have focused on the development of epistemological beliefs revealed that changes in epistemological belief begin from naïve and progresses to dualistic, sophisticated, and finally relativist (see section 2.2). A learning experience kicks start when a learner receives knowledge to construct knowledge from absolute knowing to contextual knowing. A learner's epistemological belief development can be summarized into a process model with four components, i.e., (1) what triggers epistemic doubt; (2) the experience of epistemic doubt; (3) the resolution of epistemic doubt; and (4) the result of doubt (Bendixen, 2002). The exposure to different beliefs which are not corresponded with learners' pre-epistemological beliefs will trigger the epistemological doubt within learners. Subsequently, learners will experienced the epistemological doubt, learners will feel confuse, unclear about the beliefs they hold. Followed that, learners will seek ways to resolve the doubt whether to develop new, better beliefs or to reaffirmed and strengthened of former beliefs. According to Bendixen (2002), prior epistemological belief can be disintegrated because of the people and experiences, but college is an important factor that triggers epistemic doubt and social interaction is important in the resolution of epistemic doubt.

Furthermore, it has also been proposed that domain specific epistemological beliefs are more dependent on one's academic life where domain specific epistemology beliefs are constructed socially and bounded by classroom instructional context (Muis et al., 2006). Thus, this bounds the learning experience strongly to the domain (Palmer & Marra, 2008).

There are assumptions which stated that learners hold domain general epistemological beliefs equally across all academic domains, i.e., if knowledge is certain, all the knowledge in science, history, social science and etc. are certain. However, as suggested by Schommer (2004), learners' epistemological beliefs are multidimensional and may not develop in synchronised mode. An example is that learners may hold high certainty beliefs in mathematics knowledge while low certainty in social science subjects.

In order to avoid falling into the false dichotomy of domain specificity and domain generality, it is important to understand that the idea of domain specificity and generality is not for separating the belief, but to understand the development of the beliefs. Some academicians view both domain general and domain specific aspects as parts of epistemological beliefs (Limon, 2006). They are intricately connected to each other (Hofer, 2006) while domain specific beliefs are developed from more general beliefs (Buehl & Alexander, 2006).

Such strong interconnection has also been found by Valanides and Angeli (2005) in their study on the relation between teaching approach and learners' epistemological beliefs. The result has been further supported by Kienhues et al. (2008) who suggested that different instructional interventions have significant effect on learners' academic domain epistemological beliefs. Learners' epistemological beliefs are also aligned with specific epistemological assumptions that have been embedded in the pedagogical activities of the domain. A change in learner behavior is associated with behaviorism pedagogy, though process changes as the reflection of behavior change for cognitivism pedagogy and construction of knowledge is the expected result from constructivism pedagogy (Sackney & Mergel, 2007). Besides that, as stated by Palmer and Marra (2008), the ecology model of personal epistemology has also identified that assessment exerts strong influences on the development of learners' epistemological beliefs.

To conclude, it is undeniable that the instructional context influences learners' epistemological beliefs and learning experience in physics knowledge and knowing. Continuous exposure to a specific theory, law, calculation, and factual knowledge can make the learners to become more familiar with the content, but it may cause them to believe that the knowledge is absolute (Bromme et al., 2008) when the related assignments or examinations reward rote learning, not learning that promotes deep understanding (Elby, 1999). It has become clear that instructional practices exert influences on learners' physics epistemological beliefs (Bendixen, 2002; Kienhues et al., 2008; Muis et al., 2006; Palmer & Marra, 2008; Valanides & Angeli, 2005; Buehl, & Alexander, 2006; Hammer, 1994; Hofer, 2000; Sahin, 2010; Stathopoulou & Vosniadou, 2007a; Brewe et al., 2008; Elby, 2001; Lindsey et al., 2012; Otero & Gray, 2008). However, limited explanations have been provided on how learners think about instruction and its effects on learners' physics epistemological beliefs coupled with the key elements of instruction practices that influence their beliefs. Thus, in order to utilize learners' epistemological beliefs as a stimulus to improve learners' physics conceptual understanding, an important aspect must be first revealed – learners' beliefs on instruction practices and its effects on their physics learning. In other words, by revealing how instruction practices influence physics epistemological beliefs, it helps educators to design better instructional and learning experience for students.

1.3 Problem Statement

According to research, learners with naïve physics epistemological beliefs tend to oversimplify and make improper and absolute conclusions about knowledge; seek early foreclosure or hinder knowledge relativity and reasoning; and perform poorly in school achievement (Lising & Elby, 2005; Schommer, 1990; Stathopoulou & Vosniadou, 2007a, 2007b; Trautwein & Ludtke, 2007). In addition, they demonstrate higher possibility of demonstrating surface learning approaches, rote learning, memorization of facts, and authority dependency during learning (Bing & Redish, 2012; Elby, 2001; Hammer, 1994; Habsah Ismail., 2013; Richter & Schmid, 2010; Schommer-Aikins, 2008; Stathopoulou & Vosniadou, 2007b). On the other hand, studies have shown that learners with sophisticated physics epistemological beliefs or have undergone epistemological beliefs development perform better in conceptual understanding tests (Buehl & Alexander, 2006; Hammer, 1994; Hofer, 2000; Sahin, 2009; Stathopoulou & Vosniadou, 2007a). Thus, improvements in learners' epistemological beliefs are important to develop learners' conceptual understanding and learning.

Learner's epistemological beliefs, especially academic domain epistemological beliefs, are influenced strongly by instructional and classroom context (Bendixen, 2002; Muis et al., 2006; Palmer & Marra, 2008; Valanides & Angeli, 2005; Kienhues et al., 2008). Furthermore, as mentioned in the social constructivist framework, learners construct their own epistemological beliefs through their unique and complex experiences within classroom learning (Brownlee

& Berthelsen, 2008; Provenzo, 2009). However, limited studies have been carried out to identify how learners believe in the instructional context and its influences on their physics epistemological beliefs. Also, it has not been made clear how a particular instructional context encourages or discourages the development of learners' physics epistemological beliefs and their learning strategies. Hence, the purpose of this study is to understand how current university physics instruction practices influence learners' physics epistemological beliefs from the learners' perspective.

1.4 Research Objectives

The main goal of this study is to investigate the pertinent issue on learner's physics epistemological beliefs associated with their development. This research has the following objectives:

i. To investigate university physics learners' epistemological beliefs towards current university physics instructional context.
ii. To investigate how instructional context encourages sophisticated physics epistemological beliefs.
iii. To investigate how instructional context discourages sophisticated physics epistemological beliefs.
iv. To develop a framework outlining encouraging and discouraging instructional context in sophisticated physics epistemological beliefs development.

1.5 Research Questions

Specifically, this research sought to answer the following questions;

i. How does physics instructional context influence learners' physics epistemological beliefs?
ii. What kind of physics instructional context encourages the development of sophisticated physics epistemological beliefs?
iii. What kind of physics instructional context discourages the development of sophisticated physics epistemological beliefs?
iv. What kind of framework outlines encouraging and discouraging instructional context in sophisticated physics epistemological beliefs development?

1.6 Rationale of the Study

As mentioned in the selected university physics courses' educational objectives, these courses have been designed to groom physics undergraduates as physicists equipped with problem solving and critical thinking skills and the ability to manage their own learning (FS, 2010). Thus, they are expected to have epistemological beliefs like physicists. In order to achieve the objectives, instruction practices such as lectures, tutorials, laboratories work and reporting, active learning, problem based learning, simulation and computer based learning, presentation assignment, examination, test and quiz have been introduced. Educators hope and presume from research result that the instruction practices are able to help and assess learners' conceptual understanding, though it has also been said that constructive learning experiences equip learners with sophisticated physics epistemological beliefs.

However, it is usually designed from the educators' perspective or from results of previously successful instructional context that has developed learners' physics epistemological beliefs and conceptual understanding (Sin, 2014). Limited studies have detailed out how particular instruction within an instructional context can influence learners' physics epistemological beliefs from the learners' perspective. For example, what are the activities in a traditional lecture that is actually not beneficial for learners to develop their physics epistemological beliefs? Thus, this further investigation is needed to understand how learners believe that certain instructional context can develop their physics epistemological beliefs and their learning experience.

Besides that, most studies in the field of physics epistemological beliefs and instruction interventions have only focussed on the result quantitatively (Redish et al., 1998; Adam et al., 2006; Otero & Gray, 2008; Brewe et al., 2009; Sahin, 2010; Gok, 2012; Lindsey et al., 2012). Although the significant and generalizable result motivated educators to devote more effort in developing sophisticated physics epistemological beliefs among learners, the capability in providing alternative explanation on how those interventions in influencing learners' physics epistemological beliefs is limited. Educators should understand how instruction interventions influence the development of learners' physics epistemological beliefs instead of duplicate those instruction and presumed similar result. Furthermore, this study also intended to help educators to reflect and improve current instruction practices in university physics education. This shall assist them in designing better instruction and learning experience.

1.7 Research Framework

Social constructivist epistemological beliefs served as the fundamental guideline for the development of this research. According to the concepts of social constructivist epistemological beliefs, learners' beliefs are constructed through social interaction within a social context (Brownlee & Berthelsen, 2008). Further into the social constructivist epistemological beliefs, it is believed that academic domain epistemological beliefs are primarily impacted by the academic domain context (Muis et al., 2006; Palmer & Marra, 2008; Buehl & Alexander, 2006; Brownlee & Berthelsen, 2008) (Figure 1.1). As for this study, it means that the physics classroom (the context) exerts profound direct influences on learners' physics epistemological beliefs and learning experience. The social interaction between learners and this physics classroom facilitate the development of their beliefs on physics knowledge and knowing. However, this also calls for the management of different aspects of this classroom, such as the physical space, the value creation, the classroom management, and so on. In this study, the focus is on learners' beliefs towards their physics instructional context in terms of their instructors, themselves, the content (physics), and the instructional activities pertaining to teaching, learning and motivation (Turner & Meyer, 2000).

Referring to Figure 1.1, Bendixen's (2002) process model, which is based on the development of epistemological beliefs and cognitive equilibration, has also suggested that social interaction plays an important role. Hence, in order for learners' epistemological beliefs to be changed or developed, the cognitive equilibration suggested by Piaget (1977) has been taken into account in this study where changes are expected to progress from one equilibrium stage to another. Such equilibrium is achieved after a learner feels that his or her own beliefs have become imbalance with existing beliefs and then attempts to attain equilibrium again through new experiences gained through social interactions. To date, Bendixen's process model is the only present model that can explain changes in learners' epistemological beliefs change. More studies need to be conducted especially on the effects and boundaries of learners' epistemological changes to complete the picture. Notwithstanding that, the communication path of epistemological beliefs has been postulated as being done in a classroom instructional context and has profound influence on triggering learners' epistemological beliefs development (Hofer & Pintrich, 1997; Bendixen, 2002).

On the other hand, numerous studies have attempted to identify the beliefs hold by learners toward physics knowledge and knowing (Hammer, 1994; Hofer & Pintrich, 1997; Redish et al., 1998; Adam et al., 2007). In 1994, Hammer had identified physics epistemological beliefs into beliefs about the structure and content of physics knowledge and the beliefs about physics learning. Based on Hammer's work, Redish et al. (1998) and Adam et al. (2007) had developed instruments to probe learners' physics epistemological beliefs, namely Maryland Physics

Expectations (MPEX) and Colorado Learning Attitudes about Science Survey (CLASS). Notwithstanding, the core dimensions suggested by Hofer & Pintrich (1997) on epistemological beliefs, which are simplicity of knowledge, certainty of knowledge, source of knowledge and justification of knowing had also being used by researcher in instrument development to investigate learners' physics epistemological beliefs. However, the instruments developed were identified to possessed limited capability in explaining how learners' physics epistemological beliefs were cultivated.

Although the instruments were disadvantage in providing alternative explanation on how learners' physics epistemological beliefs developed, it had been used widely by researchers to identify the significance of instruction interventions in fostering physics epistemological beliefs among learners (Otero & Gray, 2008; Brewe et al., 2009; Sahin, 2010; Gok, 2012; Lindsey et al., 2012). Results from instruction interventions showed learners' physics epistemological beliefs were improved. Again, the main weakness of these studies is the failure to address how instruction influence the development of learners' physics epistemological beliefs.

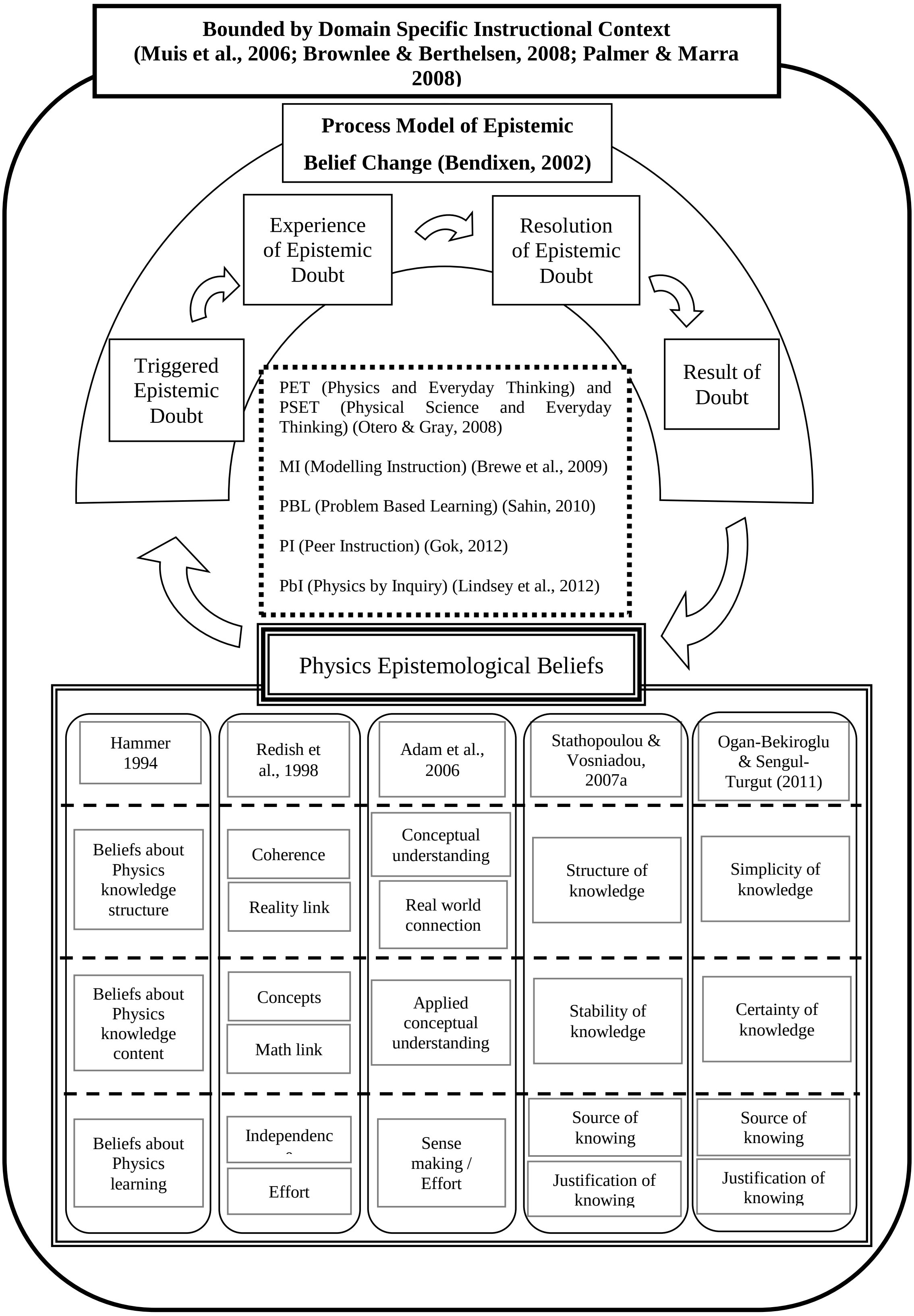

Figure 1.1: Theoretical framework

In order to solve the issues faced by educators, the fundamental aspects such as how learners believe that certain instructional context can develop their physics epistemological beliefs and their learning experience must be retrieved. This therefore has brought to the development of the framework shown in Figure 1.2. The framework proposed that learners' beliefs about physics knowledge and knowing are influenced by the instructional context. Also, the beliefs held by learners towards physics instructional context exert sufficient impact on their physics epistemological beliefs and learning experience. It should be emphasized that the framework is bounded to physics classrooms only.

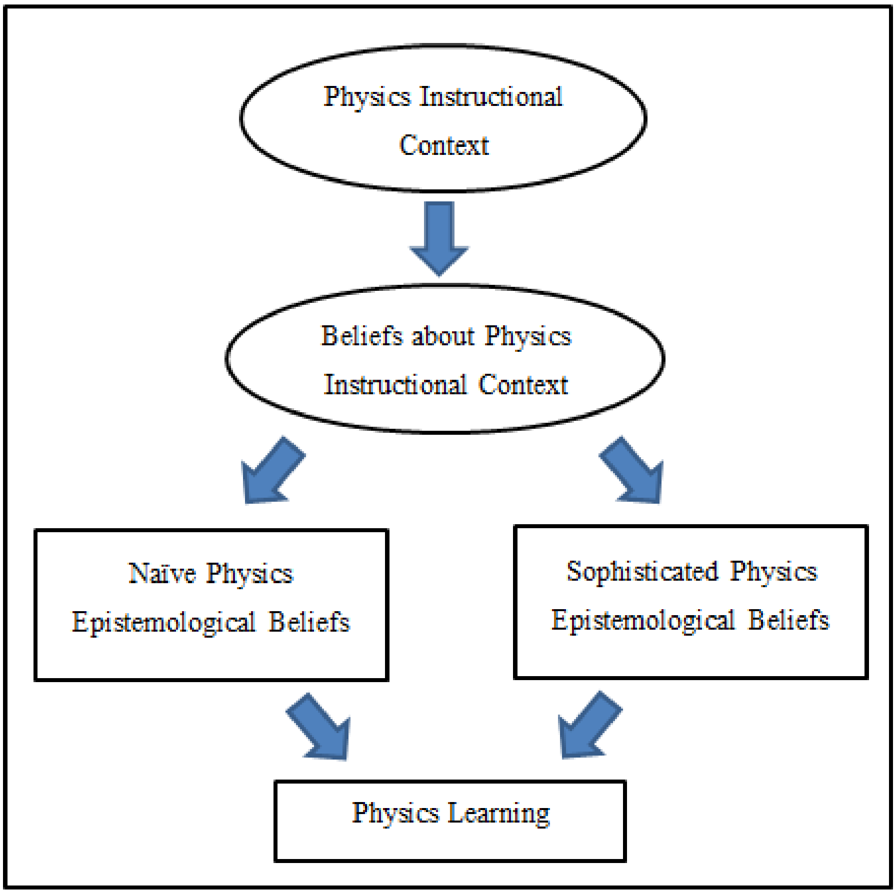

Figure 1.2: An overview framework relating the aspects in this study

1.8 Operational Definition of Terms

To date, conflicts still exist in defining terms such as belief, domain, knowledge, and knowing. Nevertheless, an effort has been made in standardizing these terms as presented below.

1.8.1 Beliefs of Physics Instructional Context

In this study, beliefs of physics instructional context refer to the beliefs learners held on physics instructional context (physics instructors, physics learners and physics instructional activities on teaching, learning and motivation) in influencing their physics epistemological beliefs and physics learning.

1.8.2 Physics Epistemological Beliefs

Physics epistemological beliefs imply the beliefs that individual hold about physics knowledge and physics knowing (Hofer & Pintrich, 1997).

1.8.3 Sophisticated Physics Epistemological Beliefs

Sophisticated physics epistemological beliefs imply that the beliefs held by individual on physics knowledge and physics knowing are on par with that of a physicist or physics expert (Redish et al., 1998; Adam et al., 2006) and the individual has acquired supporting productive learning habits (Elby, 2001). Physics epistemological beliefs sophisticated believer regards physics knowledge as being related to daily life application, are tentative, evolving, and hierarchical interrelated concepts, and mathematics symbols are used to represent the underlying concepts in a convenient way. They also regard physics knowing and learning as being related related to taking own responsibilities in justifying and making use of information available to construct own understanding and focus on conceptual understanding (Hofer & Pintrich, 1997; Redish et al., 1998; Elby, 2001; Sands, 2004; Adam et al., 2006).

1.8.4 Naïve Physics Epistemological Beliefs

Naïve Physics epistemological beliefs imply that the beliefs held by individual on physics knowledge and knowing are not on par with physicists' or physics experts' view (Adam et al., 2006). Such individual believes that physics has isolated and absolute truth facts and the mathematical symbols are not applicable in daily life. Their knowing and learning of physics are highly dependent on authorities, formulas manipulation, facts memorization, and they make menial effort in making use or making sense of information available (Hofer & Pintrich, 1997; Redish et al., 1998; Elby, 1999; Adam et al., 2006) .

1.8.5 Instructional Practice

Instructional practice implies the activity of teaching and learning undertaking to maximize the engagement of learners in activities designed to achieve the intended learning outcome (Biggs, 1996).

1.8.6 Assessment Practice

Assessment practice implies the activity of evaluating learners' performance to see what has been learned in the particular body of knowledge which has been the subject of instruction (Biggs & Telfer, 1987; Biggs, 1995).

1.8.7 Certainty of Knowledge

Certainty of knowledge implies the degree to which one sees knowledge as fixed and absolute or more dynamic, tentative, and evolving (Hofer & Pintrich, 1997).

1.8.8 Simplicity of Knowledge

Simplicity of knowledge implies the degree to which one sees knowledge as an accumulation of facts or as highly interrelated concepts (Hofer & Pintrich, 1997).

1.8.9 Source of Knowledge

Source of knowledge implies the degree to which one sees knowledge as being originated not from oneself, but from external authority and has been transmitted to oneself. This also includes having an evolving conception of self as the knower who is able to construct knowledge while interacting with others (Hofer & Pintrich, 1997).

1.8.10 Justification for Knowing

Justification of knowing implies the degree to which one evaluates knowledge claims, including the use of evidence. Under such circumstances, one is able to make use of authorities and expertise of experts as well as evaluate the experts (Hofer & Pintrich, 1997).

1.8.11 Instructional Context

Physics instructional context involves in this study refers to the physics instructors, physics learners, and physics instructional activities on teaching, learning and motivation (Turner & Meyer, 2000).

1.9 Summary

This chapter has explained the development of epistemology among learners. The uni-dimensional developmental model suggests that learner's epistemological beliefs develop through a continuum of stages and then evolves into a multi-dimensional model where the epistemological beliefs become more or less independent. It is believed that learner's physics understanding is related to learner's epistemological belief. Learners with sophisticated physics epistemological belief have higher order cognitive learning approach while learning physics and are able to better understand the knowledge. Learners with naïve physics epistemological beliefs tend to learn physics by memorizing fact and purely manipulating algorithm in solving physics problem; they disregard the interrelated information between each physics concept. Hence, they often have very surface understanding about physics knowledge.

The social constructivist framework believes that a learner's epistemological belief is constructed through the interaction with others in social contexts. Instructional context exerts strong effect on forming learner's epistemological belief, especially domain specific epistemological belief. Thus, it is important to understand the influences instructional context have on the development of learner's physics epistemological belief. By understanding it, it will help educators to include a broader set of learning objectives and learning outcomes into the design of instructional context which will customarily enhance learner's physics epistemological beliefs and physics understanding. A detailed literature review about the impact of instructional context on learner's physics epistemological beliefs shall be presented in Chapter 2.

REFERENCES

Abedalaziz, N., & Akmar , S. N. (2012). Epistemology Beliefs about Mathematical Problem Solving among Malaysian Students. *OIDA International Journal of Sustainable Development*, 5(1), 59 - 74.

Adams, W., Perkins, K., Podolefsky, N., Dubson, M., Finkelstein, N., & Wieman, C. (2006). New Instrument for Measuring Student Beliefs about Physics and Learning Physics : The Colorado Learning Attitudes about Science Survey. *Physics Education Research* (2), 1 - 14.

Baxter Magolda, M. B. (1992). *Knowing and Reasoning in College : Gender-related patterns in students' intellectual development*. San Francisco: Jossey Bass.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing : The development of self, voice and mind*. New York: Basic Books.

Bendixen, L. D. (2002). A Process Model of Epistemic Belief Change. In B. K. Hofer, & P. R. Pintrich, *Personal Epistemology : The Psychology of Beliefs About Knowledge and Knowing* (pp. 191 - 208). New Jersey: Lawrence Erlbaum Associates, Inc.

Biggs, J. (1995). Assessment of Learning. In J. Biggs, & D. Watkins, *Classroom Learning : Educational Psychology for the Asian Teacher* (pp. 167 - 194). Singapore: Prentice Hall.

Biggs, J. (1996). Enhancing Teaching Through Constructive Alignment. *Higher Education*, 32(2), 347 - 364.

Biggs, J., & Tang, C. (2007). *Teaching for Quality Learning at University*. England: McGraw Hill.

Biggs, J., & Telfer, R. (1987). *The Process of Learning*. Australia: Prentice Hall.

Bloom, B. S., Hastings, J. T., & Madaus, G. F. (1971). *Handbook of Formative and Summative Evaluation of Student Learning*. United State of America: McGraw Hill.

Brewe, E., Kramer, L., & O'Brian, G. (2009). Modeling instruction: Positive attitudinal shifts in introductory physics measured with CLASS. *Physical Review Special Topics - Physics Education Research*, 5(1), 1 - 5.

Bromme, R., Kienhues, D., & Stahl, E. (2008). Knowledge and Epistemological Beliefs : An Intimate but Complicate Relationship. In M. S. Khine, *Knowing, Knowledge and Beliefs : Epistemological Studies across Diverse Cultures* (pp. 423 - 441). Dordrecht: Springer.

Brown, S., & Knight, P. (1994). *Assessing learners in higher education*. London: Kogan Page.

Brownlee, J., & Berthelsen, D. (2008). Developing Relational Epistemology Through Relational Pedagogy : New Ways of Thinking About Personal Epistemology in Teacher Education. In M. S. Khine, *Knowing, Knowledge and Beliefs : Epistemological Studies across Diverse Cultures* (pp. 405 - 422). Dordrecht: Springer.

Buehl, M. M., & Alexander, P. A. (2006). Examining the Dual Nature of Epistemological Beliefs. *International Journal of Educational Research*, 45, 28 - 42.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about Schooled Knowledge : Domain Specific or Domain General. *Contemporary Educational Psychology*, 27, 415 - 449.

Campbell, J., Smith, D., Boulton-Lewis, G., Brownlee, J., Burnett, P. C., Carrington, S., et al. (2001). Students' Perceptions of Teaching and Learning: The influence of students' approaches to learning and teachers' approaches to teaching. *Teachers and Teaching: Theory and Practice*, 2(7), 173-187.

Confrey, J. (2006). The Evolution of Design Studies as Methodology. In R. K. Sawyer, *The Cambrige Handbook of the Learning Sciences* (pp. 135 - 152). United States of America: Cambridge University Press.

Cousin, G. (2009). *Research Learning in Higher Education : An introduction to contemporary methods and approaches*. New York: Routledge.

Creswell, J. W. (2009). *Research Design : Qualitative, Quantitative, and Mixed Methods Approaches*. United States of America: Sage.

Creswell, J. W. (2013). *Qualitative Inquiry & Research Design : Choosing Among Five Approaches*. USA: Sage Publication, Inc.

Cutnell, J. D., & Johnson, K. W. (1998). *Physics*. USA: John Wiley & Sons, Inc.

Dahl, T. I., Bals, M., & Turi, A. L. (2005). Are Students' Beliefs About Knowledge and Learning Associated with Their Reported Use of Learning Strategies? *British Journal of Educational Psychology*, 75, 257 - 273.

Dart, B. C., Burnett, P. C., Purdia, N., Boulton-Lewis, G., Campbell, J., & Smith, D. (2000). Students' Conceptions of Learning, the Classroom Environment, and Approaches to Learning. *The Journal of Educational Research*, 93(4), 262-270.

de Lisi, R., & Staudt, J. (1980). Individual difference in college student's performance on formal operations tasks. *Journal of Applied Developmental Psychology*, 3(1), 201-208.

Dick, W., & Casey, L. (1996). *The Systematic Design of Instruction*. New York: Harper Collins.

Elby, A. (1999). Another reason that physics students learn by rote. *American Journal of Physics*, 67(7), 52 - 57.

Elby, A. (2001). Helping Physics Students Learn how to Learn. *American Journal of Physics*, 69(7), 54 - 64.

Elliott, J. (2005). *Using Narrative in Social Research : Qualitative and Quantitative Approaches*. London: Sage Publications.

Erlandson, D. A., Harris, E. L., Skipper, B. L., & Allen, S. D. (1993). *Doing Naturalistic Inquiry : A Guide to Methods*. Newbury Park, California: Sage.

Fraenkel, J., & Wallen, N. (2009). *How to Design and Evaluate Research in Education*. New York: McGraw Hill.

Frederiksen, J. R., & Collins, A. (1989). A Systems Approach to Educational Testing. *Educational Researcher*, 18(9), 27 - 32.

FS. (2010). Faculty of Science Academic Guide Book. Retrieved 26 March, 2012, from Faculty of Science, Universiti Teknologi Malaysia: http://www.fs.ut,.my

Gall, M., Gail, J., & Borg, W. (2007). *Educational Research : An Introduction*. United State of America: Pearson Education Inc.

Giancoli, D. C. (2009). *Physics for Scientists and Engineers with Modern Physics*. New Jersey: Prentice Hall.

Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. London: Aldine Transaction.

Gok, T. (2012). The Impact of Peer Instruction on College Students' Beliefs about Physics and Conceptual Understanding of Electricity and Magnetism. *International Journal of Science and Mathematics Education*, 10(2), 417-436.

Gray, K. E., Adams, W. K., Wieman, C. E., & Perkins, K. K. (2008). Students Know What Physicists Believe, But They Don't Agree: A Study Using the CLASS Survey. *Physical Review Special Topics - Physics Education Research*, 4, 1 - 9.

Guba, E. G. (1981). Criteria for Assessing the Trustworthiness of Naturalistic Inquiries. *Educational Communication and Technology Journal*, 29(2), 75 - 91.

Habsah Ismail , Aminuddin Hassan, Mohd. Mokhtar Muhamad , Wan Zah Wan Ali, & Mohd. Majid Konting . (2013). Epistemological Belief and Learning Approaches of Students in Higher Institutions of Learning in Malaysia. *International Journal of Instruction*, 1(6), 139 - 150.

Hammer, D. (1994). Epistemological Belief's in Introductory Physics. *Cognition and Instruction*, 12(2), 151 - 183.

Haney, J. J., & McArthur, J. (2002). Four Case Studies of Prospective Science Teachers' Beliefs Concerning Constructivist Teaching Practices. *Science Education*, 86(6), 783-802.

Hofer, B. K. (2000). Dimentionality and Disciplinary Differences in Personal Epistemology. *Comtemporary Educational Psychology*, 25(4), 378 - 405.

Hofer, B. K. (2004). Exploring the Dimensions of Personal Epistemology in Differing Classroom Context : Student Interpretations During the First Year of college. *Contemporary Educational Psychology,* 29, 129 - 163.

Hofer, B. K. (2006). Domain Specificity of Personal Epistemology : Resolved Questions, Persistent Issues, New Models. *International Journal of Educational Research*, 45, 85 - 95.

Hofer, B. K., & Pintrich, P. R. (1997). The Development of Epistemological Theories: Beliefs about Knowledge and Knowing and Their Relation to Learning. *Review of Educatinal Research*, 67(1), 88-140.

Hornby, W. (2003). Assessing Using Grade-related Criteria: a single currency for universities? *Assessment and Evaluation in Higher Education*, 28(4), 435 - 454.

Ismail, W., Abedalaziz , N., & Hussin , Z. (2011). Epistemological Beliefs of Students at High Schools : A Survey Study in Malaysia. *OIDA International Journal of Sustainable Development*, 2(8), 39 - 46.

Kienhues, D., Bromme, R., & Stahl, E. (2008). Changing Epistemological Beliefs : The Unexpected Impact of a Short Term Intervention. *British Journal of Educational Psychology*, 78(4), 545 - 565.

King, P. M., & Kitchener, K. S. (1994). *Developing Reflective Judgement : Understanding and Promoting Intellectual Growth and Critical Thinking in Adolescents and Adults*. San Francisco: Jossey-Bass Inc.

Knight, P. T. (2002). The Achilles' heel of quality: The assessment of student learning. *Quality in Higher Education*, 8(1), 107 - 115.

Kuzborska, I. (2011). Links between Teachers' Beliefs and Practices and Research on Reading. *Reading in a Foreign Language*, 23(1), 102-128.

Langdridge, D. (2007). *Phenomenological Psychology: Theory, Research and Method*. New York: Pearson Education.

Lim, T. S. (2006). Science Epistemological Beliefs of Form Four Students and Their Science Achievement Using Web-Based Learning. *Malaysian Journal of Learning & Instruction*, 3, 33 - 52.

Limon, M. (2006). The Domain Generality-specificity of Epistemological Beliefs : A Theoretical Problem, a Methodological Problem or Both? *International Journal of Educational Research*, 45, 7 - 27.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. London: Sage.

Lindsey, B. A., Hsu, L., Sadaghiani, H., Taylor, J. W., & Cummings, K. (2012). Positive attitudinal shifts with the Physics by Inquiry curriculum across multiple implementations. *Physical Review Special Topics - Physics Education Research*, 8(1), 1 - 8.

Lising, L., & Elby, A. (2005). The Impact of Epistemology on Learning : A Case Study from Introductory Physics. *American Journal of Physics*, 73(4), 372 - 382.

Mansour, N. (2008). Science Teachers' Beliefs and Practices: Issues, Implications and Research Agenda. *International Journal of Environmental & Science Education*, 4(1), 25 - 48.

Muis, K. R., Bendixen, L. D., & Haerle, F. C. (2006). Domain Generality and Domain Specificity in Personal Epistemology Research : Philosophical and

Empirical Reflections in the Development of a Theoritical Framework. *Educational Psychology R*eview, 18(1), 3 - 54.

Murphy, P. K., & Alexander, P. A. (2006). *Understanding How Students Learn : A Guide for Instructional Leaders*. United States of America: Sage Publications.

Norton, L. (2004). Using assessment criteria as learning criteria : a case study in psychology. *Assessment and Evaluation in Higher Education*, 29(6), 687 - 702.

Ornek, F., Robinson, W. R., & Haugan, M. P. (2008). What Makes Physics Difficult? *International Journal of Environmental & Science Education*, 3(1), 30 - 34.

Otero, V. K., & Gray, K. E. (2008). Attitudinal gains across multiple universities using the Physics and Everyday Thinking Curriculum. *Physics Review Special Topics - Physic Education Research*, 4(2), 1 - 7.

Palmer, B., & Marra, R. M. (2008). Individual Domain-Specific Epistemologies : Implications for Educational Practice. In M. S. Khine, *Knowing, Knowledge and Beliefs : Epistemological Studies* (pp. 325 - 350). Springer.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years : A scheme*. New York: Holt, Rinehart and Winston.

Piaget, J. (1977). *The Development of Thought : Equilibration of Cognitive Structures*. New York: The Viking Press.

Pintrich, P. R. (2002). Future Challenges and Directions for Theory and Research on Personal Epistemology. In B. K. Hofer, & P. R. Pintrich, *Personal Epistemology : The Psychology of Beliefs About Knowledge and Knowing* (pp. 389 - 414). New Jersey: Lawrence Erlbaum Associates, Inc.

Pritchard, D. (2006). *What is this thing called knowledge?* New York: Routledge.

Provenzo, E. F. (2009). *Encyclopedia of the Social and Cultureal Foundations of Education*. London: Sage Publications.

Qhobela, M., & Moru, E. K. (2013). Examining Secondary School Physics Teachers' Beliefs about teaching and classroom practices in Lesotho as a Foundation for Professional Development. *International Journal of Science and Mathematics Education*, 12(6), 1367 - 1392.

Redish, E. F., Saul, J. M., & Steinberg, R. N. (1998). Student Expectations in Introductory Physics. *American Journal of Physics*, 66(3), 212 - 224.

Richter, T., & Schmid, S. (2010). Epistemological Beliefs and Epistemic Strategies in Self-regulated Learning. *Metacognition Learning*, 5, 47 - 56.

Sackney, L., & Mergel, B. (2007). Comtemporary Learning Theories, Instructional Design and Leadership. In J. M. Burger, C. F. Webber, & P. Klinck, *Intelligent Leadership : Construct for Thinking Education Leader* (pp. 67 - 98). Netherland: Springer.

Sahin, M. (2009). Correlations of Students' Grades, Expectations, Epistemological Beliefs and Demographics in a Problem-Based Introductory Physics Course. *International Journal of Environmental & Science Education*, 2(4), 169 - 183.

Sahin, M. (2010). Effects of Problem-Based Learning on University Students' Epistemological Beliefs About Physics and Physics Learning and Conceptual Understanding of Newtonian Mechanics. *Journal of Science Education and Technology*, 19(3), 266-275.

Sandoval, W. A. (2005). Understanding Students' Practical Epistemologies and Their Influence on Learning Through Inquiry. *Science Education*, 89(4), 634 - 656.

Sands, D. (2004). Studying Physics. New York: Palgrave Macmillan.

Savasci, F., & Berlin, D. F. (2012). Science Teacher Beliefs and Classroom Practice Related to Constructivism in Different School Settings. *Journal of Science Teacher Education*, 23(1), 65-86.

Schommer, M. (1990). Effects of Beliefs About the Nature of Knowledge on Comprehension. *Journal of Educational Psychology*, 82(3), 498 - 504.

Schommer, M. (2002). An Evolving Theoretical Framework for and Epistemological Belief System. In B. K. Hofer, & P. R. Pintrich, *Personal Epistemology : The Psychology of Beliefs About Knowledge and Knowing* (pp. 103 - 118). New Jersey: Lawrence Erlbaum Associates, Inc.

Schommer, M., Duell, O. K., & Barker, S. (2003). Epistemological beliefs across domains using Biglan's classification of academic disciplines. *Research in Higher Education*, 44(3), 347-366.

Schommer, M. (2004). Explaning the Epistemological Belief System : Introducing the Embedded Systemic Model and Coordinated Research Approach. *Educational Psychologist*, 39(1), 19 - 29.

Schommer, M., & Walker, K. (1995). Are epistemological beliefs simlar across domains? *Journal of Educational Psychology*, 87(3), 424 - 432.

Scouller, K. (1998). The influence of assessment method on students' learning approaches: Multiple choice question examination versus assignment essay. *Higher Education*, 35(4), 453-472.

Seidman, I. (2006). *Interviewing as Qualitative Research*. New York: Teachers College Press.

Sharifah Maimunah, S. Z. (2003). Reforming the Science and Technology Curriculum : The Smart School Initiative in Malaysia. Prospect, 18(1), 39 - 50.

Sharifah Norhaidah Syed Idros, Zurida Hj. Ismail, Nordin Abdul Razak , & Wan Mohd. Rani Abdullah. (2002). The Intensity of Discord in Science Learning among Malaysian High School Students. *Journal of Science and Mathematics Education in Southeast Asia*, 25(2), 140 - 152.

Shay, S. (2008). Beyong social constructivist perspectives on assessment : the centring of knowledge. *Teaching in Higher Education*, 13(5), 595 - 605.

Silverman, D. (2006). *Intepreting Qualitative Data*. London: Sage.

Sin, C. (2014). Epistemology, Sociology, and Learning and Teaching in Physics. *Science Education*, 98(2), 342-365.

Slavin, R. E. (2003). *Educational Psychology : Theory and Practice*. United States of America: Pearson Education, Inc.

Stathopoulou, C., & Vosniadou, S. (2007a). Exploring the relationship between physics-related epistemological beliefs and physics understanding. *Contemporary Educational Psychology*, 32(3), 255-281.

Stathopoulou, C., & Vosniadou, S. (2007b). Conceptual change in physics and physics-related epistemological beliefs: A relationship under scrutiny. In S. Vosniadou, A. Baltas, & X. Vamvakoussi (Eds.), *Reframing the conceptual change approach in learning and instruction* (pp. 145-163). Amsterdam, Netherlands: Elsevier.

Trautwein, U., & Ludtke, O. (2007). Epistemological beliefs, school achievement, and college major: A large-scale longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology*, 3(32), 348 - 366.

Turner, J. C., & Meyer, D. K. (2000). Studying and Understanding the Instructional Contexts of Classrooms: Using our Past to Forge our Future. E*ducational Psychologist*, 35(2), 69-85.

van Manen, M. (1990). *Researching Live Experience: Human Science for an Action Sensitive Pedagogy*. Albany, NY: State University of New York Press.

Valanides, N., & Angeli, C. (2005). Effect of Instruction on Changes in Epistemological Beliefs. *Contemporary Educational Psychology*, 30(3), 314 - 330.

Velasquez, M. (2005). Philosophy : *A Text with Readings*. USA: Thomson Wadsworth.