CHAPTER THREE
METHODOLOGY

3.0 Introduction

Many researchers had explored students’ prior conceptions of scientific concepts using a variety of techniques such as error analysis, word-associations method (Preece, 1984) and in-depth interviews (Osborne & Gilbert, 1980a). Such techniques are indeed appropriate for identifying students’ prior conceptions. However, analysis of the literature reveals that the interview methodology has been the most frequently used and the most favourable methodology for determining students’ prior conceptions or alternative frameworks of many scientific concepts.

Thus in this study, an interview-about-instances or events (IAI/IAE) methodology (Osborne & Gilbert, 1980a & 1980b) was utilized to identify students’ alternative frameworks of energy. The IAI technique basically consists of a series of line drawings that depict different situations or instances in which the energy concept may be involved, whereas the interview-about events (Osborne, 1980a & 1980b) technique consists of real or actual phenomena related to the energy concept.

Osborne and Gilbert (1980a, 1980b), while researching on students’ conceptions of force, work and electric current, found the IAI methodology
to be of considerable potential for determining students' conceptions of scientific concepts.

Firstly, it is applicable over a wide range of age of subjects. Secondly, it is non-threatening, as the interviewer and the interviewee may find the interview session enjoyable. Thirdly, the method has an advantage over written answers in terms of flexibility and depth of investigation where the interviewer can query responses for further clarification. Finally, asking students to verbalize on the instances or events is more pertinent and penetrating than asking for definitions.

In this study, six instances and three events had been prepared. Students were interviewed based on each of the instances and events. As each instance or event was presented to the students, specific questions were posed to them with regard to the energy involved. They were required to answer some open-ended questions such as "Is there energy involved in what is happening in this picture?" and "How is energy involved in this picture?" If necessary, their responses on the concept of energy were further probed to provide a clear picture of the frameworks used by the students through asking relevant guiding questions (see Appendix A). The order in which the instances and events were presented was according to the sequence of arrangement listed in Appendix A. The English Version of the interview guidelines was shown in Appendix B.
3.1 Preparation of Instances and Events for Interview

All the six instances and three events prepared were used during the pilot study. The pictures for the instances were either adapted from other sources or created by the present researcher. Similarly, the events were also either adapted or created. The creation or selection of the instances and events was based on certain criteria.

Firstly, the researcher tried to develop all the instances and events in the contexts which were familiar to or within the common experiences of students. This was to ensure that students could verbalize and elaborate their answers freely and naturally when further probing questions were posed.

Secondly, the present researcher also tried to prepare an instance or event which involved some form of transformation of energy. However, it was not the primary intention of this study to test the students' knowledge on the transformation of energy. The main focus of the study was still the identification of students' alternative frameworks of energy from their responses.

Finally, the researcher had also tried to ensure that the events used in the interview were concrete and within the imagination of the students so that the students could visualize the process of the events. This was to ensure that the events were not difficult for the students to visualize and to verbalize.
The following are further explanations as to how or why each instance or event was developed and used in the pilot study. In the subsequent text, the instances used in the pilot study were labeled in the alphabetical order whereas the instances which were later selected for use in the actual study were labeled in numerical order. The order in which the instances and events were presented to the students was according to the order in which the instances and events were listed in the next sub-sections (refer to Appendix A).

3.1.1 Instance A (Instance 1) : A Kettle of Boiling Water

The instance of a kettle of boiling water was created to investigate students’ understanding of the involvement of energy in the boiling process. This situation was one which was frequently encountered by students in their everyday life. It was hoped that students could verbalize easily on the energy involved.

In this situation, the correct explanation involving the energy concept should be the chemical energy, which takes the form of gas in the gas tank, is being transferred to the flame (on the stove) in the form of heat and light energy. The flame then causes the water to boil, that is, the heat energy from the flame is then transferred to the water inside the kettle causing the water to boil. This instance was anticipated to elicit the Depository, Product and Flow-transfer Frameworks of energy.
3.1.2 Instance B (Instance 2) : A Book on Top of a Cupboard

This instance was adapted from Kruger's (1990) study. Kruger had an instance of a stone at the edge of a cliff. It was adapted by the present researcher to represent something which was closer to students' common experiences. A book on top of a cupboard could be frequently seen by children in their homes or at school. It was hoped that students could easily verbalize on the involvement of energy in the situation.

In this instance, the correct conception of energy is that the book has potential energy due to its height above the ground. The instance was used to elicit the Human Centred and Obvious Activity Frameworks from the students.

3.1.3 Event A (Event 1) : An Electric Toy Train

This event was created by the researcher. The activity in this event was one which was often encountered by students in their childhood. Students are expected to elaborate on the energy involved in this event by saying that upon pushing the switch to the 'on' mode, the chemical energy in the battery will be transferred to the motor in the train as mechanical energy. As the train moves, the mechanical energy in the motor changes to kinetic energy. Thus, this event was used to elicit the Depository, Ingredient, Obvious Activity, Product, Functional and Flow-transfer Frameworks of energy from the students.
3.1.4 Instance C (Instance 3): A Man Lifting a Heavy Weight

This instance was adapted from an instance used in Gilbert and Osborne's (1980a) study. Students with the correct conception of energy should respond to this instance by saying that the weight has energy due to its height above the ground and that the man has energy too, as he gets his energy from the conversion of chemical energy, in the form of the food he consumed, to mechanical energy. This instance was also intended to elicit the Human Centred, Depository, Obvious Activity, Product and Flow-transfer Frameworks of energy from the students. It also served to counter-check whether some frameworks, which were manifested in the other instances and events, would be shown by the students again in this instance.

3.1.5 Instance D: A Cow Eating Grass in the Pasture

This was an instance used in Kruger's (1990) study. Correct responses expected from the students include mentioning both the cow and grass possessing energy. The grass, which converts light energy from the sun to chemical energy, stores the energy in the leaves. The cow, on the other hand, obtains its energy from the grass it feeds on. The chemical energy from the grass consumed by the cow will be converted to mechanical energy for it to perform its daily activities. The instance was anticipated to elicit the Depository, Ingredient, Product, and Flow-transfer Frameworks of energy.
3.1.6 Event B (Event 2) : A Torchlight

This created event is also something commonly encountered by the students in their life. Students with the correct conceptions of energy would say that when the switch is pushed to the 'on' mode, the chemical energy in the battery will be transferred to the torchlight in the form of heat and light energy in the bulb. This event was meant to elicit the Depository, Ingredient, Product, Functional and Flow-transfer Frameworks of energy.

3.1.7 Instance E (Instance 4) : A Man Pushing a Wheelbarrow Up a Hill Slope

This instance was adapted from an instance used in Watts' (1983) and Osborne and Gilbert's (1980a) studies. Students with the correct conception of energy would respond by saying that the man has chemical energy derived from the food consumed and that the wheelbarrow has kinetic energy while it is moving up the slope. The man transfers part of his chemical energy to the wheelbarrow as kinetic energy. At the same time the wheelbarrow is also gaining potential energy as it gains height while moving up the slope. This instance was anticipated to unravel the Human Centred, Depository, Obvious Activity and Flow-transfer Frameworks of energy.

3.1.8 Instance F : A Ball Rolling Down a Slope

This instance was adapted from an instance used in Trumper's (1993) study. Students with the correct conception of energy are expected to
respond by mentioning that when the ball is held at A, it possesses potential energy (PE) due to its height. But when it rolls down to point C, the PE is converted to kinetic energy and work done against friction while rolling down the slope. Finally, the students should say that the ball will not be able to reach point C on the other side, as some of the energy has converted to work done against friction while rolling down and up the slope.

This situation was meant to draw out the Depository, Obvious Activity and Flow-transfer Frameworks of energy.

3.1.9 Events C (Event 3) : Lighting a Match Stick With a Match Box

This event was created to see if students were able to verbalize the transformation of energy from chemical energy in the match to heat and light energy in the flame. At the same time, the researcher also hoped to find out if students were able to verbalize about the transformation of energy after the flame had been put off. This event was intended to elicit the Depository, Ingredient, Product, Functional and Flow-transfer Frameworks of energy.

3.2 The Pilot Study

The pilot study was carried out at the end of the 1996 school academic year, using the six instances and three events described in Section 3.1.1 to 3.1.9. The students used were from a school in Selangor. The researcher had purposely selected a group of students from another school for the pilot study as she did not want the students interviewed in the pilot study to
influence those whom she would use for the actual study. At the same time she also tried to find students who had similar background as the students of the actual study for the pilot study.

With the help of a school teacher from Sekolah Menengah Ulu Kelang in Selangor, a group of seven female student volunteers who had completed their Form Three public examination (Penilaian Menengah Rendah) and were waiting for their promotion to Form Four were interviewed. These student volunteers were similar to those who would be interviewed in the actual study in that they were fluent in both the Malay and the English languages. These students had also agreed to stay back after school on three separate days for the interview. Each student had to stay back for about half an hour on a day of her choice.

The main purpose of the pilot study was to determine if the instances and events prepared could be used to elicit any frameworks of energy from the students. If a particular instance or event elicited fewer frameworks from a few students when compared with the other instances or events, then it would be discarded. On the other hand, if a particular instance or event elicited some specific frameworks of energy from a significant number of students, then the instance or event would be retained. Similarly, if a particular instance or event elicited certain framework(s) that were not elicited by other instances or events, then it would also be retained.
Another purpose of conducting the pilot study was to determine if any rephrasing of the questions was necessary to ensure that the students had a clear understanding of the questions asked. In addition, a check was also carried out on the presented sequence of the instances and events to determine if any resequencing was necessary. Sequencing was extremely important to ensure that the instances or events confronted earlier did not influence the students' responses to the subsequent instance or event.

Students' responses during the interview session in the pilot study were audio-taped and later transcribed. The transcripts data were then analyzed for the frameworks manifested.

From the pilot study, it was found that some frameworks were repeatedly manifested in some students' responses to some instances and events. This was anticipated as particular frameworks could be repeatedly shown by particular students across different instances and events. Nonetheless, from the results of the pilot study, the researcher had decided to take away instances that did not reveal any framework.

The instances discarded were Instance D and Instance F. Instance D was discarded as the students used in the pilot study did not seem to be able to verbalize much when they were shown the picture of a cow eating grass. Most of them verbalize about the biological aspects of the instance rather than from the energy point of view. Instance F was discarded because the students' responses were the stereotype textbook answers found in some
examination guide books for the Form Three. This was the comment of one of the students during the pilot study.

Another reason for discarding the two instances was that the duration of the interview was a little too long. The interview lasted about 40 minutes per student. One of the students even enquired when the interview would end. Thus, with the exclusion of the two instances (Instance D and Instance F), the duration of each interview session was shortened to about 30 minutes. All the other four instances and three events were retained for use in the actual study. The order in which the remaining instances and events were presented to the student volunteers during the actual study remained the same (as listed in Appendix A). However, they were relabelled in numerical order as shown in the bracketed headings of the instances and events.

From the pilot study, it was also found that rephrasing of the questions was unnecessary as the questions could be clearly understood by the students. The sequencing of the instances was not changed as the researcher did not encounter cases where the students’ responses to a particular instance or event were made with reference to the previous instances or events.

3.3 The Subjects of the Study

Finally, the newly labeled instances and events were used in the actual study involving 33 Form Four students from a girls’ school in Kuala Lumpur. Due to the nature of the methodology used, the subjects chosen comprised only of those who volunteered to take part in the research and those who
were willing to provide responses to the questions raised. This was to ensure that the students would verbalize naturally when asked to elaborate on their responses.

The Form Four students who volunteered for the interview had learnt the same introductory ideas of the energy concept as the students used in the pilot study.

The pool of students from which the student volunteers was drawn consisted of eight Form Four science and arts classes of about 30 students each. The number of subjects used (33) was comparable with that used by Osborne and Gilbert (1980a) in three of their studies, when they were trying out their interview-about-instances methodology on the concept of force, work and electric current. In their study on work, they used 50 subjects ranging in age from seven to 18 years old. On the concept of force, they used 40 students ranging from age seven to 19 years old. Finally, on the concept of electric current, 30 students ranging from age seven to 18 years old were used. Watts (1983), who had also used the IAI methodology in his study on the concept of energy, had used 40 students of age ranging from 14 to 19 years old.

3.4 The Actual Study

Thus, 33 Form Four female students from a school in Kuala Lumpur were interviewed at the beginning of the 1997 school academic year when they were just promoted to Form Four. This particular time of the year was
chosen because these students were not yet taught the concept of energy in
the Form Four syllabus other than what they had learnt at the lower
secondary levels. Two or three students were interviewed each day. These
students were interviewed individually and personally by the researcher. In
the interview session the researcher had posed questions in the Malay
language and responses from the students were audiotaped.

Preceding each interview session, the interviewer and the student had
some friendly conversations to establish rapport and mutual trust. The
researcher had informed the students that their responses would be recorded
for reasons of reference. In addition, the researcher had also informed the
students that the actual purpose of the study was to get genuine answers from
them.

Since the interview session for each of the students was only about 30
minutes, the researcher tried to interview the students only once. During the
interview, each student was told to 'think aloud' to show the basis of her
response. The instances and events shown to the students were in the order
shown in the interview guidelines attached in Appendix A.

As far as possible, during the interview session, the researcher tried to
follow up certain comments students made to reduce embarrassment due to
extended period of silence and to clarify students' thoughts. However, in so
doing the researcher had tried to avoid introducing vocabulary which might
suggest taught scientific ideas and principles. On the contrary, the
researcher had tried to re-use the vocabulary used by the students in their
responses. Thus, during the interview, the researcher recognized her task of extracting information from the students and at the same time made sure that all these were done without putting words into students' mouths or providing clues and information which would bias students' subsequent responses. In other words, the researcher had tried to remain neutral throughout the interview session.

The environment in which the interview session was carried out was a preparation room adjacent to the science laboratory. The room was quiet and free from any other observer. This had helped to ensure that the students' responses were unaffected by any observer's gesture.