MULTIMEDIA-SUPPLEMENTED INSTRUCTIONAL UNIT FOR LEARNING HOUSEHOLD ELECTRICAL ENERGY CONSUMPTION AND CONSERVATION

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**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER IN SCIENCE
(SCIENCE AND TECHNOLOGY EDUCATION)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2014**

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entitled

MULTIMEDIA-SUPPLEMENTED INSTRUCTIONAL UNIT FOR LEARNING HOUSEHOLD ELECTRICAL ENERGY CONSUMPTION AND CONSERVATION

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MULTIMEDIA-SUPPLEMENTED INSTRUCTIONAL UNIT FOR LEARNING HOUSEHOLD ELECTRICAL ENERGY CONSUMPTION AND CONSERVATION

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science (Science and Technology Education)
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ACKNOWLEDGEMENTS

I would like to pay my heartfelt gratitude to the Thailand International Development Co-operation Agency (TICA), Thailand for supporting the scholarship. I would also like to thank the Royal Civil Service Commission (RCSC) and Ministry of Education (MOE), Bhutan in providing the opportunity for my Master Degree of Science scholarship in Science and Technology Education Program at the Institute for Innovative Learning, Mahidol University, Thailand. I pledge to serve my profession to the best of my ability.

I would gratefully acknowledge Asst. Prof. Dr. Patcharin Panjaburee, my major advisor for her invaluable guidance and support. It would not have been possible without her selfless effort and aspirations for me to complete this study. My profound gratitude also goes to Dr. Monamorn Precharattana and Dr. Wararat Wongkia, my co-advisors for their valuable comments and suggestions which immensely helped to improve my work. I would also like to extend my appreciation to Dr. Niwat Srisawasdi from Division of Science, Mathematics, and Technology Education at Faculty of Education, Khon Kaen University, the external committee for his valuable advice and necessary guidance for this research.

My special thanks go to all the lecturers and the staffs of the Institute for Innovative Learning, Mahidol University who helped me in completing my course work successfully and also for giving constant support during the entire study period. Indeed, I am also very grateful to Faculty of Graduate Study, Mahidol University for providing pertinent supports and creating conducive learning environment. I would like to acknowledge all participating students, teachers, and the principal of Jigme Sherubling Higher Secondary School, Khaling, Trashigang, Bhutan for their wholehearted cooperation in my data collection in the second study. I would also like to express my gratitude to those participants from Taktse Higher Secondary School, Trongsa, Bhutan who helped me with my first study and provided academic supports for improvement.

Finally, I would like to dedicate my research work to my parents, family, relatives and dear friends for their immeasurable love and endurance support for all these years towards me.

Ugyen Dorji

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ABSTRACT

In recent years, several researchers have attempted to apply teaching and learning strategies to promote students' conceptual understanding of energy consumption and conservation. However, students still have a lack of applied knowledge regarding electrical appliances and have sub-optimal conceptual understanding of what the major factors of energy consumption are. This results in less awareness regarding energy conservation. To address this issue, a teaching and learning strategy for promoting students' conceptual understanding on household electric energy consumption and conservation was developed based on engagement and motivation that leads to promoting students' self-awareness of energy conservation. The study was divided into 2 phases. The first phase aimed to study the possible use of the multimedia-based 5E learning cycle model in promoting students' learning about household electrical energy consumption and conservation. Moreover, the results from this phase were employed to improve the multimedia to be appropriate for the classroom and with real life situations in the second phase, the main study. Consequently, the main study developed game-inquiry based learning embedded in a multimedia-supplemented learning unit. When using the developed learning unit, the participating students were encouraged to use electrical appliances for certain durations as a meaningful way of determining energy consumption. The way to teach students to conserve energy is not simple; the developed learning unit was used to encourage them by adjusting for the appropriate duration with each electrical appliance. The main study was conducted with tenth grade students studying a physics course titled Electric Energy Consumption and Conservation in eastern Bhutan. The experimental results showed that the developed learning unit significantly improved the students' learning achievement as well as their awareness of electric energy conservation.

KEY WORDS: ELECTRICITY/ ENERGY CONSUMPTION/ MULTIMEDIA SUPPLEMENTED LEARNING/ SELF-AWARENESS

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
ECR	extended classroom
PS	primary school
LSS	lower secondary school
HSS	higher secondary school
MCQ	multiple choice question
Nu.	Ngultrum; the currency of Bhutan

CHAPTER I
INTRODUCTION

Overview

This chapter introduces on the significance and rationale of the research study for developing instructional unit to enhance students understanding on electrical energy consumption and conservation for secondary school students in Bhutan. The research objectives, questions and site of the study are also stated.

1.1 Significance of the study

Electricity is energy which has become indispensable in our day to day life. Absence of electricity not only cause inconvenience to domestic consumers but also cause economic losses for industrial sectors at large due to operation of electrical appliances. Electricity demand has been rapidly increasing, so electrical energy management for our daily usage has become very crucial, but most of consumers are unaware of their electric power management. The lack of knowledge to use electric energy efficiently results in the wastage of electric energy consumption in their daily life.

Moll et al. (2005) stated that the amount of electricity usage is not just related to household budget and size but also residents' behavior in the use of energy. An appropriate way to decrease the electricity usage in each household is to alter the residents' behavior in the use of electricity (Abrahamse, Steg, Vlek, & Rothengatter, 2005). Maharaj-Sharma (2012) specified that students' role outside school is vital in their learning science and making it meaningful in the society. Therefore, there is in a need for learning energy consumption and conservation in school science.

Electricity is one of the important topics in school science, but is also a very challenging topic to teach students because the students' conceptions about electricity are based upon material predicates, so they comprehend electricity as

attribute of electronic, but not as procedures as it is recognized in physics. Several methods and strategies have been explored to make the concept of electricity more stable for understanding to young learners but still there prevails incorrect perspective of electricity in the learners which has become difficult to modify (Chiu, Chou, & Liu, 2002; Slotta & Chi, 2006). Chiu et al. (2002) commented that activities related to analogies or metacognition during the study might help the learning process more permanent, but there is no significant conceptual development with these approaches. Therefore, there is a need for scientific concepts to develop the understanding of the conceptual hierarchies so that the way of thinking can be applied for the learners own understanding (Slotta & Chi, 2006). The focus of this study is to teach the learners to be alert in how to use electric energy efficiently in their daily life, and also to find alternative ways in reducing the wastage of electric energy consumption.

In this study the concept "household electrical energy consumption and conservation" is learnt through multimedia-supplemented instructional unit. The aim of this study is to develop a relation between a theoretical-world and students' lives outside the class, through exploration of the elements of energy consumption by daily used household electrical appliances discussed in class using multimedia.

1.2 Rationale

It is known that school science subjects, like physics, chemistry and biology contain lots of theoretical concepts which students find difficult to understand and thus have misconceptions in it. Because of this, students rarely link the knowledge gained from those sciences in day-to-day life. This is all due to the narrow relation between how they are taught and what they learn (Kurt & Ayas, 2012; Ozmen, 2008). Normally in traditional teaching approach, teachers often over-rate the importance of their content and under-rate their impact in students' learning. Thus, attempts to teach students all that they need to know become ineffective because students forget much of the content that they memorize. Most of the time in traditional teaching, teachers concern much about time limitation for teaching vast content of the subjects so they rarely encourage students in class discussion, collaborative learning, and inquiry-based activities that often take time. However, for effective learning, teachers must develop

learning activities that encourage students on how to use scientific knowledge to solve important queries and help in deep thinking rather than worrying about covering the content. Deep thinking is essential because understanding is the residue of thinking. To encourage thinking, learning should incorporate activities that create a joy, an excitement, and loves for learning so that the students will be impatient to run home, study, and contemplate– to real learning (DiCarlo, 2009).

In the recent years, there are varieties of resources developed and are available. Incorporating such resources can be the best appropriate instructions that can fit the goal of achieving active learning. This has been a challenge for science teachers especially to teach abstract concepts, such as energy to young children (Duit, 1981; Yuenyong, Jones, & Sung-Ong, 2011). So there has been always hunt for better learning method(s) to inculcate this concept in students because "Energy Education" has become an area of major importance for those who are responsible for school teaching.

Nowadays, the demand for energy is rising rapidly with limited resources to supply, so everyone agree that there is a need for school teaching to equip students with the knowledge, skills and abilities to manage energy in everyday lifestyle to live in a world faced with energy crises (Trumper, Raviolo & Shnersch, 2000). Energy supply and consumption are socio-technical in nature: technology and behavior interaction are co-evolving with each other over the time. Just having advanced technology appliances and well-designed energy efficient house are not enough to guarantee reduction in energy consumption. Energy consumption in every house can easily differ by a factor of two or more depending on the inhabitants (Sonderegger, 1978; Darby, 2006).

As per DeWaters and Powers (2011), energy education enables clients to identify the better ways to save energy. However, the study indicated that while almost everybody agrees that they want to conserve energy, this often does not translate into action. Further, the study also showed that domestic energy usages are invisible to the consumers most of the time. This is simply because most people have only a vague idea of how much energy they are using for different purposes and what sort of difference they could make by changing day-to-day behavior or investing in efficient methods. For this reason, energy consumption has not declined significantly in reality

(Boyde, 2002; Yang, Chien & Liu, 2012). This difficulty may be due to the fact that users usually either do not know how much electricity is consumed by their household electrical appliances or do not have any idea of how to save electricity in an appropriate way.

As stated by Bates (2003), to meet the consequences of the paradigm shift from industrial age to information age, the current approaches and methods of instructions are insufficient. Eventually, the instructional designers are facing with the challenges of making learning situation to fit an instructional design/ development of model rather than selecting suitable model to fit the needs of changing learning situations (Gustafson & Branch, 2002). In recent years, there are many books and articles published, indicating various approaches for learning the different forms of energy, energy transformation, and the law of conservation of energy (Aggul, Yalcin, Acikyildiz, & Sonmez, 2008). However, student's prevailing ideas about energy are still found to be different from the scientific perspective.

Therefore, this study develops a multimedia-supplemented learning unit incorporating with learning strategy. This study also investigates the effectiveness of the multimedia-supplemented instructional unit on students' achievement and their awareness of household electrical energy consumption and conservation in Bhutanese classroom teaching and learning. This study would be the eye-opening research for future researchers and its result could be of the usage for aspiring teachers and educators to improve the test achievement and turn positive attitudes toward teaching and learning of science in Bhutanese classroom.

1.3 Research objectives

1. To examine the students' learning achievement on the household electrical energy consumption and conservation.
2. To promote the students' awareness on the energy conservation.
3. To investigate the students' attitude towards the developed multimedia-supplemented instructional unit.

1.4 Research questions

1. To what extent can the developed multimedia-supplemented instructional unit help students find out the household electrical energy consumption?
2. What is student's level of awareness of energy conservation?
3. What is student's attitude towards the developed multimedia-supplemented instructional unit?

1.5 Scope of the study

The study determines the effectiveness of using the developed instructional unit in grade 10 students for learning science in Bhutanese classroom. It could also provide guidelines for Bhutanese teachers to implement ICT (information and communications technologies) in teaching science lessons.

1.6 Expected outcomes

1. Students who participate in the developed instructional unit will have better learning achievement of electrical energy consumption and conservation.
2. Students who participate in the developed instructional unit will exhibit higher level of awareness on energy conservation.
3. Students who participate in the developed instructional unit will have positive attitude toward the developed instructional unit.

1.7 Location of the study

The study will be carried out in one of the higher secondary school in Trashigang district, Bhutan. It is located at the eastern part of the country as shown in Figure 1.1. The school is regarded as one of the pioneer schools of the country. It has the class level from 9 till 12 with the population of about 550 students and about 30 teachers (Policy and Planning Division, Ministry of Education, Royal Government of Bhutan, 2012). The study will be implemented with grade 10 students.

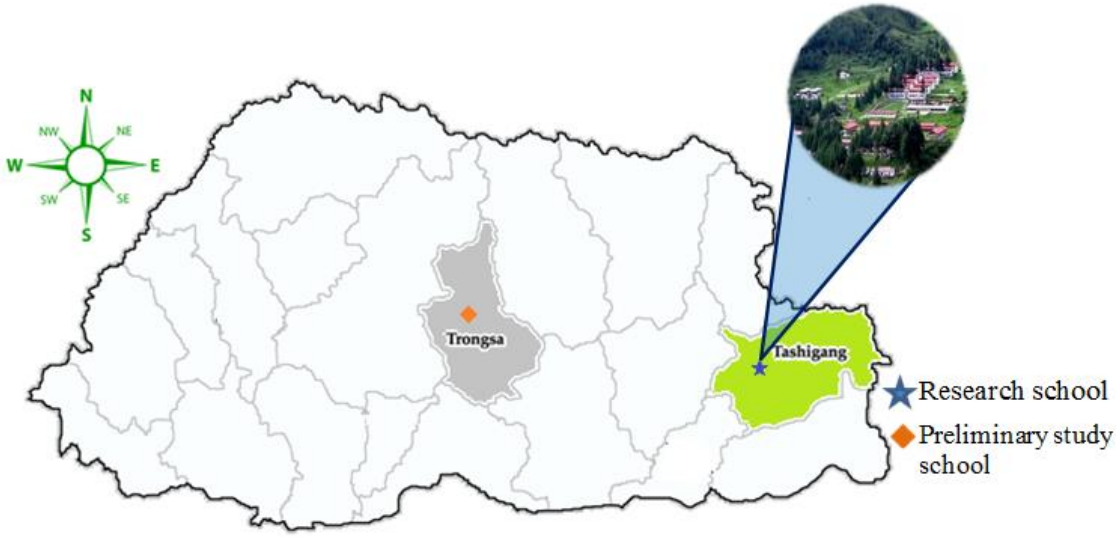


Figure 1.1 Location of research school

CHAPTER II
LITERATURE REVIEW

Overview

This chapter presents a review of relevant literatures for the research. It includes the literatures on important for learning energy concept in schools and are explained in relation with the Bhutanese science curriculum. This section also includes discussion about the learning theory, the significant and effects of incorporating multimedia-supplemented instructions in learning and teaching abstract concepts as, household electrical energy consumption and conservation topic. Moreover, it also explains the importance of embedding appropriate learning cycle model for effective learning outcomes both in students' achievement level and in application of knowledge learned from science classes into their day to day life.

2.1 Energy education

In the present world scenario, we are so much dependent on the electrical energy. These kinds of energy are very important in the factories, business establishment, houses and in the recreational facilities. The shortage of electricity for few days or even few hours can cause lots of inconveniences. It even causes economic instabilities due to the reduction of industrial production. Many advanced and developed countries such as U.S.A and Europe has come up with the numerous energy efficiency policies and programs which focus on the use of technologies that can save energy and design practices concentrating on the individual behavior (DeWaters & Powers, 2011). But these could not help in terms of saving energy and cost effectiveness beside it could not reduce the daily household consumption of electrical energy in their every day's household usage (Vastamäki, Sinkkonen, & Leinonen, 2005). This may be the reasons for most of the consumers being ignorant in their

management of the electric power which bring to the wastage of electric consumption in their day-to-day life (Boyde, 2002). By only having highly sophisticated energy saving appliances at home is not enough for the reduction of one's energy consumption but developing advocacy is more important for saving electrical energy and developing awareness to manage the daily consumption of electricity. In order to fulfill this goal, energy education has become very important element to educate students on the basic energy concept on daily electrical energy consumption and conservation. It help students to identify basic factors on which energy consumption depend and provide useful ways for reducing daily energy consumption both in and outside of their home and school (Haakana, Sillanpää, & Talsi, 1997). Understanding the learners and integrating appropriate learning approaches for teaching the concept is very important for any effective learning process. Thus, introducing the concept of energy education into the ways the students understand is crucial for any educator (Gustafson & Branch, 2002).

2.2 Learning theory

According to Lever-Duffy and McDonald (2005), learning is a complex activity that can be seen differently depending on individual's needs, because the perception of learners differs on how and why they do that way. The learning can take place in three different means such, auditory, visual, and kinesthetic. Learning includes the selection, arrangement, and information delivery in a suitable environment and in the way learners interact with the information (Smaldino, Russel, Heinich, & Molenda, 2005). Riding and Smith (1997) stated that every individual have different learning abilities and styles, and they possess and represent knowledge in diverse ways. Some students learn more effectively when taught with their preferred methods. With ever increasing demand to teach students with computers and the Internet, it has become vital for educators to be familiar with how students learn best when using multimedia technology (DiGiacinto, 2007).

2.3 Significant of the multimedia in teaching and learning

Multimedia helps in conveying concepts in more flexible manner through words, pictures, and sounds. It can be built or played as well as read or watched. Multimedia permit learners to take more active roles in learning. It convey information quickly and effectively to all learners and keep them interested and engaged in learning process. Through multimedia students get opportunity to learn more and develop new knowledge. Teachings with multimedia also help in developing interactions among teachers, students, and peers, making the learning environment more interactive. The use of multimedia in teaching inspires intellectual curiosity of students and enhances students' interest (Zimmer, 2003). Selection of media can be based on the goal, objective, level of the children and relevancy of the topics for its effectiveness and efficiency in teaching. Thus, the effectiveness of multimedia can be measured through the achievement of instructional goals and objectives (Clark & Mayer, 2003).

2.3.1 Effects of using multimedia in learning the concept

According to Kinshuk and Patel (2003), if the multimedia can adequately represent the tasks and concepts of the domain knowledge then it can contribute towards the success of learning. Different multimedia objects may facilitate different requirements of various learning tasks. But only collecting and incorporating multimedia objects in a system does not assure adequate learning. When there are numerous multimedia approaches available to teach the same concept, the selection of suitable media is very crucial for the effective delivery of the content. Rasch and Schnotz (2009) conveyed that facilitating learning through pictures together with text can help students to build mental models that are vital for comprehending the information to be learned; thereby it enlarges the retrieval possibility of the information. Integrating multimedia with teaching and learning instructions has found to improve students' understanding of concept and retention power. It also help the students with low aptitude in spatial and mental abilities to learn better but it has no apparent effects on the students with high prior knowledge of the same subject (Macaulay, 2003; Kunz, Drewniak, & Schott, 2004; Mayer, 2005). Sally Murphy concluded that using multimedia in the classroom not only benefits students' learning but also have advantages to teachers while

teaching; teachers no more have to depend on chalks and blackboard. They can freely choose from varieties of educational multimedia which motivate the students to learn correctly in the right time and in the right place.

According to Murphy (2012), multimedia in the classroom motivate pupils to work in collaboration with their friends, encouraging team work, promoting skills and learning in peers. Multimedia consisting of animation, simulation, and video provides varieties of ways in understanding the concept. Multimedia in the lesson involves students in active roles, which help them to think more critically about their own progress and abilities by connecting them with outside resources and society at large.

Florida Center for Instructional Technology confirms that multimedia activities promote students in collaborating learning towards expressing their knowledge in multiple ways, such as solving problems, revising individual works, and constructing new knowledge. The use of multimedia gives students a sense of achievement. Multimedia can make lessons more interesting by incorporating pictures, power points, YouTube and even video clips. Stewart (1999) stated that the use of multimedia can help a teacher engage students and allows teachers to present academic information in an engaging manner. Multimedia as a teaching tool expands teachers' ability to deliver study resources that help students to get close to the subject matter in an easy and interesting way. Shank (2005) said that multimedia affect learning, and also found that the use of multimedia would be beneficial for effective learning if the strategy; such as choosing the right media with the appropriate characteristics for communicating clear information are considered.

Motivation and transferring of learning can be enhanced by employing well-designed multimedia. The use of appropriate multimedia provides learning outcomes that replicates the real world experiences that allow learners to apply what they have learned from the various phenomena. Development of students' technical and research skills that they cannot obtain from text books can be helped through computer-based multimedia because it allows examples to be more vivid and realistic. Multimedia enables the students to see what is going on, and help to understand the important points in the lesson which encourage them to explore more about the topic by themselves (Zimmer, 2003).

2.4 Instructional multimedia

Instructional media encompasses all the materials such as chalkboards, handouts, charts, slides, OHPs (overhead projectors), real objects, and videotape or film, as well as newer materials and methods likes computers, DVDs, CD-ROMs, the Internet, and interactive video conferencing that help teachers to facilitate students' achievement on the set instructional objectives. It can make learning easy; enhance understanding of the material through easy communication when learning becomes a demanding process. In general, these media can increase understanding, efforts to achieve a variety of hidden instructional goals. According to the research reports by Clark and Mayer (2003), Macaulay (2003), Mayer (2005) and Shank (2005), multimedia has gained recognition with many benefits derived from its usage; there is 56% gain in learning, 50-60% better learning consistency and 25-50% higher in retention of content. Instructional multimedia technology can be more effective, if it is supported by scientific instructional design. Therefore, multimedia has become part and parcel in everyday teaching and learning process in the classroom.

Every multimedia has a capacity to teach the content either whole or part of it. Multimedia being a powerful tools for presentation, it also offers unique advantages in classroom teaching which enables students through exploration, discovery, and experiences. With multimedia, the process of learning can become more goals oriented and more participatory. So it is vital that the teachers match the learning objectives and choose the media that appropriately fits for learning unit.

Instructional multimedia is the integration of various forms of media in the instructional process in teaching and learning of concept. According to the research reports by Mayer (1999), multimedia has become so popular, as one can derive numerous benefits from its use. Multimedia technology has become an integral part in teaching any lesson in the classroom. In teaching the lesson, it is important to match the learning objectives and decide the types of media to design and learn from it because each media can offer the concept in teaching either the whole or part of the content besides being a powerful tool for making presentations.

Nowadays, several interactive multimedia learning units with simulations and games have been developed for educational purpose in many disciplines such as in mathematics, science, engineering, humanities, and social sciences (Cai et al., 2006;

Eck, 2006). Moreover, it has been observed that most students prefer learning by using computer games because of its advantage in students' habits and interests (Gee, 2006; Prensky, 2007). Educational games serve as nearly realistic situations that allow students to interact and to gain from the learning experiences. While playing games, students apply their knowledge, skills and strategies to make decisions in their assigned role. As a result, students' cognitive abilities and expectations about learning are promoted. Integration of games and simulations with contents help to teach concepts through the transformation of experiences (Papastergiou, 2009). Therefore, games as a learning vehicle have been used to teach factual information as well as worksheet activities in most of lessons in teaching and learning in education (Spraggins & Rowsey, 1986).

2.4.1 Educational computer game

Computer games play an important role to any fields of education. The use of computer games in education has shown positive outcomes by using it as a tool for instructional purposes. Several studies support that the use of educational computer games increase motivation and better learning achievement. The positive impact is well received as new strategies in teaching by many people as compared to traditional teaching. For example, Titilayo, Ovigueraye, and Adenubi (2012) stated that educational games are good tools to promote students participation in learning activities and then to motivate in their learnings as it encourages learning within enjoyable environment. Through game play – teacher can encourage children's abstract thinking into a concrete concept and further foster their higher order thinking abilities. Computer games are able to boost learning motivation of players through its features like adventures, challenges and fantasy world (Carbonaro, O'Brate, & Giannakakou, 2011). As per the studies by Burguillo, 2010 and Liu et al., 2009, playing educational computer game for long-term had a positive effect on students' learning abilities and construct knowledge. Intellectual skills and cognitive strategies are acquired during the academic games (Lee & Chen, 2009). Computer games are claimed to have cognitive development effects on visual skills including "spatial representation", "iconic skill" and "visual attention". So, while playing games the player(s) become more skilled in games, their visual attention become proportionally

better (Greenfield, 1984 cited in Subrahmanyam et al., 2001). Moreover, Dondlinger (2007) articulated that motivation by game can promote the learning achievement even in the complex concept. For instance, a study by Ke (2008) indicated that the educational computer games had more impact in promoting motivation in learning than conventional chalk and talk method.

Games in general motivate learners to take responsibility for their own learning, which lead to intrinsic motivation. Prensky (2007) said that gaming activities have the potential to engross the learners into a state of flow and consequently cause better learning through focus and pleasant rewards while increasing their motivation and attainment. So, in recent years numerous educational computer games have been designed in several difficult subject domains to supplement teaching and learning for improving students' academic achievement, including mathematics (Lee & Chen, 2009), language (Chen, Liao, Chien, & Chan, 2011), software programming (Connolly, Stansfield, & Hainey, 2007), management education (Chen et al., 2013; Kiili, 2007), medical education (Moreno-Ger, Burgos, Martínez-Ortiz, Sierra, & Fernández-Manjón, 2008), and sports education (Mueller, Gibbs, & Vetere, 2010). Educational computer games support "active, productive, creative and collaborative learning methods" (Hoppe & Colleagues, 2003).

Moreover, past studies have shown that the computer game can be utilized for teaching various environmental and conservation awareness concepts. Researchers have implemented different forms of games as tools for increasing environmental and conservation awareness. Hewitt (1997) used board games to teach environmental topics to school children. The study showed that there was significant improvement in their knowledge and understanding of various environmental concepts and behavior. A study by Evans et al. (2007) also demonstrated that while learning through games, learners (students) developed positive attitudes regarding the environment besides they also exhibit in an environmentally responsible manner. Computer simulation games can be implemented in various teaching learning fields for promoting environmental awareness and explore attitudes toward environmental conservation (Torres & Macedo, 2000). Hansmann, Scholz, Francke and Weymann (2005) indicated that the simulation game can effectively improve the environmental knowledge, attitudes, and behavior of the learner (players). Moreover, a recent study by Yang, J.C., Chein,

K.H., & Liu, T.C (2012) has shown that a digital game-based learning system can be used as a strategy to promote the self-awareness regarding energy conservation and enable learning energy conservation with higher motivation and willingness. The developed unit incorporated game-based learning environment for nurturing of a cyber-pet where learners cautiously operate electric appliances to ensure a balance between the comfort and survival of the pet and the reduction of the energy consumption. The results advocated that the system had positive affected learners' self-awareness, learning motivation, and willingness to conserve energy.

However, integration of these innovative approaches (computer games) into the classroom teaching does not necessarily ensure successful learning (Liu, 2007). Therefore, to ensure effective and successful learning, development of any innovative approach need to incorporate appropriate learning strategies into teaching and learning activities (Chuang & Chen, 2009; Wang & Chen, 2010).

2.5 Educational theoretical framework: How people Learn?

According to National Research Council (2000), the authors summarized their research findings that students' learning has parallel implications on the classroom instructions; which is the translations of those implications into curriculum materials that can imply both for students and for teachers. They stated that learners have different preconceptions about how the world works. If the teachers do not engage and link their initial understanding into new concepts then, the learners may fail to grasp the new concepts and information that were taught, or they may land up learning for the purpose of test only. So, to develop competence in an area of inquiry, students must (a) have a proper foundation of factual knowledge, (b) comprehend facts and ideas in the context of a conceptual framework, and (c) organize knowledge that facilitates retrieval and application. Metacognitive is an instructional approach that can assist children in learning to control of their own learning by defining learning goals and monitoring their progress and achievement. Thus, the teachers must link the pre-existing understandings that students bring with them and teach the concept matter thoroughly by providing relevant examples to provide the strong foundations of the factual knowledge. Therefore, it is vital to choose appropriate methods to use

developed multimedia tools and design the instruction according to the need of students.

2.5.1 5E learning cycle model

The 5E learning cycle model is a realistic, constructivist method of learning which employs students through well-designed learning process (Bybee et al., 2006). It is based on the constructivism theory of John Dewey and Jean Piaget. It was first designed by Robert Karplus in the early 1960s, and later in 1993, Bybee and his team in the Biological Science Curriculum Study (BSCS) conducted full study and developed a method, named "The 5E Learning Cycle" (David, 2003; Khataybeh & Nawafleh, 2000). According to Bybee et al. (2006), the learning cycle model consists of five phase inquiry approach. They are engagement, exploration, explanation, elaboration and evaluation.

Engagement

In this phase, the teachers evaluates the students' prior knowledge and helps them in connecting their previous knowledge and present learning experiences by setting organizational base work for upcoming activities through class discussion or video shows that promotes curiosity and elicits prior knowledge for learning unit.

Exploration

In this phase, students are asked to complete activities that help them implement their previous knowledge to generate new ideas that give students with a common set of experiences within the present concepts. Students have the opportunity to compare ideas that identify inadequacies of current concepts. Students are not just passive receptors; they also have the chances to acquire knowledge actively. Here, the teacher's role is to provide required materials and guidance that help them to focus in the learning unit.

Explanation

During explanation phase, students have an opportunity to share and explain their understanding of the concepts and processes they are learning. Here, it also provides opportunities for teachers to clarify students' misconceptions and help them in introducing new concepts and skills.

Elaboration

During this phase, students get chances to extend the concepts they have learned, link to other related concepts and apply their understandings into real world situations in new ways. Here, teacher challenges and extends students' conceptual understanding and skills of the concept by conducting additional activities that focus on adding breadth and depth to current understanding.

Evaluation

The evaluation phase provides opportunities for self-assessment as well as formal assessment for both students and teacher to determine how much learning and understanding has taken place and whether they have met the learning outcomes or not.

Several previous studies advocated that the use of the 5E learning cycle instruction had positive effect on students' achievement. Moreover, 5E learning cycle instruction was able to relate their conceptual learning with ability to apply in their daily life situations, which was the gap in that of traditional learning method (Gerdprasert, Pruksacheva, Panijpan, & Ruenwongsa, 2010; Kaveevivitchai et al., 2009; Kaynar Tekkaya, & Cakiroğlu, 2009; Liu et al., 2009). For example, a study by Kaynar et al., (2009) showed that the 5E learning cycle model was more effective in enhancing students' achievement in cell concepts topic over the traditional learning. Gerdprasert et al., (2010) stated that supplemented web-based learning unit incorporating 5E inquiry cycle model was significantly more effective than the traditional lecture alone for learning mechanism of labour for nursing students. Beside the 5E learning cycle model has been recognized as one of the best teaching approach in learning abstract concepts in several subjects in school education (Cepni & Sahin, 2012; Campbell, 2006; Akar, 2005; Madu & Amaechi, 2012; Tuna & Kacar, 2013). For instance, Cepni & Sahin, (2012) concluded that students had better learning outcomes when taught through 5E learning cycle model compared with different teaching methods in learning buoyancy force. Similarly, Campbell (2006) observed that 5E learning cycle model had better effect in understanding of force and motion concepts to fifth grade students, 5E learning cycle model was found effective on students' understanding of acid-base concepts (Akar, 2005). Madu and Amaechi (2012) articulated that the concept of elasticity in physics would be better learned

through five-step learning cycle model than traditional approach. A recent study by Tuna and Kacar (2013) indicated teaching trigonometry concepts with 5E learning cycle model enhanced students' academic achievement and longevity of their knowledge. Therefore, the aforementioned researches suggest the 5E learning cycle model is one of the widely-adopted pedagogies that involve brain-hands-minds in learning for enhancing their understanding. It is an guided inquiry-based scientific pedagogy (Bybee & Landes, 1988; Bybee et al., 2006; Stamp & O'Brien, 2005) where learners are engaged in new concept by relating their previous knowledge by exploring and explaining through their experiences, then elaborating on what they have learned, and eventually evaluating their understanding on that new concept under the guidance of teachers (Uzunöz, 2011).

However, several past researches also indicated that 5E learning cycle is an effective teaching strategy for promoting awareness of their own learning besides enhancing students' conceptual understanding and achievement in the subjects. In their study, Bevenino, Dendel and Adams (1999) stated that 5E learning cycle encourages students to develop their own frames of thoughts by linking theoretical learning and their applications. This promotes self-awareness on learning. Results from the study by Colburn and Clough (1997) showed that 5E learning cycle is an effective way to help students enjoy science, understand concept and apply scientific process and concepts to authentic situations which help students in promoting awareness in understanding science better. Moreover, 5E learning cycle model based on inquiry-based approach not only could improve more conceptual understanding of concepts with an effective hands-on, minds-on especially for enhancing conceptual understanding but also promote self-awareness on their learning with the ways in which students learn nature of the world.

When organized and correctly operated, this 5E learning cycle model cannot only enhance the students' achievement but also the permanence of knowledge by promoting awareness of their own learning in various fields of education.

2.6 Science education in Bhutan context

Modern education in Bhutan started from 1914 by first hereditary King Gongsar Ugyen Wangchhuk with English, Arithmetic, Hindi and Dzongha (National language of Bhutan) as learning classes. Since then English was used as the medium of instruction to teach all subjects except Dzongkha. It gave more importance to the development of skills and knowledge, which they believed would produce citizens like doctors, engineers, administrators which would be useful for the development of the country (Rabgay, 2012). The system give special attention to inculcate "principles and values including critical and creative thinking, ecology literacy, practice of the country's profound ancient wisdom and culture, contemplative learning, a holistic understanding of the world, genuine care for nature and others to deal effectively with the modern world, preparation for right livelihood and informed civic engagement" (Karen & Ronald, 2009). In Bhutanese education system, science curriculum is introduced from primary level onwards and when it reaches in higher secondary standard it is then segregated into three disciplines, namely physics, chemistry and biology. The aim of having this is to make the curriculum more relevant to the need of the society or localization and to bring a shift in the teaching style from teacher centered to learner centered.

Despite of the various efforts that the government has placed, undesirable trends like the teacher centered classrooms, rote learning, exam oriented learning and poor academic achievements still prevails which resulted in poor quality of science education. Due to poor quality of science education in Bhutan it failed to produce skilled people and our developmental activities are hindered. In many schools in Bhutan, teacher-centered instruction is a common practice. Teacher centered learning does not allow conceptual understanding of what is taught (Zakaria & Iksan, 2007). Most students in Bhutan lack understanding of concepts and they learn by memorization or rote. Many science teachers feel and my own personal experience as a science teacher for the past eight years tells me that the answers that students write in the exams are just regurgitation of what they have learnt by rote. Any twist or rephrasing of the questions made the students difficult or unable to answer the questions.

In Bhutanese context, almost all science classes are taught as that of arts and social science classes. In science classes, teacher-centered classrooms do not provide opportunities for students to engage in the learning process and develop scientific skills such as investigation, experimentation, observation, enquiry, testing and discovery. According to Snyder and Shickley (2006), these scientific skills are essential as they enable students to solve the new kinds of problems they will inevitably face in the future. Students also don't get opportunity to learn by interaction and develop social skills but they learn individually and competitively.

In recent years the education system supplied hundreds of computers all over the nation under the project "Chiphen Rigphel Project" (ICT Project) with grand from Indian government. The objective of the project is to equip every student with IT (information technology) literacy and improve science education. Now the system is stressing more on the practical oriented learning that enable students to acquire the skills that can be applied in the practical context. So, it (system) has observed that multimedia supplemented instructions as one of the ways to achieve that goal. Therefore there is strong need for teachers to change the instructional practices from teacher centeredness to child-centeredness by practicing effective teaching strategies with integration of multimedia-supplemented instructions like computer games, animations, simulations and more, especially in learning abstract concepts in science curriculum.

Summary

As per the literature review on the use of multimedia in teaching lesson, it has been learned that multimedia is necessary to make students learn the concept better. The integration of multimedia help teacher to manage the students and motivates students' learning ability. The multimedia helps students to take active participation in learning activities. Inclusion of interactive game in the multimedia can keep students alert active and focused on the lesson as it is appealing. It will benefit students immensely if the teacher can use it successfully. Integration of multimedia helps teachers to decrease classroom management issues and provides opportunities for the teachers to have real student audience. With the rapid growth of technology-

enhanced learning approach, educational computer game has been recognized to motivate students' learning in several courses. In recent years, there have been numerous developments of computer games that are used for supporting learning and teaching in schools as well as in some higher level of education. Many studies concerning educational computer games have shown the effectiveness of such an approach in engaging students in learning. Although those studies have shown the effectiveness of such educational computer game in consensus way as motivating students' learning, on the other hand, without incorporating educational theory or applying teaching and learning strategies, the educational computer games might not be significant for meaningful learning (Mayer, 2005). Constructivist's approach, the 5E learning cycle model has capability to move science teaching from simple hand-on, discovery approach to creating an environment where students can explore new concepts, re-evaluate their post experiences and accommodate their new experiences and concepts into their existing schemata.

Commonly in traditional style of teaching, teachers keep speaking and writing, but the teaching of the content are limited. The students write and record the lectures, and cannot concentrate in understanding of the content. In Bhutan many teachers teach in the same style and they hardly use multimedia technology. The most common instructional multimedia the teachers in Bhutan use in teaching science are text books with laboratory instruments and pictures. Integration of multimedia in the lesson can give students good feeling, enjoy learning and understand the concept. The multimedia-supplemented instructional unit for teaching household electrical energy consumption and conservation is going to make course content more compact and better teaching. Therefore, students can acquire more knowledge from outside the textbook and broaden their horizons, and encourage students to obtain knowledge and skills. Further it can make easy for the teacher to transfer the knowledge and also easy for the students to acquire the knowledge in just one approach. So the study focus on students' achievement level and awareness on energy conservation by the developed multimedia-supplemented instructional unit for learning household electrical energy consumption and conservation of grade 10 students learning physics in Bhutanese education system.

CHAPTER III
THE EXPLORATORY RESEARCH

Overview

This chapter presents the reports of the first study conducted in one of the higher secondary school in Bhutan to investigate possibility of implementing multimedia for teaching and learning energy consumption and conservation topic.It also includes data analysis, results and the feedbacks to improve the multimedia to fit with the real classroom teaching and learning and relate with students' daily life.

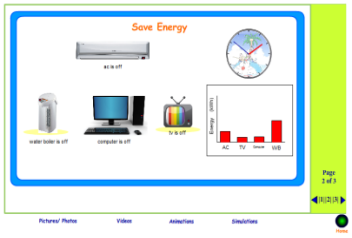
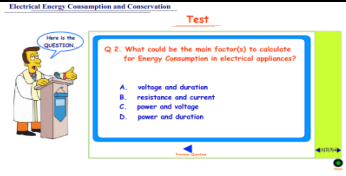
3.1 The multimedia with 5E learning cycle model

This study aimed to promote students' learning on household electrical energy consumption and conservation through developed multimediawith 5E learning cycle model.Moreover, itsobjectivewas to investigate the drawback of the developed multimedia. Table 3.1 shows a computer-aided multimedia using 5E learning cycle model.

Table 3.1 Snapshots of multimedia-supplemented instructionwith 5E learning cycle

5E learning modelPhases	Pictorial representation	Learning activities
Engagement (10 minutes) (Video)		Objective: To determine students' prior knowledge about electrical energy consumption and conservation. It has a video that shows about energy transmission and how the energy is utilized at our home. This gives overall view of the topic to be learnt. The test on the topic further checks students' prior knowledge about the topic; this links between what students know and organize their thinking toward the learning outcomes of current activities.

Table 3.1Snapshots of multimedia-supplemented instruction with 5E learning cycle (Cont.)

Exploration (30 minutes) (Interactive animations)		Objective: To identify the factors affecting energy consumption in the appliances. This phase encourage students to explore through the interactive media to investigate the factors for energy consumption by comparing the variation in the graphs. This activity requires students to discuss with peers and present their findings. The teacher supplements on their findings and encourage for further explanation during their presentation.
Explanation (20 minutes) (Lessons-text based content)		Objective: To summarize finding for energy consumption and integrate these factors into theformula to calculate energy consumption. During this phase, students refer to content (text) in-depth explanation. They also learn relationship of thefactors in various formulas for calculation for energy consumption.Then they calculate monthly power bills of the household with assigned class activity.
Elaboration (20 minutes) (Shopping)		Objective: To extend students' conceptual understanding in new situations. This interactive shopping game enables students to apply theoretical knowledge into pseudo-environment by choosing commonly used home electrical appliances from the list and find out how efficient are those appliances with the help of simulated energy meter. It also elaborate how theseappliances are better than other and develop sense of awareness on buying energy efficient appliances to conserve energy as to save money in long term.
Evaluation (10 minutes) (Test)		Objective: To evaluate their conceptual understanding. In this phase students evaluate their understanding, findings, explanation, and elaboration of the concept by assessing through the test items and measure their level of conceptual understanding. Students can revisit the learning unit and test again if they are not satisfied with their response.

To examine the students' learning achievement on the topic, the quasi-experimental design was employed during this exploratory research as shown in Figure 3.1.

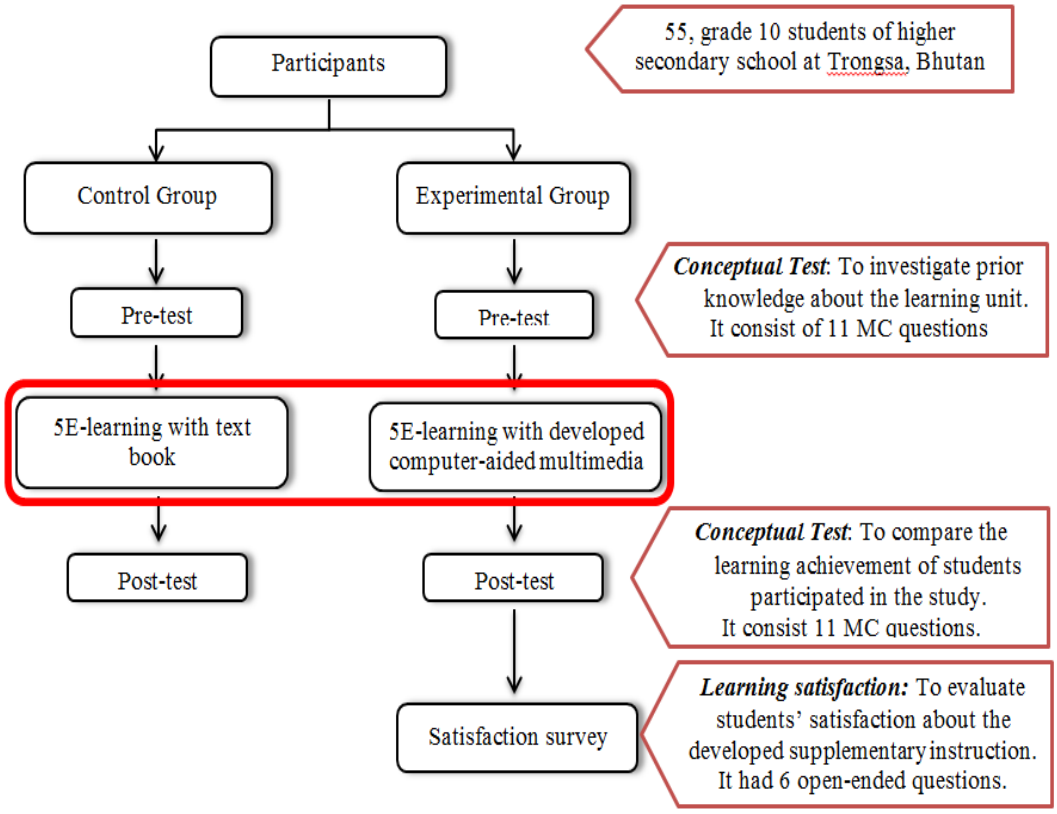


Figure 3.1 The exploratory research design

In the exploratory research, total of 55 grade 10 students whose age range were within sixteen and nineteen yearsparticipated.Of 55 students, 29 students consisting 17 girls and 12 boys were categorized in the experimental group whereas 26 students consisting 16 girls and 10 boys were categorized in the control group. The categorization was solely done using lucky draw.

In this study, the same developed conceptual tests were administered to compare the conceptual understanding between two groups before and after the use of computeraided multimedia instruction. Questionnaire and observation forms were developed to collect data for measuring the level of learning satisfaction after

participating in the developed computeraided multimedia instruction for the participants in experimental group only.

The learning took place forninety minutes each inboth the groups. Lesson was started with recapitulation of prior knowledge using KWL charts (Know, Want to know, Learned) and class discussion which engaged and motivated them for learning the unit. In experimental group, after taking pre-teststudents were briefed by the researcher about the instructions for activities using developed multimedia.Then the researcher used developed multimedia instruction as supplementary tools along with traditionalteaching method (lecture method) for teaching electrical energy consumption and conservation lesson. The developed multimedia instructions consisted of plain text, animations, and simulations for learning the concept. Students actively participated in two phases of game play: “identifying factors for energy consumption” and “household electrical bill calculation”. After every game, they participated question-answer sessions, where they presented their findings from the activity and identify the factors for energy consumption in electrical appliances. Further, researcher probed them with various questions related to the topic for better understanding. After these activities, students were asked to summarize the concepts derived from two activities in their own understanding. At the end, the researcher conducted follow-up activity/debriefing with short question-answer session in which he (researcher) engaged all students to participate actively to ensure that they met the learning objectives. During this session, the researcher also asked key questions to promote further students’ reflection of the conventional knowledge gained from the game activities with acknowledging reinforcement. After finishing the debriefing session, students took the post-test and also responded to the open-ended questionnaire for attitude test.

Similarly, in control group the lesson was taught with same learning activities but without the computeraided multimedia instruction or it used text books as supplementary material.

3.1.1 Pre-test results

The summary of the achievement results of pre-test of the two groups arepresented in Table 3.2. The main aim of this test was to find out whether students in

experimental group and control group had the similar in learning ability in energy consumption and conservation knowledge before the start of the study.

Firstly, the Shapiro-Wilk test was conducted to investigate data normality before analyzing data with specific inferential statistic tests. It was found that the data in both groups were normally distributed with *p*-value greater than 0.05 (i.e. control: p=0.106 and experimental: p=0.270). Thus, the parametric test, *t*-test for independent samples was conducted between two groups. The comparison of the mean and standard deviation were analyzed using *t*-test between the experimental and control group asshownin Table 3.2.

Table3.2*t*-test for pre-conceptual tests

Groups	**N**	**Mean ± SD**	***t***	***p*-value**
Control group	26	5.577 ±1.447	0.901	0.186
Experimental group	29	5.931 ±1.462		

Table 3.2 shows pre-test mean and standard deviation between the experimental and control group. The mean score of pre-test for the experimental group was 5.931, with the standard deviation of 1.462 and the mean score of control group was 5.577 with the standard deviation of 1.447. The calculated *p*-value was 0.186, which was greater than significant*p*-value 0.05 (p>0.05). Statistically, result was not significant (t =0.901). So, it was concluded that both groups were having same level of learning ability in energy consumption and conservation knowledge at the beginning. Therefore, the participants in both experimental and control groups were homogeneous in learning ability.

3.1.2 Post-test results

The purpose of post conceptual test (parallel test as ofpre-test) was to compare the achievement scores between the pre-test *vs* post-test and the learning achievement between the groups. So, post-test items consisted of same content and

concept to test as those of pre-test items except there were change in question sequence and numerical figures for calculation.

Before post-test data were analyzed, the data normality was checked by Shapiro-Wilk test using SPSS software. It showed that data were not normally distributed, with *p*-value less than 0.05 (control: p=0.021 and experimental: p=0.002). Therefore, the non-parametric test; the Mann-Whitney U test was conducted as shown in Table 3.3.

Table 3.3 Mann-Whitney U test to examine students' post-test scores in both the groups

Groups	**N**	**Mean ± SD**	*z*	***p*-value**
Control group	26	6.500 ±1.449	4.055	0.000*
Experimental group	29	8.069±1.280		

*p<0.05

According to data analysis for the post conceptual tests, the mean score of the experimental group was 8.069 with the standard deviation of 1.280, whereas the mean score of control group for the same test was 6.500 with the standard deviation of 1.449. The difference in the mean scores between the two groups was 1.569 with *z*-value of 4.055;the calculated *p*-value was 0.000, which was less than the significant *p*-value of the study. This showed that the result was statistically significant since the *p*-value was lower than 0.05. Moreover, the increase in the post-tests scores indicated that the participants had better conceptual knowledge in electrical energy consumption and conservation concept after participating in the study. Therefore, it was concluded that computeraided multimedia instruction was statistically more effective in teaching the topic "electrical energy consumption and conservation" than the traditional teaching method in Bhutanese grade10 students.

3.1.3 Analysis of students' learning satisfaction.

The researcher intended to find the learning satisfaction of the students with regards to students' attitude and learning satisfaction as a result of using

computeraided multimedia instruction in teaching electrical energy consumption and conservation lessonsin experimental group.

The questions were made simple to the level of grade 10 students and moreover the researcher explained the questions before answering them. The total of 29 students in experimental group answered the questionnaire. Although overall remark in the questionnaire revealed a positive response (100% liked) by participants in using developed supplemented instruction for learning the concept; further analysis of the students' responds were done by classifying their statements into following categories.

Respondents' satisfaction statements for the use of multimedia to learn the lessons.

Q1. What do you think about learning this unit? Why?
- "I can calculate energy consumed by each appliance by myself".
- "I can compute their household daily and monthly electrical bill".
- "I got lessons about electricity and energy consumption by various household appliances".
- "It provides me knowledge regarding voltage and power for buying electrical appliances".
- "It provides me information about proper use of energy and save money by conserving it".

Q2. What do you think about the multimedia/game implemented in this learning unit?
- "It helps me to visualize energy consumption by appliances clearly and better understanding".
- "It helps me to identify the main factors affecting the cost of energy consumption".
- "It provides me knowledge to buy electrical device regarding power rating".
- "I got ideas how to use electrical appliances to save money".
- "It develops awareness on energy conservation by buying low energy consuming appliances forlong run".

Q3. Which parts of the multimedia do you like the most? Why?
- 55% liked shopping game;
  "It gave practical information on selecting appliance for low energy use".
- 35% liked calculation;
  "It helped me in calculating cost of energy bills very easily".
- 10% liked quiz;
  "It motivated me to learn more about the lessons".

Q4. How does this multimedia help you to find out the actual cost of electrical energy consumption?
- "It helps me identifying the factors of devices and calculating using the formula".
- "It gives me idea of high wattage rated meaning that it consumes high energy and more money".
- "It gives knowledge about more time usage meaning that more energy will consume, i.e. more money".
- "It helps me to visualize the daily life situations in calculating energy bill and ways to save money".
- "It provides me knowledge to save money meaning that use electricity for short duration and low wattage appliances".

Q5. Learning through this multimedia, do you think it will help you in saving/conserving electrical energy? How?

- "It gave me awareness on proper use of electrical energy which saves money".
- "It provided me ideas about buying any electrical appliances looking at its rating to saving energy and money".
- "It gave me information about how long various appliances should be used to save electricity".
- "It helped me in choosing qualitative electrical appliances to save money in long run".
- "It helped me to compare our daily life scenario, how much monthly electric bill is paid and how much is saved monthly".

Q6. What is your suggestion to improve this multimedia?

- "Make the game more interactive".
- "Add more questions related to awareness for energy conservation".
- "Show clearly how duration/time affects the cost of energy(factors)".
- "Includeupdated cost of energy per unit".

As per the participants' respond, it was concluded that multimedia provided higher level of learning satisfaction in students. Traditional teaching methods with books, chalk and board cannot offer same level of satisfaction and stimulation because majority of the students felt that multimedia helped them to enjoy, participate, interact and develop critical thinking. It has produced higher learning achievement as supported by the mean scores of the post-test which was significantly higher than those of pretest.

Students' reflection in the questionnaires also revealed that they enjoyed themselves through game playing and thereby sustained their involvement in learning for longer time, resulting in better learning. They also stated that through developed supplementary multimedia, they were able tovisualize the abstract concept of energy consumption and conservation.Therefore, they can apply their knowledge, skills and strategies to make decisions in their assigned role. These helped them in promoting their cognitive abilities for fostering the development of self-awareness and social consciousness towards energy conservation.

However, some students suggested that the developed computeraided multimedia could be more effective instruction and self-directed learning unit for household electrical energy consumption and conservation if it includesgames that are more interactive to the learners. They stated thatgames resembling real life scenarios, blending plane text with animations, adding more updated content to elaborate the concept clearly andhelp in critical thinking, that are vital for the real learning to take

place in the classroom. They also added that interactive media that educate awareness on energy conservation and factors affecting energy consumption can be develop with animation or simulations. These might help them visualizing the concept much better and understand clearly.

Summary

Based upon the findings from the first study, it is concluded that the 5E learning activities with text books, chalks and board merely give learning satisfaction to students. It cannot create joy, an excitement, and a love for learning. So, how hard and different approaches teacher use to teach the concept like energy conservation effectively, it still remains as abstract and vague in their brains. That is why the theoretical learning from school is never put into application.

If we are to inspire and engage students in learning then we should show them how we learn rather than tell them what we know. This desire for learning can be fulfilled by supplementing the traditional teaching methods (lecture) with educational games and multimedia instructions. Educational games and multimedia instructions provided higher level of learning satisfaction in students. They also serve almost realistic situations that allow students to interact and to gain from the learning experience. In the game, students apply their knowledge, skills and strategies to make decisions in their assigned role. Fromthe results, students' abilities and expectations about learning are promoted. Integration of games and simulations into contents help to teach abstract concepts through the transformation of experiences. Thus, there is a need for multimedia-supplemented instructions with inclusion of interactive games for learning abstract concept of household electrical energy consumption which is vital for energy-saving.

Therefore, the second study needed to develop an instructional unit considering the components that overcome the weakness of multimediaaided instruction implemented in the first study. It should incorporate interactive games that replicate real life scenarios with learning objectives to relate theoretical concept into reality besides including animations and simulations that develops curiosity and encourage learners to participate in learning unit. The learning unit should

beblendedthe plain text context into some animations, so the participants couldlearn through play and evaluate their learning simultaneously. Moreover, the instructional unit should be inculcated the design rationale that transforms learners' knowledge on electric energy consumption into awareness on electric energy conservation by applying the theoretical concepts into the simulated-daily life scenarios through games. The study also needed to include the questionnaire that evaluates the learners' awareness level in energy conservation, besides conceptual tests and attitude questionnaire to investigate the effectiveness ofthemultimedia-supplemented instructional unit in the Bhutanese classroom in learning household electrical energy consumption and conservation topic.

CHAPTER IV
THE MAIN STUDY

Overview

This chapter presents the details of the multimedia-supplemented instructional unit for learning household electric energy consumption and conservation. It includes design rational for the developed interactive-games and the 5E learning cycle model for enhancing students' conceptual understanding about energy consumption by various household appliances and for promoting awareness on energy conservation as well.

4.1 Multimedia-supplemented instruction: Interactive game-based learning unit

The second study, the multimedia-supplemented instructional unit for learning household electric energy consumption and conservation was developed based upon the comments and suggestions accumulated from the first study which implemented a computer aided multimedia instruction for learning the same concept. The developed learning unit embedded interactive media incorporating with 5E learning cycle model. It included interactive games, animations and simulations with learning objectives that replicate real life scenarios which can help learners to relate their classroom learning with real life situations. Unlike in the computer aided multimedia instruction developed in exploratory study, this study followed the design rationale for the interactive game-based learning units that can help transforming theoretical concept into the practical. Moreover, it also included awareness questionnaire to compare learners' level of awareness on electrical energy conservation after learning the lesson.

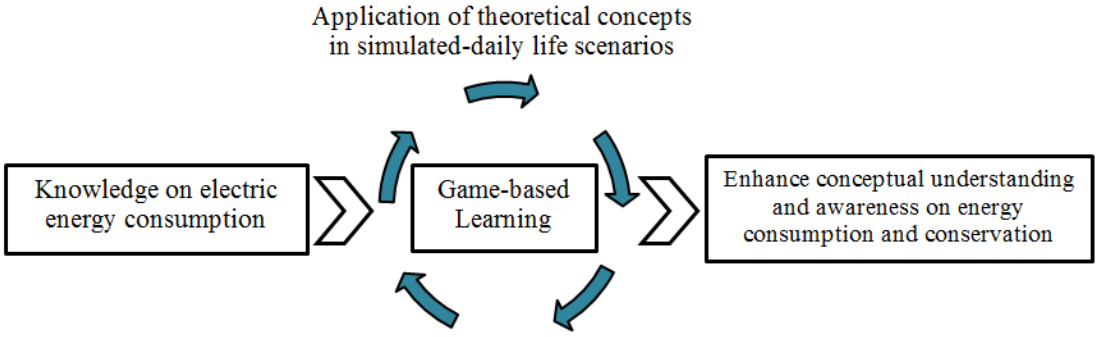


Figure 4.1 Design rational for the interactive-game based learning unit

Figure 4.1 illustrates the design rationale for the proposed game-based learning units embedded into multimedia-supplemented instructional unit for learning household electrical energy consumption and conservation. It shows how the learners transform their knowledge on electric energy consumption into awareness on electric energy conservation by applying the theoretical concepts into the simulated-daily life scenarios through conducting game-based learning.

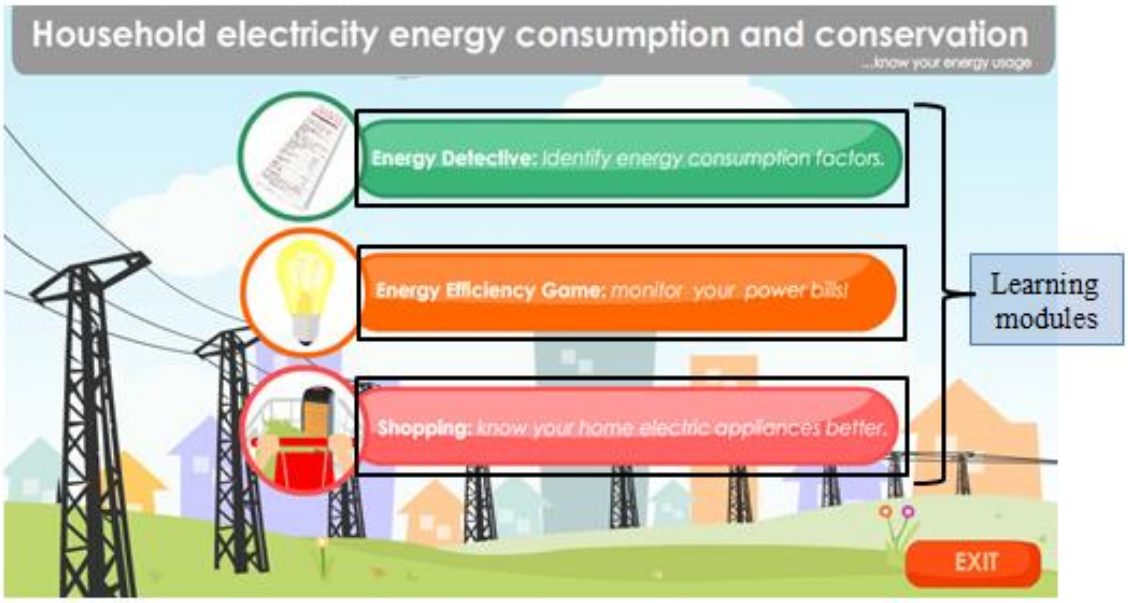


Figure 4.2 Learning modules in the developed instructional unit

Based on the design rationale the instructional unit is developed; it consists of three different types of learning modules as shown in Figure 4.2. Before learners go into those learning activities, the learning concept is being introduced with an engagement phase. In this phase, learners' prior knowledge is tested by involving them into a scenario that commonly happens at home. This scene develops curiosity in learners for learning factors affecting energy consumption by those electrical appliances used at home. Now the learning modules are introduced, viz. Energy Detective, Energy Efficiency Home and Shopping.

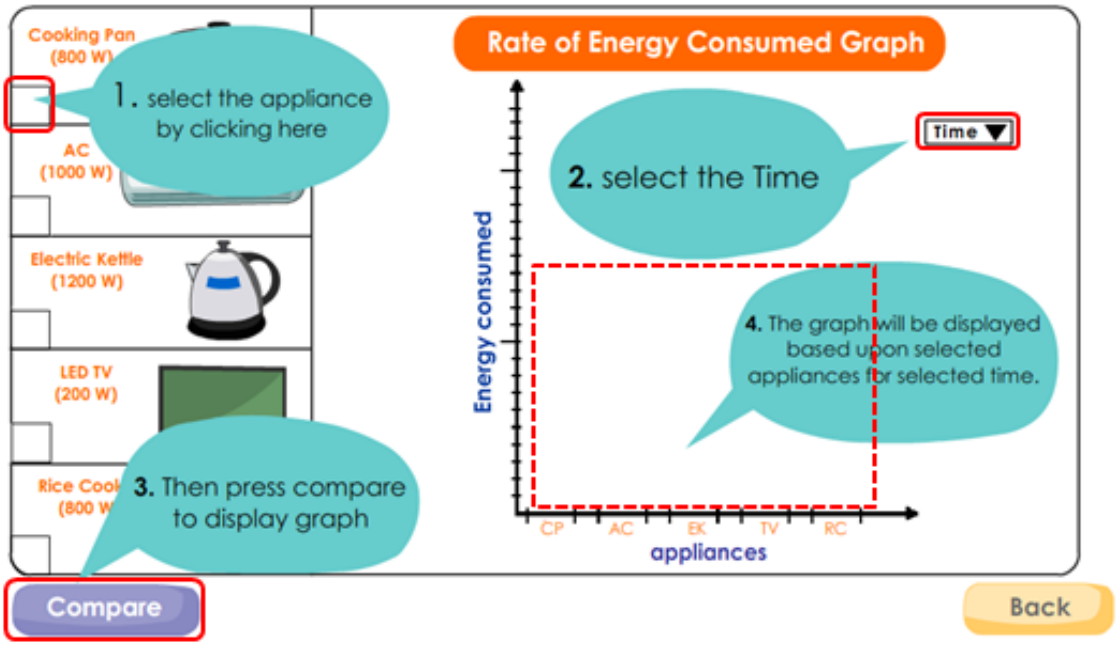


Figure 4.3 Energy detective learning module interfaces

The objective of "Energy Detective" module is to identify energy consumption factors in electrical appliances. This learning module starts with case study scenarios; the learner is the detective, he/she has to explore cases individually to find out the factors responsible for energy consumption. Each case consists of interactive learning activity, whereby the learner can chose those commonly used electrical appliances and time/ duration of usage to compare the energy consumption as illustrated in Figure 4.3. Then the simulated graph will display the energy consumed by each selected items. Based upon displayed graph, series of questions will be asked which help learners to develop self-explanation for identifying the factors for

energy consumption in appliances. For clear visualization of concept, learners can revisit the activity again and again. At the end of the investigation, learner's conceptual understanding is evaluated with multiple choice questions (MCQ). If they (student) are not confident they can revisit the units, otherwise the lesson is extended further where students are introduced with concepts of electrical energy in relation with power (watt), voltage (volt), current (ampere) and time (second). It also includes meaning of electric appliance rating, formula for calculating energy consumption by each electrical appliance, monthly electric bill and more.

"*Energy isn't free. You have to pay for all the electricity that you use in your house. So wasting energy is same as wasting money - and we know that is not a good idea!*"

The objective of "Energy Efficiency Home" is to know how energy consumption is calculate in term of money and also how can they apply those identified factors in monitoring power bill by playing interactive game as shown in Figure 4.4. The game is designed with scenarios of our home, comprising electrical appliances that are commonly operated. It is classified into various levels; player can go to those levels by passing each level.

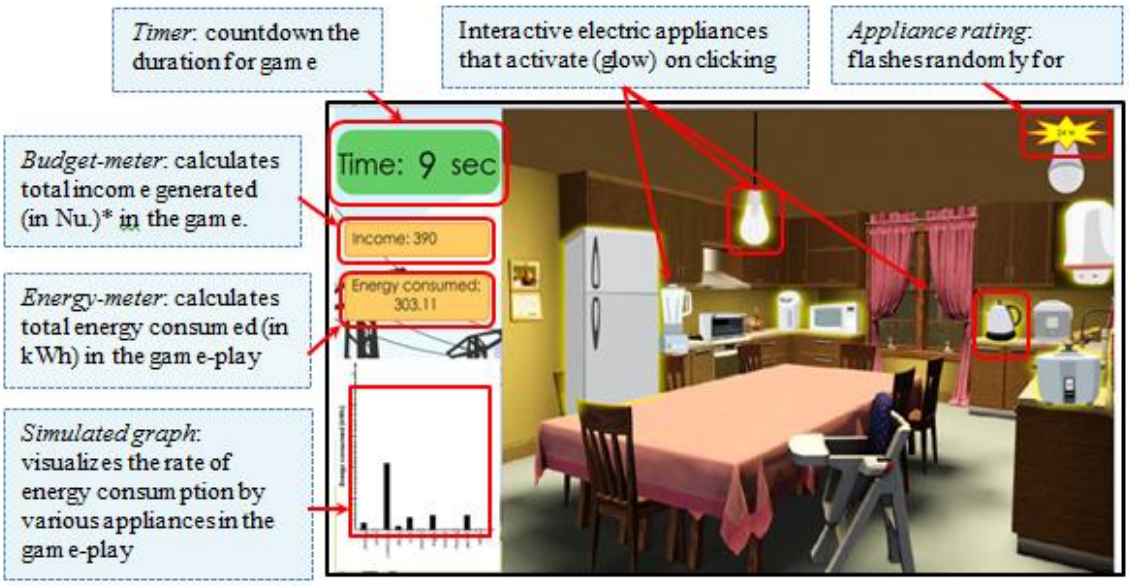


Figure 4.4 Learning interfaces in energy efficiency game module

To get into another level of the game, player (student) should have enough income/budget earned from current stage. For that player should hunt/collect hidden

coins which depend upon wattage of those appliances in that room. Player (student) has to take cautious decisions on selecting appliances to get those coins because every time he/she collects coins it activates that appliance which then consumes energy, and he/she has to pay at the end. So, player (student) has to study the wattage of each appliance that will be shown randomly at certain interval. The value of hidden coins in each appliance remains constant whether it is chosen at the beginning or at last, but the energy consumption depends on wattage of the appliance and duration of usage. While playing the game, whatever coins are accumulated and how much energy has consumed are automatically calculated and displayed in graphical format at the side of the game screen. These help students to apply their theoretical knowledge, skills and strategies to make decisions in their assigned role which promotes the understanding of concept. At the end of 30 second, the game automatically stops by displaying "Time Up", after that simulated graph for energy consumption will be displayed for those appliances that the player operated during the game. Based on that, cost for energy consumed is calculated and then saving of the player is shown (your saving = income – cost of energy). If the saving is positive, the player can continue the game in second stage otherwise he/she cannot go further or can play again. The game is designed in line with practical situations of energy consumption in our daily life. To save money, minimize energy consumption and this helps in developing sense of awareness on energy conservation.

The objective of the "Shopping" learning module is to develop awareness on energy conservation while operating household electrical appliances. In this module, students play a simulation game which is designed with a scene of shopping mall. Player (student) is engaged in choosing commonly used electrical appliances by drag and drop into the shopping cart as shown in Figure 4.5. During the selection, he/she has to explore carefully because there are many appliances that are used for same purposes at our home but the energy consumption by each of them is different. So, choosing appropriate and the best energy efficient appliances not only use the energy less (do not waste energy) but save huge amount of money as a whole. During the game, player (student) makes decision in choosing the required appliances from given list of similar items within the given time (60 seconds). Player (student) awareness on energy conservation is then evaluated at the end of 60 second by

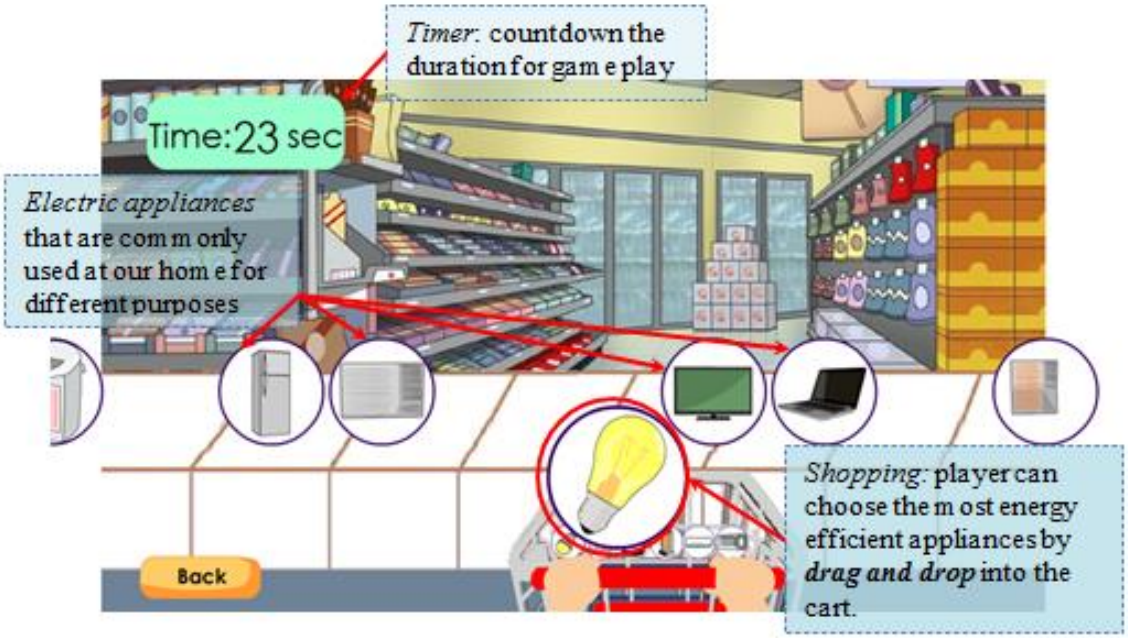


Figure 4.5 Learning interfaces in shopping game module

displaying a table containing that items he/she selected. The table consists of appliance name, wattage and remarks. Each item in the table has its commonly rated wattage which is self-explanatory for the rate of energy consumption. Still the appliance is energy efficient if operated wisely, this is elaborated in remarks column for each item which provides lots of knowledge about easy ways to save energy at home. For example, the best ways to save energy at home:

- Shut off the lights when you are done using them, and unplug the connection of the TV, computer, video games and other electrical stuffs when you leave the room because some of them still use electricity for its auto program.

- Do not leave the refrigerator door open. Every time you open the door, up to one-third of the cold air can escape. It is an energy lost.

- Buy energy-smart light bulbs and use appliances in right ways: Replace a burnt-out light bulb and incandescent light bulbs with a new compact fluorescent bulb as it use 75 percent less energy and they last 10 times longer.

- Take a short shower instead of a long bath. It might take 25 gallons of hot water to fill the bathtub, compared to only seven gallons for a quick shower.

- Close the curtains during hot summer days to block the sun. During the winter, keep the curtains open to let heat in and etc.

4.2 Learning model

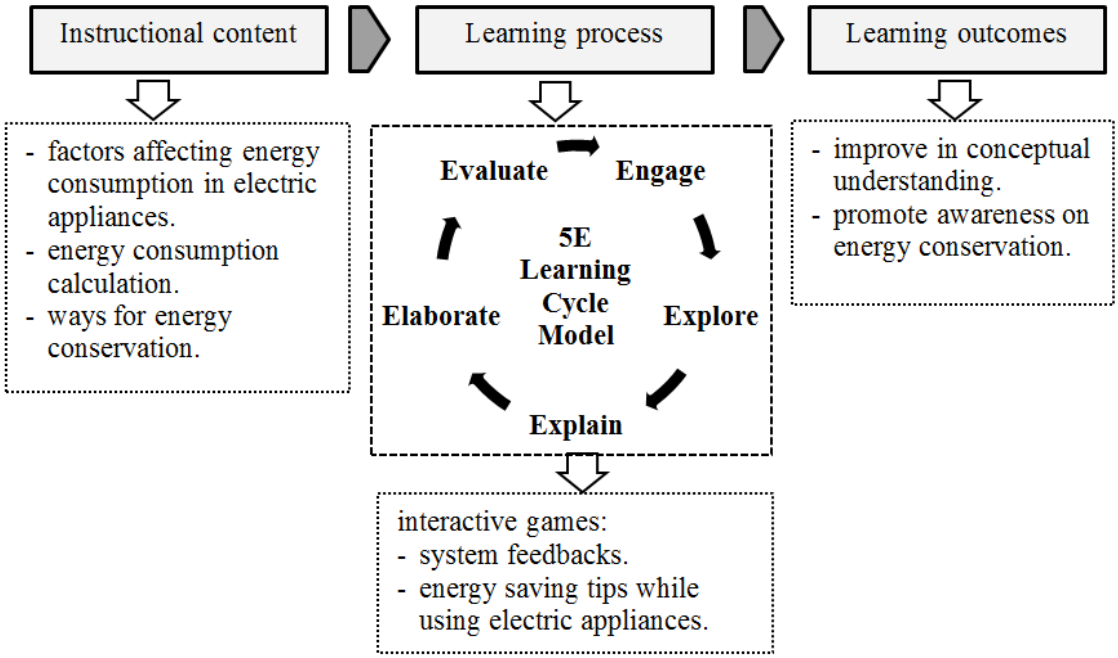


Figure 4.6 The learning model in the multimedia-supplemented instructional unit

Figure 4.6 shows the learning model in multimedia-supplemented instructional unit. It comprises three steps: instructional content, learning process and learning outcomes. The instructional content includes identifying the factors affecting energy consumption and how to calculate energy consumed, and also the ways to conserve energy. These contents are learned through the process of 5E learning cycle model; which include interactive games that provide system feedbacks and energy saving tips when using those electric appliances.

The 5E learning cycle model consists of following 5 phases: engagement, exploration, explanation, elaboration and evaluation as shown in Table 4.1. Through these 5 phases of learning cycle, students can explore new concepts, re-evaluate their post experiences and adjust their new experiences and concepts into their existing knowledge patterns. Eventually, this provides students learning experiences that enhance conceptual understanding about the subject (Bybee, 2006). So, in the learning process the players (students) are always triggered with awareness on energy consumption which helps them to transform knowledge into promoting awareness on

energy conservation. Consequently, this would promote awareness on energy conservation and enhance conceptual understanding of subject when students learn with the supplementary instructional unit.

Table 4.1 Phases of 5E learning cycle embedded in developed instructional unit

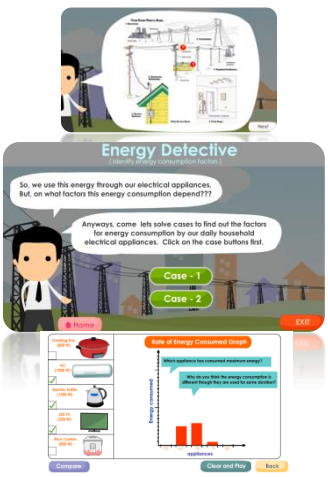
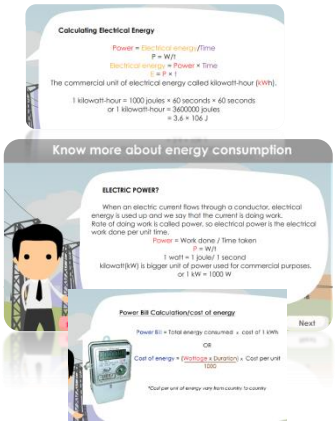
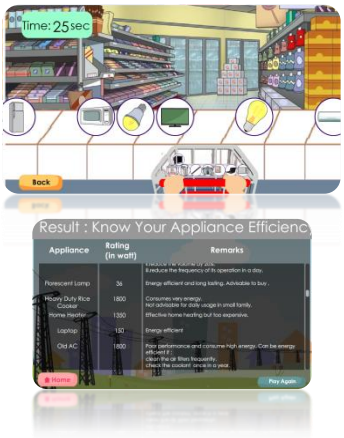
Phases of 5E learning cycle model	Pictorial representation	Learning activities
Engagement		The lesson begins with scenario that commonly happens at our home. Example, father gets a monthly power bill claiming Nu. 6,500/-. But his monthly salary is just Nu. 10,000/- now he has pay ***more than 50%*** of his income just on power bill. This arise curiosity and engage students to investigate the cause of power consumption. Teacher further encourages them with some common questions, like - list down electrical appliances operated at our home? - any idea how much energy is been consumed by those appliances? Eventually, teacher will link to learning unit.
Exploration		To investigate reason for high power bill, students explore the cases in "Energy Detective"- interactive simulated learning module to identify the factors for energy consumption. It also explains, elaborates and evaluate students understanding on transmission of electricity to our home, how power bill is calculated, unit of electrical energy is derived, etc. In the meanwhile, teacher keeps note of the findings and reinforce participants to find reasons to support their findings.

Table 4.1 Phases of 5E learning cycle embedded in developed instructional unit (Cont.)

Explanation		After exploring through the interactive units to identify the factors for energy consumption, students solve problems provided in the worksheets and present their findings to the class. Teacher then displays and compares their findings, and ask them to summarize the findings in identifying the factors for energy consumption in electrical appliances. Subsequently, teacher introduces important formulas, relations and units related to energy consumption context.
Elaboration		Theoretical knowledge of energy consumption is then extended into the interactive game "Energy Efficiency Game: know your power bill". This provide students opportunity to apply the abstract concept of energy consumption to into practical, which help them to visual and understand clearly in a playful way. Students find ideas about rate of energy consumption and how to conserve it. Thus, the knowledge on energy consumption is elaborated into energy conservation. In the meantime, teacher ask the students the ways of saving more money while playing the game and encourage them to share the ideas with rest of the friends.
Evaluation		"Shopping: know your home electric applaince better" is an interactive game, students can interact and choose commonly used home electrical appliances from the list. This module evaluates students' self-awareness in using electrical efficient appliances to conserve energy. Further, teacher elaborates the this context into daily life situations and provide additional information on it and provide opportunity to students to share their knowledge on energy saving at their home and school. Finally, the teacher summarize/ debrief on the learning unit.

Summary

The developed multimedia-supplemented instructional unit for learning household electric energy consumption and conservation offers unique advantages in classroom teaching. It provides ways by which learners can experience their subject in different manners. The developed multimedia brings the world (reality) into the classroom and appeals to different learning styles, actively engaging students. While learning through this multimedia, the students are provided opportunity to think more critically about their own progress and abilities. Moreover, it includes interactive games, animations and simulations with learning objectives that replicate real life scenarios that help students to relate their classroom learning with real life situations. The developed instructional media follows the design rationale for the proposed game-based learning units that guide the students to transforming their knowledge on electric energy consumption related to awareness on energy conservation. Furthermore, these learning modules are embedded within 5E learning cycle model based on inquiry-based learning approach. It helps learners engaged in a new concept by relating their previous knowledge by exploring and explaining through their experiences, then elaborating on what they have learned, and eventually evaluating their understanding on that new concept under the guidance of teachers. Eventually, this enhances students' conceptual understanding of subject and develops better sense of awareness on energy conservation.

CHAPTER V
RESEARCH METHODOLOGY

Overview

This chapter describes the general procedure adopted to collect data for the study. It is a quasi-experimental study where the researcher used two groups of samples, experimental and control group. The chapter composes of the research design and information on how the population and sampling was done for the study. It also talks about the development of the research instruments and its validity and reliability. In the last part of the chapter, it includes the procedure for data collection and data analysis.

5.1 Research design

The objectives of this study was to examine the students' learning achievement and awareness level on electrical energy consumption and conservation and also to investigate the students' attitude on the developed multimedia-supplemented instructional unit for learning household electrical energy consumption and conservation in grade 10 Bhutanese student. The research type is quasi-experimental in nature, so the researcher used quantitative method using MCQ for pre- and post-achievement tests and Likert scales for awareness and attitude survey questionnaires.

Experimental researches have a unique ability to demonstrate cause and effect of relationships, where changes in the independent variables produce resultant changes in the dependent variables. Although true experiments are preferred, but quasi-experimental designs are considered worthwhile because they permit researchers to reach reasonable conclusions even though full control is not possible (Ary, Jacobs, Razavieh, & Ary, 2009). Therefore, this study implemented quasi-experimental design as shown in Figure 5.1 to fulfill the set objectives of the study.

In the study, the achievement test items were developed to compare the achievement level between the two groups before and after the use of multimedia-supplemented instructional unit for that lesson. To assess students' level of awareness on energy conservation, the awareness survey questionnaires using 3-points Likert scale was developed and administered before and after the lesson for both control and experimental groups. Finally, to survey students' attitude level on the developed multimedia, 5-points Likert scale attitude questionnaire was developed and conducted after completion of lesson in the experimental group only.

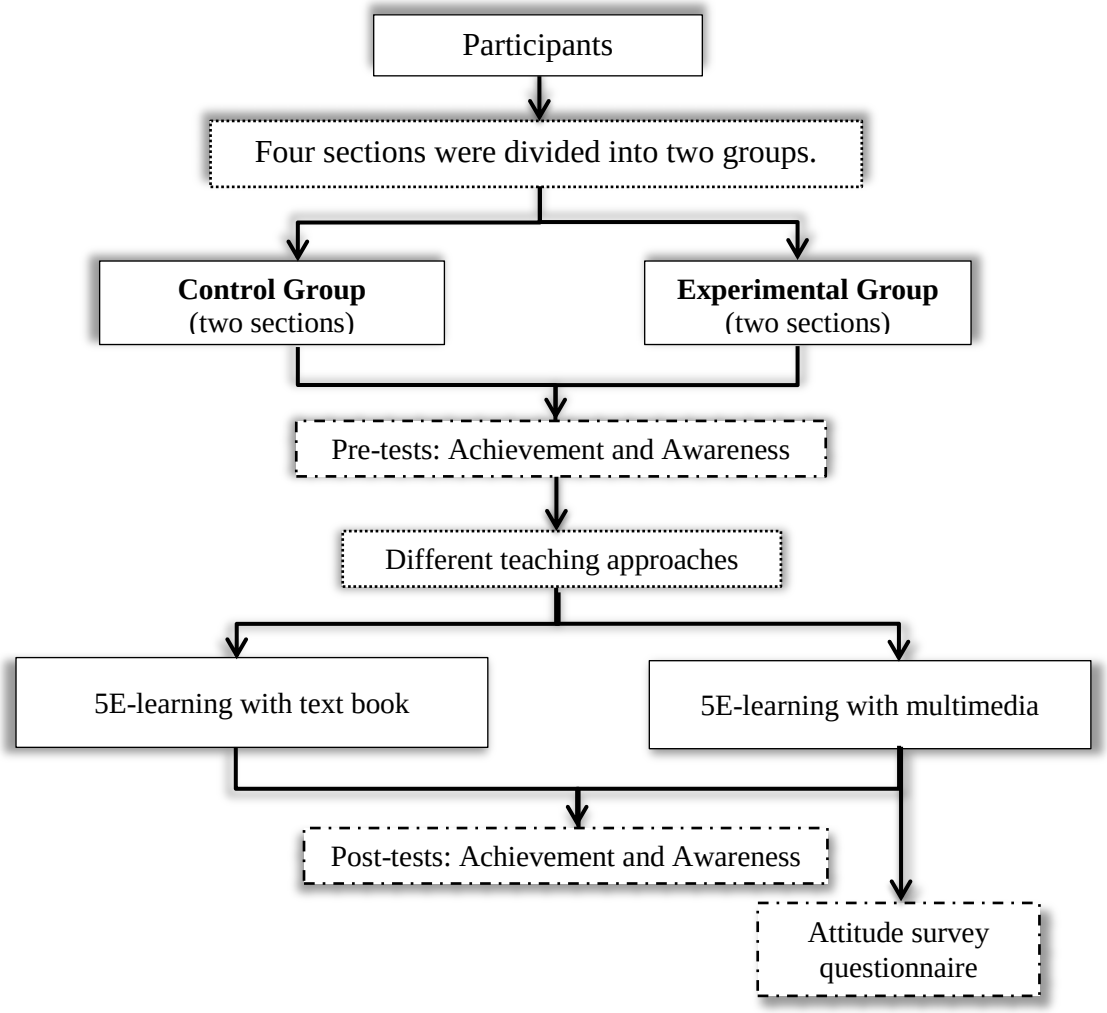


Figure 5.1 Research design for the main study

5.2 Population for the study

The main objective of this study is to examine the students' learning achievement on the electrical energy consumption and awareness on the energy conservation using developed multimedia-supplemented instructional unit. It also focuses on investigating the students' attitude towards the developed learning unit for household electrical energy consumption and conservation taught in grade 10 physic course. Therefore, all grade 10 students studying Bhutanese science curriculum is taken as population of the study.

But for this experimental study, grade 10 students of one of the school in Bhutan are taken as sample. The research site is located in Trashigang district, eastern part of the country. The district has 69 schools including 9 ECR[1], 41 PS[2], 10 LSS[3] and 4 HSS[4]. The study was carried out in one of the higher secondary school. The research school had the class level from 9 to 12 with 550 students and 30 teachers. Since it is higher secondary, it offered science, commerce and arts streams for students in grade 11 and 12 only (Policy and Planning Division, Ministry of Education, Royal Government of Bhutan, 2012). The focus group for this study was grade 10 students studying electrical energy lessons in physics. Reason behind choosing grade 10 students were that subject physics was compulsory subject in that grade and the developed multimedia-supplemented instructional unit for learning household electrical energy consumption and conservation was applicable under electrical energy topic in physics. So, 135 grade 10 students registered to participate in the study.

As per the nature of the research design, the required number of sample size in each group was approximately 65[1]. According to 2013 academic year statistic of the school, total of 135 students were registered in four sections of grade 10. All students from four sections volunteered and registered for participating in the study.

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[1]**Sample Size Estimation for t-test statistics:** The minimum sample size for each group is calculated by the formula: $\boldsymbol{n/group = 2\left[\frac{(Z_{\alpha/2}+Z_{\beta})\sigma}{\Delta}\right]^2}$

n = **sample size**,

σ = **common SD of outcome var. in group 1, 2**

Δ = **difference in mean b/w 2 groups**

α = 0.05, β = 0.2 and effect size(Δ/σ)**=0.5**

So, there were about 67 students in each group, which was sufficient to satisfy the requirement for the research activities.

ECR[1] = Extended Class Room, PS[2] = Primary School, LSS[3] = Lower Secondary School, HSS[4] = Higher Secondary School

5.2.1 Sampling technique

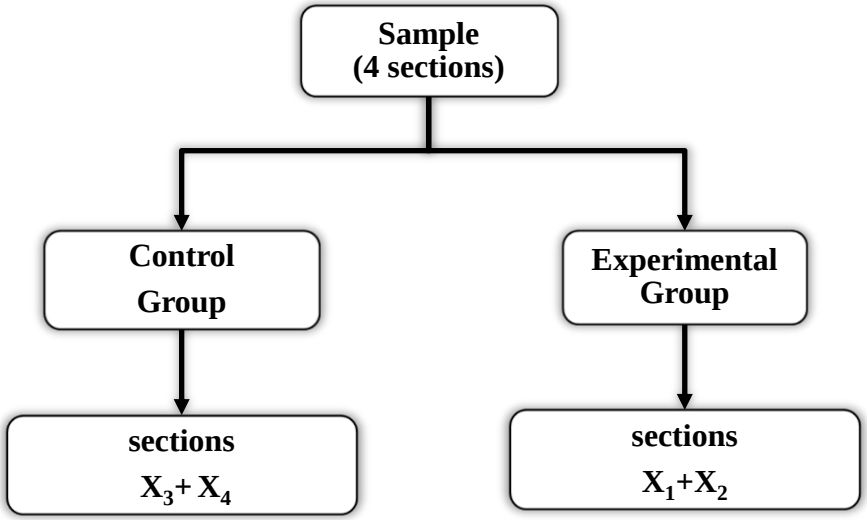


Figure 5.2 Sampling technique

Of 135 students from four sections of grade 10 who registered to participate, were divided into two groups. For more convenient they were grouped based upon their sections. So, these sections were randomly divided into two groups with two sections as control (X_3+X_4) and another two sections as experimental groups (X_1+X_2) respectively as shown in Figure 5.2. Each group had about 67 participants of equivalent number of genders.

5.2.2 Learning ability

To know the students' learning ability, mid-term examination report in physics subject of each student was studied before segregating them into control group and experimental group. The aim of this was to make sure that students in both groups were similar academic learning ability in physics in order to get the expected results.

5.3 Research instruments

The following instruments were used in collecting data from the samples.

5.3.1 Achievement tests

The achievement tests were classified into two categories, pre- and post-test respectively. Both the tests consist of 20 items each (refer to Appendix B) but were parallel in nature. The test items were purely based on the concept/content that was taught with the following learning objectives:

1. To identify factors that determines electrical energy consumption in electrical appliances.

2. To calculate the energy consumption and cost for operating daily used household electrical appliances.

The level of difficulty and discrimination of the items were examined based upon the scores and remarks set by pilot test and the experts. The instruments were revised and improved accordingly as per the experts' comments and recommendations to better appropriate for the students of grade 10 in the Bhutanese science context. Finally, the test items were validated by three Bhutanese experts who has experienced in teaching these contents for more than four years, and the cumulative index of item-objective congruence (IOC) were determined for pre- and post-conceptual tests respectively. For investigating the reliability of the instruments, it was surveyed with a group of students who have already learnt the concept in one of the higher secondary school in Bhutan, and the Cronbach's alpha coefficient for internal consistency reliability were also determined separately. Based upon its scores the instruments were acceptable and were made fit for this research.

Pre-Conceptual test

The objective for implementing pre-test was to determine the level of knowledge that the student possessed prior to teaching of the lessons and also to find homogeneity in learning ability. So, it was conducted before the start of the lesson in both the control and experimental group respectively. The test items were checked and tested, and the aggregate score/index of item-objective congruence (IOC) was determined 0.64 and the Cronbach's alpha coefficient was 0.626 which was

considered as reliable. It also had an overall difficulty index of 0.732 that remarked the items were of average difficulty.

Post-Conceptual test

Similarly, the objective of administrating post-test was to investigate students' level of achievement in the subject after participating into two different interventions and also to compare the effects of the developed supplementary-instructional unit with the conventional teaching approach in term of learning outcomes, for learning electrical energy consumption and conservation lessons. So the test was implemented at the end of lesson in both the groups. As of item-objective congruence (IOC) index, it had an average score of 0.62 and the reliability index for Cronbach's alpha coefficient was 0.566, which were acceptable. The items were remarked as an average difficulty with overall difficulty index of 0.612, which are appropriated for the students.

5.3.2 Awareness questionnaire

The Awareness questionnaire was adapted from Kang, Cho and Kim (2012) which was published in energy and building journal. The items in the questionnaire were revised and standardized accordingly as per the pilot study remarks and experts' comments as to fit into the Bhutanese grade 10 students' understanding. The final set of items in the questionnaire was validated by three Bhutanese teachers who had experience in the relevant subject and was scored 0.77. To find reliability for internal consistency of the items, it was piloted with grade eleventh students who already learned this concept, in one higher secondary school at Trongsa, Bhutan. The finding revealed that Cronbach's alpha coefficient was 0.99 which indicated good questionnaire. The questionnaire consists of 50 items as shown in Appendix C. They were grouped into six categories: window insulation, room heating, cooling, lighting, energy stars and house appliances. It measures degree of awareness on energy conservation.

The questionnaire used 3-points Likert scale representing 3 for "Know very well", 2 for "Know some of them" and 1 for "Don't know at all" as shown in Table 5.1.

Table 5.1 3-points Likert scale to measure degree of awareness on energy conservation

Degree of Awareness	Scores
Know very well	3
Know some of them	2
Don't know at all	1

The data collected from this questionnaire were analyzed by mean scores and standard deviations to determine the degree of awareness on energy conservation. The means of degree of awareness were then compared to the predetermined criteria as shown in Table 5.2.

Table 5.2 Criteria to measure the degree of awareness on energy conservation

Mean score of students awareness	Students Awareness
1.00 - 1.50	No Awareness
1.51 - 2.50	Moderate Awareness
2.51 - 3.00	High Awareness

Pre-Awareness Questionnaire

The objective for implementing pre-awareness survey questionnaire was to investigate the degree of awareness on electrical energy conservation that the student possessed before learning the lessons and also to find homogeneity in learning ability in both the groups. So, it was conducted simultaneously with pre-conceptual test, before the start of the learning activities in both the groups respectively.

Post- Awareness Questionnaire

Same questionnaire was used in the post-awareness survey but with the different objectives. Here, the focus were to investigate students' degree of awareness in the subject after learning through into the interventions, and also to compare the learning outcomes of two different interventions in enhancing the awareness level for

energy conservation. Therefore, the questionnaire was implemented after completing the lesson in both the groups.

5.3.3 Attitude questionnaire

The attitude questionnaire was adopted from Subba (2011). It consisted of 18 items as referred in Appendix D, which were categorized into three categories: interest, participation, and satisfaction. The questionnaire was used to investigate students' attitude level towards the developed multimedia-supplemented instructional unit for learning household electrical energy conservation and conservation through students' interest, participation and learning satisfaction. The questionnaire was very much suitable with the research objective and moreover it had high internal consistency reliability with the Cronbach's alpha of 0.877.

Since the survey questionnaire was used for measuring students' attitude level towards the developed multimedia-supplemented instructional unit, it was administered only with the participants in the experimental group after completing the whole teaching learning session.

To measure learners' attitude level, questionnaire items used 5-points Likert scale. For measuring "Interest" and "Participation" levels; 5 represents for "Strongly agree", 4 for "Agree", 3 for "Neutral", 2 for "Disagree" and 1 for "Strongly disagree". Whereas in "Satisfaction" category; 5 represents for "Highest Satisfaction", 4 for "High Satisfaction", 3 for "Moderate Satisfaction", 2 for "Low Satisfaction" and 1 for "Least Satisfaction" as given in Table 5.3.

Table 5.3 5-points Likert scale to measure student's attitude

Categories	Scores	Level
1. Interest 2. Participation	5	Strongly agree
	4	Agree
	3	Neutral
	2	Disagree
	1	Strongly Disagree
3. Satisfaction	5	Highest satisfaction
	4	High satisfaction
	3	Moderate satisfaction
	2	Less satisfaction
	1	Least satisfaction

The data collected from this questionnaire was analyzed in term of mean scores and standard deviations to determine learners' attitude toward developed instructional unit in teaching electrical energy lesson. The means score from each item was then compared to the predetermined criteria shown in Table 5.4.

Table 5.4 Interpretation of students' attitude level

Categories	Mean Score	Interpretation
1. Interest 2. Participation	1.00 - 1.50	Strongly disagree
	1.51 - 2.50	Disagree
	2.51 - 3.50	Neutral
	3.51 - 4.50	Agree
	4.51 - 5.00	Strongly agree
3. Satisfaction	1.00 - 1.50	Least satisfaction
	1.51 - 2.50	Low satisfaction
	2.51 - 3.50	Moderate satisfaction
	3.51 - 4.50	High satisfaction
	4.51 - 5.00	Highest satisfaction

5.4 Data collection

Administrative and ethical procedures were strictly followed to get approval to conduct the study with the focus group of students. Research approval letter issued from the Graduate Study of the university was taken into reference to get approval from the District Education Officer, Trashigang, Bhutan well in advance. Formally, the school administrator (principal) was approached to get permission to conduct the study in his school. After getting the approval from the school principal then class teachers and the physics subject teacher(s) teaching in 10^{th} grade were informed about the research details and other necessary arrangements were made accordingly. The study was then deployed for 90 minutes (block periods- 45 minutes per period) for experimental group and control group separately. Control group was taught with the lesson plan in traditional teaching method (lecture with 5E learning cycle approach) with supplementary text books. Whereas for experimental group, the researcher used the same lesson plan but integrated with developed multimedia-supplemented instructional unit and was taught in traditional method. Learning in both groups had same student activities. So, teaching in control group took first and then in experimental group in following days. Students in both the groups took all the tests and submitted the questionnaire to the researcher for analyzing the results.

Participants' anonymity was maintained strictly. None of the students were allowed to use their personal information in all data collection items; instead they used random codes generated during the study.

5.5 Data analysis

To analyze data, following procedure were used with help of SPSS software:

i. Demographic data were analyzed using frequency and percentage.

ii. The inferential statistics with $p<0.05$ level of significance was used to analyze the data to compare the pre-and post-achievement tests of two groups.

iii. The data collected through awareness questionnaires were analyzed by *t*-test.

iv. Attitude questionnaire data were analyzed by descriptive statistics using frequency, percentage, mean and standard deviation.

Summary

Table 5.5 shows the summery of study including research questions, objectives and tools for collecting data.

Table 5.5 Research questions, research objectives and research tools

Research Questions	Research Objectives	Research Tools
1. To what extent can the developed multimedia-supplemented instructional unit help students find out the household electrical energy consumption?	1. To examine the students' learning achievement on the household electrical energy consumption and conservation	1. MCQ pre- and post-test questions
2. What is student's level of awareness of energy conservation?	2. To measure the students' awareness level on the energy conservation.	2. Pre- and post-Awareness questionnaires
3. What is students' attitude towards the developed multimedia-supplemented instructional unit?	3. To investigate the students' attitude towards the developed multimedia-supplemented instructional unit	3. Attitude questionnaire

CHAPTER VI
RESULTS

Overview

This chapter presents the key findings of the research study, the result of using multimedia-supplemented instructional unit for learning household electrical energy consumption and conservation in grade 10 physics lesson in one of the higher secondary school in Trashigang, Bhutan. Of 135 students registered only 131 students were able to participate in the study. The students in the experimental group were taught using developed multimedia instructional unit as supplementary materials, whereas the students in control group were taught in 5E learning cycle without multimedia instructional unit (using chalk, chalkboard and text books as supplementary materials). Moreover, this chapter reflects detail about the results from the pre- and post-test of both conceptual and awareness tests. It also shows the significant of implementing developed multimedia-supplemented instructional unit for learning household electrical energy consumption and conservation over the traditional teaching and learning method in terms of students' achievement and attitude towards multimedia supplemented instructional unit.

6.1 Learning achievement analysis

To answer the first research question, "to what extent can the developed multimedia-supplemented instructional unit help students find out the household electrical energy consumption?" and its corresponding research objective, "to examine the students' learning achievement on the household electrical energy consumption and conservation" the pre and post-test were administered in both the groups. The main purpose of pre-test was to examine students' prior knowledge about the content of the subject in both the control and the experimental groups. Whereas, the post-test focused to investigate students' level of achievement in the subject after participating

into two different interventions and also to compare the effects of the developed supplementary-instructional unit with the traditional approach in term of learning outcomes, in teaching electrical energy consumption and conservation lessons in grade 10 physics class. Before conducting the inferential statistic tests, data normality tests were conducted and found that pre-test scores from both control and experimental groups were normally distributed by Shapiro-Wilk tests of $p>0.05$ (control: $p=0.158$ and experimental: $p= 0.148$). Therefore, it was dealt with parametric hypothesis test, *t*-test for independent samples. Statistical analysis was conducted between two groups and the mean score and standard deviation of experimental and control group were compared as shown in Table 6.1

Table.6.1 *t*-test results to investigate students' prior knowledge in different groups

Groups	**N**	**Mean ± SD**	***t***	***p*-value**
Control Group	60	7.52 ± 2.244	0.230	0.409
Experimental Group	69	7.61 ± 2.289		

According to results from *t*-test for independent samples, the mean and standard deviation of pre-test for the experimental group was 7.52 ± 2.244, and of control group was 7.61 ± 2.289 with *p*-value of 0.409. There was no significant difference in the scores ($t=0.230$) and also the *p*-value of the test was greater than significant *p*-value of the study (i.e. $p=0.05$). So, the conclusion was made that the result was statistically not significant. Thus, it was concluded that students in both the groups had similar prior knowledge/concept regarding energy consumption and conservation.

However, in order to explore the effect of each treatment, another analysis was conducted to compare the learning improvement of the students in the two groups (i.e., control and experimental groups). Before conducting the inferential statistic test in control group, the data normality between pre- and post-test scores were tested. As per the Shapiro-Wilk test, it was found that the pre-test scores were normally distributed ($p=0.156$), but the post-test scores were not normally distributed ($p=0.021$). Similarly in experimental group, the pre-test scores were normally distributed by ($p=$

0.148) but its post-test scores were not normally distributed (p=0.002). Therefore, it was dealt with non-parametric hypothesis test; Wilcoxon test to analyze the pre- and post-test results as shown in Table 6.2. It was found that the overall learning outcomes in both groups have improved after participating in the study. But on further data analysis it was observed that there were differences in their improvement.

Table 6.2 Wilcoxon's matched pairs test result for students' achievement level after participating in the study

Group	N	Pre-test	N	Post-test	*z*	*p*-value
Cont. Gr.	60	7.52 ± 2.244	52	10.08 ± 3.330	3.775	0.000*
Exp. Gr.	69	7.61 ± 2.289	69	11.97 ± 3.839	6.091	0.000*

* $p < 0.05$

Regarding control group, pre-test mean and standard deviation were 7.52 ± 2.244 and in post-test were 10.08 ± 3.330. So, there was increased in mean by 2.44 with *z*-value of 3.775, this indicated that there was a significant difference in students' achievement level after participating in the study. Also the calculated *p*-value was 0.000, which was less than significant *p*-value 0.05(i.e. $p<0.05$). Thus, the conclusion was made that the result was statistically significant. Similarly, in experimental group the post-test mean and standard deviation increased to 11.97 ± 3.839 from the pre-test score of 7.61 ± 2.289 by 4.36 ± 1.550 with *z*-value of 6.091. The calculated *p*-value was 0.000, which was less than significant *p*-value 0.05(i.e. $p<0.05$). Thus, the conclusion was made that the result was statistically significant, which stated that students' conceptual understanding on the subject was better after their participation in this study.

Furthermore, to explore how the learning achievement was affected by the treatments after the implementation of the developed learning unit, the post-test scores of both control and experimental groups were analyzed with non-parametric hypothesis test; Mann-Whitney U test as shown in Table 6.3.

Table 6.3 Mann-Whitney U test result for students' post-test achievement scores

Groups	N	Mean ± SD	*z*	*p*-value
Cont. Gr.	52	10.08 ± 3.330	2.537	0.005*
Exp. Gr.	69	11.97 ± 3.839		

*$p < 0.05$

The result of the mean and standard deviation of the experimental group was 11.97 ± 3.839, and that of control group was 10.08 ± 3.330. The calculated *z*-value was 2.537 and the *p*-value was 0.003 (i.e. $p<0.05$). This indicated that the result was statistically significant as the *p*-value was lower than the significant *p*-value of the study (i.e. 0.05) and moreover the mean score of the experimental group was higher than control group by 1.894. Therefore, the result advocated that the developed multimedia-supplemented instructional unit for learning household electrical energy consumption and conservation had positive influence in learning the concept compared to the traditional method.

6.2 Awareness analysis

To answer the second research question, "what is student's level of awareness of energy conservation?" The awareness questionnaire was surveyed with an objective to measure the students' awareness level on the energy conservation. So, the awareness tests were administered using "Awareness of the Energy Saving which can be practiced easily at home" questionnaire. There were total of 50 questions in the questionnaire (grouped into six categories: window insulation, room heating, cooling, lighting, energy stars and house appliances) to measure individual awareness on energy conservation. Students were asked to rate this consumers' life habit questionnaire using 3-points Likert scale (1= "Don't' know at all", 2= "Know some of them", 3= "Know very well").

Table 6.4 Comparison of students' prior knowledge about "Awareness on energy conservation"

Awareness	Mean (SD)	Cont. Gr.	Exp. Gr.	*t*	*p*-value
Window: Awareness on windows insulation with minimum energy lost.	**1.80**(0.31)	1.85(0.32)	1.76(0.31)	1.63	0.052
Room Heating: Awareness on heating rooms with minimum energy lost	2.11(0.44)	2.17(0.43)	2.05(0.44)	1.53	0.065
Cooling: Awareness on using different electrical appliances for cooling rooms.	2.01(0.46)	2.09(0.43)	1.92(0.53)	1.93	0.028*
Lighting: Awareness on lighting rooms for less energy consumption.	**1.96**(0.58)	1.88(0.58)	2.04(0.57)	1.57	0.060
Household Appliances: Awareness on daily life habits in operating household appliances to minimize energy conservation.	2.05(0.31)	2.08(0.32)	2.02(0.30)	1.05	0.149
Energy Stars: Awareness on buying electrical appliances looking into Energy Star Rating for it energy efficiency.	**1.91**(0.70)	1.87(0.72)	1.95(0.67)	0.61	0.272

*$p < 0.05$

According to the pre-awareness survey result as shown in Table 6.4, it was found that students had fairly good ideas about the awareness on energy conservation such as "Awareness on heating rooms with minimum energy lost (Heating room)", "Awareness on using different electrical appliances for cooling

rooms (cooling)", "Awareness on daily life habits in operating household appliances to minimize energy conservation (Household Appliances)", but they had comparatively lower awareness about the "Awareness on windows insulation with minimum energy(window)", "Awareness on lighting rooms for less energy consumption (Lighting)", "Awareness on buying electrical appliances looking into Energy Star Rating for it energy efficiency (Energy Stars)" as shown in the bold text in Table 6.4.

When classifying this into groups, the survey result showed that the participants in both the groups had similar level of awareness towards energy conservation. Statistically, there was no significant difference in participants' prior knowledge about awareness on energy conservation in both groups except in term of the 'cooling' factor*. The result indicated that participants in the control group exhibited better awareness in term of using electrical appliances for cooling rooms than that those participants in experimental group. This might be because the study was conducted in that location of country where they did not have to operate those electrical appliances for cooling the rooms, so majority of the students studying in that school did not have good knowledge about those electrical appliances.

T**able 6.5** Level of awareness on energy conservation between two groups of participants learned through different interventions

Awareness	Mean (SD)	Cont. Gr.	Exp. Gr.	*t*	*p*-value
Window: Awareness on windows insulation with minimum energy lost.	**2.55(0.40)**	2.48(0.44)	2.62(0.37)	-1.97	0.03*
Room Heating: Awareness on heating rooms with minimum energy lost	**2.43(0.40)**	2.36(0.42)	2.50(0.39)	-1.95	0.03*
Cooling: Awareness on using different electrical appliances for cooling rooms.	**2.50(0.47)**	2.41(0.58)	2.60(0.36)	-2.19	0.02*
Lighting: Awareness on lighting rooms for less energy consumption.	**2.66(0.46)**	2.56(0.58)	2.75(0.34)	**-2.38**	0.01*
Household Appliances: Awareness on daily life habits in operating household appliances to minimize energy conservation.	**2.56(0.31)**	2.53(0.36)	2.60(0.26)	**-2.93**	0.00*
Energy Stars: Awareness on buying electrical appliances looking into Energy Star Rating for it energy efficiency.	**2.47(0.51)**	2.40(0.62)	2.54(0.41)	**-2.51**	0.01*

*$p < 0.05$

Table 6.5 shows the participants' level of awareness on energy conservation who participated in two different interventions; it advocated that overall students' consciousness on electrical energy conservation had enhanced after taking part in this study as indicated by the average mean(SD) scores. The results also reflected that the participants who learned through developed multimedia-supplemented instructional unit exhibited better awareness than those who learned through traditional method. Moreover, it indicated that students who learned thorough

the developed instructional unit showed significantly higher level of awareness/consciousness about electric energy conservation, such as in "Awareness on daily life habits in operating household appliances to minimize energy conservation (Household Appliances)", "Awareness on buying electrical appliances looking into Energy Star Rating for it energy efficiency (Energy Stars)" and "Awareness on lighting rooms for less energy consumption (Lighting)" as shown in the bold text in Table 6.5. These are the common factors that contribute majorly in saving energy in our daily life.

Therefore, it was confirmed that the developed multimedia- supplemented instructional learning unit was better in promoting students' awareness on electric energy conservation, particularly in operating those household electrical appliances that are used in their day to day life.

6.3 Attitude analysis

Finally, to answer the third research question, "what is students' attitude towards the developed multimedia-supplemented instructional unit?" The attitude questionnaire was implemented with a research objective, "to investigate the students' attitude towards the developed multimedia-supplemented instructional unit" with those students participated in experimental group. This questionnaire found students' attitude with regards to students' interest, participation and learning satisfaction as a result of using developed multimedia-supplemented instructional unit for learning electrical energy consumption and conservation lesson.

The questions were made simple to the level of grade 10 students and moreover the researcher explained the statements to participants before answering them. The total of 66 students in experimental group answered the questionnaire. The data collected from attitude questionnaire were analyzed by mean and standard deviation to determine learners' attitude toward developed instructional unit for learning electrical energy consumption and conservation lesson. The means of students' attitude level in the categories of "interest", "participation", and "satisfaction" were then compared to the predetermined criteria as shown in Table 6.6.

T**able 6.6** Students' attitude level for the developed instructional unit

	Satisfaction	Mean	SD	Remark
Interest	• I enjoy physic lessons very much with multimedia technology.	4.27	0.78	Agree
	• I become more curious and observant in the class when the lesson is integrated with multimedia technology.	4.39	0.76	Agree
Participation	• I enjoy participating in class activities when the lessons are taught using multimedia.	4.45	0.77	Agree
	• The lessons using animations, game and simulated activities make me more attentive in the class.	4.56	0.73	Strongly agree
	• Integration of multimedia in the lesson promotes better interaction amongst friends and teachers.	4.33	0.73	Agree
Satisfaction	• It is easier for me to understand the content with multimedia technology.	4.45	0.59	High satisfaction
	• I get learning satisfaction when I learn the lesson with multimedia.	4.38	0.67	High satisfaction
	• Multimedia technology in the lesson helps me to develop confidence in learning electrical energy calculation.	4.53	0.75	Highest satisfaction
	• I found the graphics and multimedia useful in visualizing the concepts.	4.26	0.69	High satisfaction
	• Multimedia in learning helps me to think and analyze the real things in world.	4.48	0.71	High satisfaction
	• It helps me to develop the relevance between the course and real world situations.	4.20	0.85	High satisfaction
	• Multimedia lessons allow me to develop skills needed in the real world.	4.39	0.72	High satisfaction
	• I like the way the teacher uses multimedia technology to teach energy consumption by various household appliance lesson.	4.70	0.58	Highest satisfaction
	• The use of multimedia in the lesson helps me to build confidence in understanding the concept of energy consumption clearly.	4.32	0.68	High satisfaction

Table 6.6 Students' satisfaction level for the developed instructional unit (Cont.)

• I like multimedia in learning electrical energy consumption and conservation sessions because it enables me to learn faster.	4.53	0.71	Highest satisfaction
• I gain confidence when I learn the lesson using multimedia.	4.23	0.65	High satisfaction
• I like electrical energy lessons with multimedia because the lessons are interesting, informative and help to visualize the abstract concepts of energy better.	4.48	0.71	High satisfaction
• I like multimedia technology integration in all the subjects to help enhance our critical thinking.	4.30	0.84	High satisfaction

Table 6.7 Summary of students' attitude level in term of three classified factors

Category	**Attitude Level**					**Total**
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Interest	0%	0%	18.2%	**51.5%**	30.3%	100 %
Participation	0%	0%	6.1%	39.4%	**54.5%**	100 %
	Least satisfaction	Low satisfaction	Moderate satisfaction	High satisfaction	Highest satisfaction	
Satisfaction	0%	0%	0%	**56.1%**	43.9%	100 %

The overall analysis from the questionnaires revealed that 51.5% of learners rated "Agree" for the developed multimedia instructional unit for being able to develop interest in learning the concept of electrical energy consumption and conservation. 54.5% of the participants also stated that they had "Strongly agree" towards the developed multimedia-instruction as it encouraged them to participate in the learning activities through its interactive games and 56.1% of the participants rated that they had "High" level of satisfaction in learning concept of electrical energy

consumption and conservation through the developed instructional unit as shown in the bold text in Table 6.7. Eventually, the conclusion was derived that students were satisfied and had positive learning attitude towards the developed multimedia-supplemented instructional unit for learning the concept of electric energy consumption and conservation.

CHAPTER VII
DISCUSSION

This study was conducted to investigate the effectiveness of the developed multimedia-supplemented instructional unit in students' learning achievement and their awareness in household electrical energy consumption and conservation, compare to traditional instruction for the grade 10 students studying physic subject in Bhutanese classroom teaching. Although there were numerous studies done on energy consumption and conservation in various situations, but there has not been a concrete study done on multimedia-supplemented instructional unit for learning household electrical energy consumption and conservation incorporating 5E learning cycle model in line with academic syllabus, especially in Bhutanese context.

The overall results of this study indicated that the 5E learning cycle model learning unit with the instructional-interactive multimedia significantly outperformed the traditional method in promoting students' understanding of the key concepts of energy consumption and awareness on energy conservation in daily household electrical appliance usage. Through interactive games in developed supplementary learning instruction, students explored the concept of energy consumption in a playful manner that helped them in better understanding of the concepts and promoted awareness in energy saving. Unlike traditional teaching method, the 5E learning model consists of 5 stages - each stage builds upon the previous. This helped students to learn from simple hand-on, discovery approach by creating an environment where students explored new concepts, re-evaluated their post experiences and accommodated their new experiences and concepts into their existing schemata. The whole process of 5E learning cycle model put the student at the center of learning experience.

The findings from this study showed that students implementing developed multimedia-supplemented instructional unit incorporating 5E learning cycle model had better achievement in conceptual test, which was consistent with various educational researches that advocated the correct use of the 5E learning cycle

instruction accomplished both effective learning of concepts and an ability to apply concepts. The positive effect of 5E learning cycle instruction on students' achievement was supported by previous studies in the literature (Hokkanen, 2011; Piyayodilokchai et al., 2013; Yadigaroglu & Demircioglu, 2012). For instance, Piyayodilokchai et al. (2013) indicated that the 5E learning cycle model–based, interactive multimedia-supplemented instructional unit caused significantly better acquisition of principal conceptions related to SQL commands than traditional instruction in second-year undergraduate students for enhancing their basic knowledge of SQL and ability to apply SQL to a database. Yadigaroglu and Demircioglu (2012) conducted a research to investigate the effect of activities based on 5E learning cycle model on grade 10 students' understanding of general properties of gas. They used experimental design of research with 40 grade 10 students in two classes. During the treatment, the control group was taught by traditional approach and the experimental group was taught by using the activities developed based on 5E model of the constructivist approach. It was found that 5E learning cycle model had greater impact in understanding of general properties of gas than the traditional approach. Hokkanen (2011) investigated the effects of 5E learning cycle model on improving student achievement, interest and confidence in science. The study determined that the 5E model has the potential to improve student academics, interest and confidence in science, when implemented properly and with dedication and fidelity. Moreover, Gerdprasert et al. (2010) showed that supplementing the conventional lecture with the developed web-based learning unit made learning significantly more effective than the traditional lecture alone and students responded positively toward this learning unit. They developed the web-based learning unit by integrating the principles of the mechanism of labor with the 5E inquiry cycle model. Thus, the result of the present study was also parallel with the results reported by earlier studies that indicated positive effect of 5E learning cycle instruction on students' ability to apply their knowledge.

This study also indicated the positive effect of integrating interactive multimedia with a learning approach on students' understanding and their motivation. The result from the present study represented the similarity with the study by (Yang, Chien, & Liu, 2012) which developed an Energy Conservation Pet (ECOPET) system using a game-based learning strategy to encourage learners to conserve home energy

usage. The results from the study demonstrated that the system significantly promoted learners' self-awareness, learning motivation, as well as willingness to conserve energy in a playful and engaging way. Another study by Torres and Macedo (2000) demonstrated that simulation games promoted environmental awareness and developed positive attitudes toward environmental conservation. Evans et al. (2007) conducted the study to examine participants' environmental awareness through game based approach. The results of the study showed that participants had developed positive attitudes regarding the environment besides behaving in an environmentally responsible manner. Moreover, Moon and Baek (2009) stated that the simulation game can effectively improve the environmental knowledge, attitudes, and behavior of the players. Murphy (2012) also stated that multimedia in the classroom encourages students to work with each other, developing teamwork, skills and learning from their peers. Integration of multimedia in the lessons provides students with more active roles. While using multimedia, students often think more critically about their own progress and abilities. Theoretical content with multimedia aided instruction brings the world into the classroom and appeals to different learning styles, actively engaging students.

Overall result of this study suggested that when students participate in appropriate multimedia-supplemented instructions, it helps them understand relevant concept better by enabling them to visualize those abstract concepts. This helps students to link the knowledge gained from the school into their daily life. Thus, they are able to apply their knowledge, skills and strategies to make decisions in the real situations. Similarly, the developed innovative learning units helped the students in promoting their cognitive abilities in understanding the concept of electrical energy consumption and foster the development of self-awareness and social consciousness towards energy conservation. Thus, the students were able to score better in achievement tests and enhance level of awareness on energy conservation.

CHAPTER VIII
CONCLUSIONS

Overview

This chapter concludes the research study with the conclusion, practitioners' notes, and limitations and recommendations of the research study.

8.1 Conclusion

From the above findings, it is concluded that the developed multimedia instruction provided higher level of learning satisfaction in students. The traditional teaching methods with books, chalks and board merely gave learning satisfaction to students. It cannot create a joy, an excitement, and a love for learning. So how hard and different approaches teachers use for teaching the concept like energy consumption and conservation, it still remained as abstract and vague in their brains. That is why the theoretical learning from school was never put into application. If we are to inspire and engage students in learning then we should show them how we learn rather than tell them what we know. This desire for learning can be fulfilled by supplementing the traditional teaching methods with educational games and multimedia instructions.

The instructional multimedia offers unique advantages in classroom teaching. It enables us to provide ways by which learners can experience their subject in different manner. Multimedia brings the world into the classroom and appeals to different learning styles, actively engaging the learners. While using multimedia, students often think more critically about their own progress and abilities. Further inclusion of educational games can enhance the learning environment because while playing they become aware of their own ideas, beliefs and attitudes by using some simple tasks which are related to everyday "systems", tasks, or phenomena (Ebenezer, Chacko, Kaya, Koya, & Ebenezer, 2010). Therefore, the learners are engaged and

motivated via direct experiences. Instructional multimedia can be more effective, if it is backed up by scientific instructional design. 5E learning cycle model, based on inquiry-based approach has capability to enhance conceptual understanding better. It includes activities which allow students to learn through hands-on, minds-on especially for enhancing understanding of concept with the ways in which students learn nature of the world. Besides, the literature on previous studies revealed that teacher-centered and text book oriented science instructions were less to improve students' conceptual understanding on subject and leave many errors. Thus, there was need for multimedia-supplemented instructions with inclusion of interactive games for learning abstract concept of household electrical energy consumption which is vital for energy-saving.

The developed supplemented learning unit was designed incorporating 5E learning cycle model so the students can engage, explore, explain, elaborate and evaluate their knowledge on subject through developed learning activities. The instructional unit is so designed with a scenario-based situation that commonly happens at home. This accessed the learners' prior knowledge and links between what they (students) know and organize their thinking toward the learning outcomes of current activities by developing curiosity in learners. The learning modules viz. "Energy Detective", "Energy Efficiency Home" and "Shopping" assisted students to explore through the interactive games to identify the factors for energy consumption in electrical appliances. Moreover, the developed learning unit provided participants the opportunity to explain, to argue, and to debate their understandings which guided them to construct the new concept into their existing knowledge.

Thus, this study stated that the interactive games embedded in developed multimedia supplemented instructional unit incorporating 5E learning cycle model was significantly effective than the conventional teacher-centered and textbook-oriented instructions for enhancing students' conceptual understanding on energy consumption and awareness on energy conservation.

8.2 Practitioner notes

The developed multimedia supplemented instructional unit for learning electrical energy consumption and conservation can be implemented in any learning institutions for teaching and learning the aforementioned concept. The learning outcomes for implementing the multimedia-supplemented instructional unit can be more effective if the practitioner/teacher/instructor follow the guidelines as set below.

(1) The lesson is introduce with the scenario-based, so teacher(s) should emphasis on the objective of the scene with further explanation to develop curiosity for learning the lesson.(e.g. why monthly electric bill is more?). This should not take more than 5 minutes.

(2) Participants should be instructed to follow the learning modules in sequence.

First: Energy Detective: Identify energy consumption factors.

Second: Energy Efficiency Game: monitor your power bills.

Third: Shopping: Know your home electric appliances better.

The time allocation for these activities is assigned for 50 minutes tentatively as to suit the time needed by the students for different activities depending upon the ability of the students.

(3) At the end of each phase, the teacher(s) need to provide participants opportunities to share and explain their understanding of the concepts, skills and processes they are learning. In the meantime, teacher(s) should take opportunities to clarify students' misconceptions and help them in introducing new concepts, process and skills. Moreover, teacher(s) should challenge and extends students' conceptual understanding and skills of the concept by conducting additional activities that focuses on adding breadth and depth to current understanding.

(4) The learning process is vital aspect of the developed supplemented instructional unit. Therefore designing a formative assessment that suit the students' background and learning environment to follow students learning process to help in evaluating more authentic learning outcomes are required.

Beside the mentioned points, it is always advisable that teachers/practitioners inform the students about the learning process of the instructional unit before the implementations, as the new type of teaching and learning

approach might not be familiar for some students in some schools. This would minimizing confusion and time wastage, and eventually help in setting good flow while implementing the learning unit. Still if any teachers/instructors/practitioners having difficulty in executing the teaching and learning activities related to multimedia supplemented instructions embedded with 5E learning cycle model, the authors will be willing to provide a guided lesson plans, a manual of the interactive multimedia or technical assistance upon request.

8.3 Limitations and recommendations of the study

The above study was conducted with small sample size of the population in one of the higher secondary school, so the result revealed might not be good enough to compare whole population. Similarly, the high score of the experimental groups may not be attributed to only the exposure to the developed learning unit. Students' own pursuit knowledge in the textbooks and other web-based sources might also contribute to better achievements. For generalization, there is a need to conduct the study with larger population size, students' learning process and their background in more details. The result of this study also suggested that the use of multimedia supplemented with 5E learning cycle approach is an alternative method to traditional instruction but to promote meaningful learning in electrical energy concepts, it is necessary to compare this approach with the help of different instructional methods rather than traditional one. The researchers also suggest that the effectiveness of developed supplemented-instruction can be further explored by infusing other 21st century teaching skills.

REFERENCES

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, *25*(3), 273–291.

Aggul, F., Yalcin, M., Acikyildiz, M., & Sonmez, E. (2008). Investigation of effectiveness of demonstration simulation based instruction in teaching energy conservation at 7th grade. *Journal of Baltic Science Education*, *7*(2), 64–78.

Akar, E. (2005). *Effectiveness of 5E Learning cycle model on students' understanding of acid-base concepts*. Middle East Technical University. Retrieved from http://goo.gl/HFjGMJ

Ary, D., Jacobs, L. C., Razavieh, A., & Ary, D. (2009). *Introduction to research in education*. Belmont, CA: Wadsworth.

Bates, T. (2003). *Effective teaching with technology in higher education: foundations for success* (1st ed.). San Francisco, CA: Jossey-Bass.

Bevenino, M. M., Dendel, J., & Adams, K. (1999). Constructivist theory in the classroom. *The Clearing House*, 275-278.

Boyde, S. (2002). Green lubricants. Environmental benefits and impacts of lubrication. *Green Chemistry*, *4*(4), 293–307.

Burguillo, J. C. (2010). Using game theory and competition-based learning to stimulate student motivation and performance. *Computers & Education*, *55*(2), 566–575.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Carlson Powell, J., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins and effectiveness*. Colorado Springs, CO: BSCS. Retrieved from http://goo.gl/XEhGm

Cai, Y., Lu, B., Zheng, J., & Li, L. (2006). Immersive protein gaming for bio edutainment. *Simulation & Gaming*, *37*(4), 466–475.

Campbell, M., A. (2000). *The effects of the 5e learning cycle model on students' understanding of force and motion concepts* (Published Master's Thesis). B.S. Millersville University, Orlando, Florida.

Carbonaro, M., O'Brate, A., & Giannakakou, P. (2011). Microtubule disruption targets HIF-1 mRNA to cytoplasmic P-bodies for translational repression. *The Journal of Cell Biology*, *192*(1), 83–99.

Cepni, S., & Sahin, C. (2012). Effect of different teaching methods and techniques embedded in the 5E instructional model on students' learning about buoyancy force. *Eurasian Journal of Physics and Chemistry Education*, *4*(2). Retrieved from http://goo.gl/tqHGCy

Chen, Z.-H., Lu, C.-H., Chou, C.-Y., Chen, L.-C., Ching, C.-W., & Wan, C.-F. (2013). My-investment: Using digital games to help children learn financial management. *Research & Practice in Technology Enhanced Learning*, *8*(2). Retrieved from http://goo.gl/8TIJ1A

Chen, Z. H., Liao, C. C. Y., Chien, T. C., & Chan, T. W. (2011). Animal Companions: Fostering children's effort-making by nurturing virtual pets. *British Journal of Educational Technology, 42*(1), 166-180.

Chuang, T. Y. & Chen, W. F. (2009). Effect of computer-based video games on children: an experimental study. *Educational Technology & Society, 12*, 2, 1–10.

Chiu, M.-H., Chou, C.-C., & Liu, C.-J. (2002). Dynamic processes of conceptual change: Analysis of constructing mental models of chemical equilibrium. *Journal of Research in Science Teaching*, *39*(8), 688–712.

Clark, R. C., & Mayer, R. E. (2003). *E-Learning and the science of instruction: proven guidelines for consumers and designers of multimedia learning*. San Francisco, CA: Jossey-Bass/Pfeiffer.

Colburn, A., & Clough, M. (1997). Implementing the learning cycle: A gradual transition to a new approach. *The Science Teacher, 64*, 29-33.

Connolly, T. M., Stansfield, M., & Hainey, T. (2007). An application of games-based learning within software engineering. *British Journal of Educational Technology*, *38*(3), 416–428.

Darby, S. (2006). *The effectiveness of feedback on energy consumption*. Oxford, United Kingdom: Environmental Change Institute, University of Oxford. Retrieved from http://www2.z3controls.com/doc/ECI-Effectiveness-of-Feedback.pdf

David, W. (2003). Constructivism in the processes of teaching and learning mathematics. Paper presented in The Third Arab Conference "Systemic Approach in Teaching and Learning", Ain Shams University, 3-4 April, 2003.

DeWaters, J. E., & Powers, S. E. (2011). Improving energy literacy among middle school youth with project-based learning pedagogies. In *Frontiers in Education Conference (FIE), 2011* (p. T1D–1). Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6142961

DiCarlo, S. E. (2009). Too much content, not enough thinking, and too little FUN! *AJP: Advances in Physiology Education*, *33*(4), 257–264.

DiGiacinto, D. (2007). Using multimedia effectively in the teaching-learning process. *Journal of Allied Health*, *36*(3), 176–179.

Dondlinger, M. J. (2007). Educational video game design: A review of the literature. *Journal of Applied Educational Technology*, *4*(1), 21–31.

Duit, R. (1981, September). *Students' notions about the energy concept-Before and after physics instruction*. Paper presented at the conference on "Problems Concerning Students' Representation of Physics and Chemistry Knowledge", Ludwigsburg, West Germany.

Ebenezer, J., Chacko, S., Kaya, O. N., Koya, S. K., & Ebenezer, D. L. (2010). The effects of Common Knowledge Construction Model sequence of lessons on science achievement and relational conceptual change. *Journal of Research in Science Teaching*, *47*(1), 25–46.

Eck, R. V. (2006). Digital Game- Based Learning: It's Not Just the Digital Natives Who Are Restless. *EDUCAUSE Review*, *41*(2), 16–30.

Evans, G. W., Brauchle, G., Haq, A., Stecker, R., Wong, K., & Shapiro, E. (2007). Young children's environmental attitudes and behaviors. *Environment and Behavior*, *39*(5), 635–658.

Gee, J. P. (2006). Are Video Games Good for Learning? Presented at the Curriculum Corporation 13th National Conference, Adelaide.

Gerdprasert, S., Pruksacheva, T., Panijpan, B., & Ruenwongsa, P. (2010). Development of a web-based learning medium on mechanism of labour for nursing students. *Nurse Education Today*, *30*(5), 464–469.

Gustafson, K. L., & Branch, R. M. (2002). *Survey of instructional development models* (4th ed.). Syracuse, N.Y: ERIC Clearinghouse on Information & Technology.

Haakana, M., Sillanpää, L., & Talsi, M. (1997). The effect of feedback and focused advice on household energy consumption. In *Proceedings of the 1997 ECEEE Summer Study*.

Hokkanen, S. L. (2011). *Improving student achievement, interest and confidence in science through the implementation of the 5E learning cycle in the middle grades of an urban school*. Montana State University, Bozeman, Montana. Retrieved from http://goo.gl/9bH5bY

Hansmann, R., Scholz, R. W., Francke, C.A.C., & Weymann, M. (2005). Enhancing environmental awareness: Ecological and economic effects of food consumption. *Simulation & Gaming, 36*(3), 364-382.

Hewitt, P. (1997). Games in instruction leading to environmentally responsible behavior. *The Journal of Environmental Education, 28*(3), 35-37.

Hoppe, H.U., Joiner, R., Milrad, M., & Sharples, M. (2003). Guest editorial: Wireless and mobile technologies in education. Journal of Computer Assisted Learning, 19, 255–259

Karen, H., & Ronald, C. (2009). Educating for GNH. Presented at the Educating for Gross National Happiness Workshop, Thimphu, Bhutan.

Kang, N. N., Cho, S. H., & Kim, J. T. (2012). The energy-saving effects of apartment residents' awareness and behavior. *Energy and Buildings*, *46*, 112–122.

Kaveevivitchai, C., Chuengkriankrai, B., Luecha, Y., Thanooruk, R., Panijpan, B., & Ruenwongsa, P. (2009). Enhancing nursing students' skills in vital signs assessment by using multimedia computer-assisted learning with integrated content of anatomy and physiology. *Nurse Education Today, 29*(1), 65-72.

Khataybeh, A. & Nawafleh, M. (2000). The effect of using the learning cycle in the achievement of the first secondary grade students in industrial chemistry. *Mutah Journal for Research and Studies, 15*(7): 11-31.

Kaynar, D., Tekkaya, C., & Cakiroğlu, J. (2009). Effectiveness of 5E learning cycle instruction on students' achievement in cell concept and scientific epistemological beliefs. *Hacettepe University Journal of Education, 37*, 96-105.

Ke, F. (2008). Computer games application within alternative classroom goal structures: cognitive, metacognitive, and affective evaluation. *Educational Technology Research and Development*, *56*(5-6), 539–556.

Kiili, K. (2007). Foundation for problem-based gaming. *British Journal of Educational Technology*, *38*(3), 394–404. doi:10.1111/j.1467-8535.2007.00704.x

Kinshuk, & Patel, A. (2003). Optimizing domain knowledge representation with multimedia objects. Retrieved July 14, 2013, from http://goo.gl/VlLNQ

Kunz, Drewniak, & Schott. (2004). Implementing educational controlling: Web-based training, performance and controlling. In *Learning support systems for organizational learning* (Vol. 8). New Jersey : Singapore: World Scientific.

Kurt, S., & Ayas, A. (2012). Improving Student's Understanding and Explaining Real Life Problems on Concepts of Reaction Rate by Using a Four Step Constructivist Approach. *Energy Education Science and Technology Part B: Social and Educational Studies*, *4*(2), 979–992.

Lee, Y. C, & Chen, P. M. (2009). A computer game as a context for non-routine mathematical problem solving: The effects of type of question prompt and level of prior knowledge. *Computers & Education, 52*(3), 530-542.

Lever-Duffy, J., & McDonald, J. B. (2005). *Teaching and learning with technology* (2nd ed.). Boston: Pearson.

Liu, T.-C., Peng, H., Wu, W.-H., & Lin, M.-S. (2009). The effects of mobile natural-science learning based on the 5E learning cycle: A case study. *Educational Technology & Society*, *12*(4), 344–358.

Macaulay, M. (2003). The effects of multimedia on learning in third world children. *Questia - Trusted online research*. Retrieved from http://goo.gl/VlLNQ

Madu, B. C., & Amaechi, C. C. (2012). Effect of five-step learning cycle model on students' understanding of concepts related to elasticity. *Journal of Education & Practice, 3*(9). Retrieved from http://goo.gl/yHj0dg

Maharaj-Sharma, R. (2012). What are upper primary school students' perceptions of science? The Trinidad and Tobago context. Retrieved from http://uwispace.sta.uwi.edu/dspace/handle/2139/13705

Mayer, R.E. (1999). Multimedia aids to problem-solving transfer. *International Journal of Educational Research, 31*, 611-623.

Mayer, R. E. (2005). Cognitive theory of multimedia learning. *The Cambridge Handbook of Multimedia Learning*. Cambridge: Cambridge University Press. 31–48.

Moll, H. C., Noorman, K. J., Kok, R., Engström, R., Throne-Holst, H., & Clark, C. (2005). Pursuing more sustainable consumption by analyzing household metabolism in European countries and cities. *Journal of Industrial Ecology*, *9*(1-2), 259–275.

Moon, H. K., & Baek, Y. K. (2009). Exploring variables affecting player's intrinsic motivation in educational games. In S. C. Kong, H. C. Ogata, C. K. K. Chan, T. Hirashima, F. Klett, J. H. . Lee, S. J. H. Yang (Eds.), *Proceedings of the 17th International Conference on Computers in Education* (pp. 718–722). Retrieved from http://goo.gl/V3mYjB

Moreno-Ger, P., Burgos, D., Martínez-Ortiz, I., Sierra, J. L., & Fernández-Manjón, B. (2008). Educational game design for online education. *Computers in Human Behavior*, *24*(6), 2530–2540. doi:10.1016/j.chb.2008.03.012

Mueller, F., Gibbs, M. R., & Vetere, F. (2010). Towards understanding how to design for social play in exertion games. *Personal and Ubiquitous Computing*, *14*(5), 417–424.

Murphy, S. (2012). Effects of using multimedia in the classroom. *eHow mom*. Retrieved July 15, 2013, from http://goo.gl/6sd0J

Murphy, S. (2012). Motivation and self-esteem. *eHow mom*. Retrieved July 14, 2013, from http://goo.gl/6sd0J

National Research Council (U.S.). (2000). *How people learn: brain, mind, experience, and school* (Expanded ed.). Washington, D.C: National Academy Press.

Ozmen, H. (2008). Turkish primary students' conceptions about the particulate nature of matter. *International Journal of Environmental & Science Education*, *3*(3). Retrieved from http://www.ijese.com/IJESE_v6n1_Ozmen.pdf

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & Education*, *52*(1), 1–12.

Piyayodilokchai, H., Panjaburee, P., Laosinchai, P., Ketpichainarong, W., & Ruenwongsa, P. (2013). A 5E learning cycle approach–based, multimedia-supplemented instructional unit for structured query language. *Educational Technology & Society*, *16*(4), 146–159.

Royal Government of Bhutan, Ministry of Education, Policy and Planning Division. (2012). *Annual education statistics, 2012*. Thimphu, Bhutan: Author.

Prensky, M. (2007). *Digital game-based learning*. St. Paul, Minn.: Paragon House.

Rabgay, T. (2012). Brief history of education in Bhutan. *The Novice Pen*. Retrieved from http://goo.gl/7N5vl

Rasch, T., & Schnotz, W. (2009). Interactive and non-interactive pictures in multimedia learning environments: Effects on learning outcomes and learning efficiency. *Learning and Instruction*, *19*(5), 411–422.

Riding, R. J., & Smith, E. S. (1997). Cognitive styles and learning strategies. *International Journal of Training and Development*, 199–208.

Shank, P. (2005). The value of multimedia in learning. Retrieved July 15, 2013, from http://goo.gl/7D9JT

Slotta, J. D., & Chi, M. T. (2006). Helping students understand challenging topics in science through ontology training. *Cognition and Instruction*, *24*(2), 261–289.

Smaldino, S. E., Russel, J. D., Heinich, R., & Molenda, M. (2005). *Instructional technology and media for learning* (8th ed.). New Jersey: Pearson.

Snyder, S. S., & Shickley, N. (2006). *Cooperative learning groups in the middle school mathematics classroom* (Action Research Project). University of Nebraska-Lincoln. Retrieved from http://goo.gl/xZanr

Sonderegger, R. C. (1978). Movers and stayers: the resident's contribution to variation across houses in energy consumption for space heating. *Energy and Buildings*, *1*(3), 313–324.

Spraggins, C. C., & Rowsey, R. E. (1986). The effect of simulation games and worksheets on learning of varying ability groups in a high school biology classroom. *Journal of Research in Science Teaching*, *23*(3), 219–229.

Stewart, D. (1999). How to use multimedia in the classroom. *eHow mom*. Retrieved June 21, 2013, from http://goo.gl/JmHtJW

Subba, C. (2011). *The result of using multimedia in teaching geography class vii in Woochu lower secondary school, Paro: Bhutan* (Unpublished Master's Thesis). Rangsit University, Pathumthani, Thailand.

Subrahmanyam, K., Greenfield, P., Kraut, R., & Gross, E. (2001). The impact of computer use on children's and adolescents' development. *Journal of Applied Developmental Psychology*, *22*(1), 7–30.

Titilayo, A. A., Ovigueraye, E. P., & Adenubi, O. S. (2012). Multimedia and the management of open and distance learning for teacher education in Nigerian universities. *Management*, *3*(1). Retrieved from http://www.savap.org.pk/journals/ARInt./Vol.3(1)/2012(3.1-41).pdf

Torres, M., & Macedo, J. (2000). Learning sustainable development with a new simulation game. *Simulation & Gaming*, *31*(1), 119–126.

Trumper, R., Raviolo, A., & Maria Shnersch, A. (2000). A cross-cultural survey of conceptions of energy among elementary school teachers in training—empirical results from Israel and Argentina. *Teaching and Teacher Education*, *16*(7), 697–714.

Tuna, A., & Kacar, A. (2013). The effect of 5E learning cycle model in teaching trigonometry on students' academic achievement and the permanence of their knowledge. *International Journal on New Trends in Education and Their Implications*, *4*(1), 73–87.

Uzunöz, A. (2011). The effects of the activities of current textbook and 5E model on the attitude of the students: Sample of "the global effects of natural resources unit." *Educational Research and Reviews*, *6*(13), 778–785.

Vastamäki, R., Sinkkonen, I., & Leinonen, C. (2005). A behavioral model of temperature controller usage and energy saving. *Personal and Ubiquitous Computing*, *9*(4), 250–259.

Wang, L. C. & Chen, M. P. (2010). The effects of game strategy and preference-matching on flow experience and programming performance in game-based learning. *Innovations in Education and Teaching International, 47*, 1, 39–52.

Yadigaroglu, M., & Demircioglu, G. (2012). The effect of activities based on 5e model on grade 10 students' understanding of the gas concept. *Procedia - Social and Behavioral Sciences*, *47*, 634–637.

Yang, J. C., Chien, K. H., & Liu, T. C. (2012). A digital game-based learning system for energy education: an energy conservation pet. *TOJET*, *11*(2). Retrieved from http://tojet.net/articles/v11i2/1123.pdf

Yuenyong, C., Jones, A., & Sung-Ong, S. (2011). Student energy conceptions. In *Science Education in International Contexts* (pp. 3–16). Springer. Retrieved from http://link.springer.com/chapter/10.1007/978-94-6091-427-0_1

Zakaria, E., & Iksan, Z. (2007). Promoting cooperative learning in science and mathematics education: A Malaysian perspective. Eurasia Journal of Mathematics, Science & Technology Education.

Zimmer, J. (2003). Teaching effectively with multimedia. *Visionlearning*. Retrieved July 14, 2013, from http://goo.gl/YFMhD

APPENDICES

APPENDIX A
IRB APPROVAL LETTER

COA. No. 2013/084.0409

Certificate of Approval
Mahidol University Institutional Review Board (MU-IRB)

Protocol No.:	MU-IRB 2013/100.2608
Title of Project:	Multimedia-Supplemented Instructional Unit for Learning Household Electrical Energy Consumption and Conservation (Thesis for Master Degree)
Principal Investigator:	Mr. Ugyen Dorji
Co- Investigator:	Lecturers Dr. Patcharin Panjaburee
Affiliation:	Instituted for Innovative Learning
Approval includes:	1) MU-IRB Submission form version date 4 September 2013 2) Participant information sheet version date 26 September 2013 3) Informed Consent form version date 26 August 2013 4) Questionnaire version date 26 August 2013 5) Assessment form for Pre-Post Testing version date 26 August 2013

Mahidol University Institutional Review Board is in full compliance with International Guidelines for Human Research Protection such as Declaration of Helsinki, The Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

Date of Approval: 4 September 2013

Date of Expiration: 3 September 2014

Signature of MU-IRB Chair: ..... (Professor Shusee Visalyaputra) 4 September 2013 version date

Signature of Institute Representative: ..... (Professor Prasit Palittapongarnpim) Vice President for Research 4 September 2013 version date

Office of the President, Mahidol University, 999 Phuttamonthon 4 Rd., Salaya, Phuttamonthon District, Nakhon Pathom 73170. Tel. (662) 8496223-5 Fax. (662) 8496223

COA MU-IRB version date 31 January 2013

APPENDIX B

ACHIEVEMENT TEST

Pre Test **Student ID:**……..……

ATTENTION: ***The paper is neither an examination nor related to your academic. This paper filled by you will never be shown to the teachers, parents etc. So, please answer all the questions by selecting ONLY one response for each question with check mark [√] in the box that corresponds to your level of agreement.***

Instructions: This questionnaire consists of 2 sections:

Section 1: Personal information of respondent

Section 2: Student's conceptual test on the unit, to promote the learning in Energy Consumption

Part A: <u>Personal Information</u>

Select/ Tick [✓] for the appropriate answer of your choice in the given box☐

Gender: ☐ Male ☐ Female

Age: ☐ <16 ☐ 16 ☐ 17 ☐ 18 ☐ >18

Grade in Physics: ☐ < 40 ☐ 41 – 60 ☐ 61 – 80 ☐ > 81

Part B: <u>Student's conceptual test on the unit: *Household Electrical Energy Consumption and Conservation*</u>

Q 1. S.I unit of electrical energy is

- ❑ watt
- ❑ joule
- ❑ kilowatt-hour
- ❑ volt-ampere

Q 2. In which case you have to pay **the most** money for the energy, if a video game of 400 watt is operated for following duration?

- ❑ 18 hours
- ❑ 12 hours
- ❑ 10 hours
- ❑ 8 hours

Q 3. Commercial electric products are always rated in voltage and

- ❑ resistance
- ❑ power
- ❑ current
- ❑ duration

Q 4. Find out in which situation you will need to pay **the most** money for the electrical energy used?

- ❑ CFL (40 watt) lighted for 18 hours
- ❑ Rice cooker(1600 watt) operated for 2 hours
- ❑ Washing machine (700 watt) operated for 1 hours
- ❑ Water cooler (70 watt) used for 22 hours

Q 5. What will be the power rating of the bulb if it draws 0.4 A current from 12 V source when connected for 6 minutes?

- ❑ 28.8 W
- ❑ 30 W
- ❑ 4.8 W
- ❑ 0.8 W

Q 6. What are the factors that affect the cost of energy consumption in electrical appliances?

- ❑ voltage and duration
- ❑ resistance and current
- ❑ power and duration
- ❑ voltage and power

Q 7. Two electrical fans of same brand are bought and operated for same duration. Later, in the monthly electrical bills it was found that the cost was different. How could you explain the above situation regarding the relationship between appliances energy consumption and its power rating?

- ❑ higher value of power rated means less energy consumed by appliances.
- ❑ lower value of power rated means more energy consumed by appliances.
- ❑ higher value of power rated means more energy consumed by appliances
- ❑ no logical relationship between power rated and energy consumption by that appliances.

Q 8. What will be the current drawn through the filament of the lamp rated, 80 W, 220 V when connected to 230 voltage?

- ❑ 0.36 ampere
- ❑ 2.75 ampere
- ❑ 76.5 ampere
- ❑ 83.6 ampere

Q 9. What is the power of the appliance if it consumes 7,200 J in 60 second?

- ❑ 0.120 kWh
- ❑ 120 W
- ❑ 432000 Js
- ❑ 1.20 kW

Q 10. An electric bulb is rated 36 W but when connected to the circuit it gives only 24 W. What is its efficiency percentage?

- ❑ 1.5 %
- ❑ 150 %
- ❑ 0.67 %
- ❑ 66.67%

Q 11. What will be the unit of electrical energy from the given expression?

$$\boldsymbol{Power}\ of\ Appliance \times \boldsymbol{Duration}\ of\ usage$$

- ❑ Watt-hour(Wh)
- ❑ Joule
- ❑ Kilowatt-Hour(kWh)
- ❑ Volt Ampere -second(VAs)

Q 12. What will be the cost of energy consumed in 10 hours at the rate of Nu. 1.20 per unit, when an electric oven rated 1.5 kW, 230 V is connected to a 230 V mains?

- ❑ Nu. 414
- ❑ Nu. 18
- ❑ Nu. 7.83
- ❑ Nu. 2.76

Q 13. A 15 volts battery has capacity to produce 60 ampere of current for 2 hours. How long can that battery keep a 100 W bulb on?

- ❑ 18 hours
- ❑ 50 hours
- ❑ 8 hours
- ❑ 9 hours

Q 14. You are operating 4 bulbs of 80 W for 5 hours and 2 tube light of 40 W for 10 hours daily. What will be your electricity bill amount for a month of 30 days? The cost per unit is Nu. 1.50.

- ❑ Nu. 10.8
- ❑ Nu. 72
- ❑ Nu. 36
- ❑ Nu. 108

Q 15. Which of the following is **CORRECT** relation for electric energy?

- ❑ $E = \frac{IR^2}{t}$
- ❑ $E = V^2It$
- ❑ $E = \frac{I^2t}{V}$
- ❑ $E = I^2Rt$

Q 16. A 100 W incandescent lamp is lighted all hours daily for one month (30 days). What will be his total energy bill if the cost of energy is Nu. 2.00 per unit ?

- ❑ Nu. 6
- ❑ Nu. 200
- ❑ Nu. 144
- ❑ Nu. 6000

Q 17. A 30 V source is connected across a 150 Ω resistor. How much energy is used in 5 minutes?

- ❑ 375 Wh
- ❑ 22.5×10^3 J
- ❑ 5.0 kWh
- ❑ 0.5 Wh

Q 18. How is power related to voltage and current?

- ❑ $P = VI$
- ❑ $P = V^2I$
- ❑ $P = VI^2$
- ❑ $P = \frac{V}{I}$

Q 19. Electric rice cooker of different brands have been operated for same duration. Which one do you think will consume **the most** energy?

- ❑ Otto (600 W)
- ❑ Sharp (800 W)
- ❑ International (450 W)
- ❑ Panasonic (420 W)

Q 20. An electric kittle draws a current of 3 amperes for 5 minutes. If the resistance of the filament is 200Ω, what will be the electrical energy drawn by it?

- ❑ 0.15 kWh
- ❑ 9 kWh
- ❑ 3 kWh
- ❑ 50 kWh

Post Test

Student ID:……..……

ATTENTION: ***The paper is neither an examination nor related to your academic. This paper filled by you will never be shown to the teachers, parents etc. So, please answer all the questions by selecting ONLY one response for each question with check mark [√] in the box that corresponds to your level of agreement.***

Instructions: This questionnaire consists of 2 sections:

Section 1: Personal information of respondent

Section 2: Student's conceptual test on the unit, to promote the learning in Energy Consumption

Part A: <u>Personal Information</u>

Select/ Tick [✓] for the appropriate answer of your choice in the given box☐

Gender: ☐ Male ☐ Female

Age: ☐ <16 ☐ 16 ☐ 17 ☐ 18 ☐ >18

Grade in Physics: ☐ < 40 ☐ 41 – 60 ☐ 61 – 80 ☐ > 81

Part B: <u>Student's conceptual test on the unit: *Household Electrical Energy Consumption and Conservation*</u>

Q 1. Power rating of electrical device is usually related to

- ❑ resistance
- ❑ voltage
- ❑ current
- ❑ duration

Q 2. Which appliance uses **<u>the most</u>** energy among the appliances that are commonly used at home?

- ❑ Water heater
- ❑ Washing machine
- ❑ Refrigerator
- ❑ Oven

Q 3. Different brands of electric fans are operated for same duration. Which one will consume **the most** energy?

- ❑ Singer (200 W)
- ❑ Sharp (320 W)
- ❑ Hatari (400 W)
- ❑ Panasonic (420 W)

Q 4. A curry cooker is rated 15kW, 220v. If it is connected to a 230 V mains, what will be the energy consumed in 10 hours?

- ❑ 150 kWh
- ❑ 33000 kWh
- ❑ 156.8 kWh
- ❑ 345 kWh

Q 5. Where do you have to pay **the most** money for the energy in the following case, if an AC of 2000 watt is operated for following duration?

- ❑ 8 hours
- ❑ 10 hours
- ❑ 15 hours
- ❑ 20 hours

Q 6. The commercial unit for household electrical energy consumption is measured in

- ❑ joule
- ❑ kilowatt-hour
- ❑ kilowatt
- ❑ watt/second

Q 7. Electrical energy is calculated by

- ❑ power x time
- ❑ voltage ÷time
- ❑ power ÷ voltage
- ❑ time × current

Q 8. Find out in which situation you will need to pay **the most** money for the electrical energy used?

- ❑ Washing machine (700 watt) operated for 2 hours
- ❑ CFL (40 watt) lighted for 10 hours
- ❑ Water cooler (70 watt) used for 15 hours
- ❑ Rice cooker(1600 watt) operated for 4 hours

Q 9. How is electrical energy related to voltage, current and time?

- ❑ $E = V^2It$
- ❑ $E = VIt$
- ❑ $E = \frac{V^2}{I}t$
- ❑ $E = \frac{VI}{t}$

Q 10. If it takes 400 seconds to use 12,000 J of energy when connected to 220 V, the power is

- ❑ 6.6 kW
- ❑ 0.14 W
- ❑ 54.6 W
- ❑ 30 W

Q 11. Calculate the energy released by a heater, which draws a current of 10 A at 220 V for 30 minutes?

- ❑ 1.1 kWh
- ❑ 5 kWh
- ❑ 0.3 kWh
- ❑ 66 kWh

Q 12. What is the cost for lighting 100 W bulb for 8 hours in a day, if the cost of electrical energy is Nu. 4 for 1kWh?

- ❑ Nu. 0.32
- ❑ Nu. 3.2
- ❑ Nu. 32
- ❑ Nu. 3200

Q 13. An electric kittle draws a current of 3 amperes for 5 minutes. If the resistance of the filament is 200Ω, what will be the electrical energy drawn by it?

- ❑ 0.15 kWh
- ❑ 9 kWh
- ❑ 3 kWh
- ❑ 50 kWh

Q 14. For 12 V and 40 mA rated appliance when connected for 30 seconds to the source, the power is

- ❑ 0.3 W
- ❑ 0.480 W
- ❑ 14.4 W
- ❑ 9.0 W

Q 15. An electric oven is heated at 1500W, 250V and draws a current of 6A. If it is connected to 250V mains, calculate the cost of energy consumed in 20 hours at the rate of Nu. 2 per unit.

- ❑ Nu. 240
- ❑ Nu. 120
- ❑ Nu. 60
- ❑ Nu. 30

Q 16. A consumer uses a 32 W CFL lamp all hours daily for one month (30 days). What will be his total energy bill if the cost of energy is Nu. 1.20 per unit ?

- ❑ Nu. 1152
- ❑ Nu. 1.15
- ❑ Nu. 27648
- ❑ Nu. 27.65

Q 17. A power supply produces a 0.6 W output with an input of 0.7 W. Its percentage of efficiency is

- ❑ 8.57%
- ❑ 42.85%
- ❑ 4.28%
- ❑ 85.7%

Q 18. When does it consume **the most** energy to cool a house when

- ❑ AC operated at its lowest temperature (17^{o}C) but for short duration.
- ❑ AC operated at its highest temperature (32^{o}C) but for very long duration.
- ❑ Equal energy consumption
- ❑ Not sure

Q 19. A 120 V source is connected across a 12 Ω resistor. How much energy is used in 3 minutes?

- ❑ 480 kWh
- ❑ 30 kWh
- ❑ 60 kWh
- ❑ 72 kWh

Q 20. If you are operating 600 W washing machine for 2 hours and 100 W bulb for 8 hours a day respectively. What could be your average monthly electrical bill if the rate is Nu. 2 per unit?

- ❑ Nu. 40
- ❑ Nu. 80
- ❑ Nu. 120
- ❑ Nu. 210

Thank You for your cooperation

APPENDIX C

AWARENESS TEST

Student ID:……

Questionnaire- Part A (Awareness on energy conservation)

Read the statements carefully and check [√] in the appropriate box about the "*Awareness of the Energy Saving which can be practiced easily at home"*.

The numbers for rating are indicated as follows:

3= "Know very well", 2="Know some of them" and 1= "Don't know at all"

Items	Rating		
Window	**3**	**2**	**1**
1. I use thick curtains in winter			
2. I use dual glasses or Low-E glasses (low thermal emissivity glasses).			
3. I installed dual or triple windows.			
4. I use window panes with good insulation performance.			
5. I applied window sealing paper around the window panes and the doorframe.			
Room Heating			
6. I use highly efficient room heater.			
7. I clean off dust on heater and filaments regularly.			
8. I utilize auto temperature controller of the heater very effectively.			
9. I do not turn off the heater unless I go out for a long time.			
10. I maintain room temperature as 18~20℃ in winter.			
Cooling			
11. I use the products with good energy efficiency			
12. I clean the air conditioner filters frequently.			
13. I use the fan and air conditioner at the same time.			
Lighting			
14. I select compact fluorescent bulbs to replace incandescent bulbs.			
15. I use light-colored, loose-weave curtains on windows for day lighting.			

Household Appliances			
16. I use the high energy efficient appliances.			
17. I unplug the water boiler once the water is boiled.			
Refrigerator			
18. I leave 10% free space in the refrigerator.			
19. I reduce frequency of refrigerator door opening to 4 times every day.			
20. I decrease refrigerator door keep-open duration to 10 seconds.			
21. I install the refrigerator in very low-ventilated place.			
22. I remove the dust on the cooling coils of the refrigerator regularly.			
23. I adjust the temperature control of the refrigerator within 3°C ~5°C.			
Air conditioner	**3**	**2**	**1**
24. I reduce the air conditioner using time an hour a day.			
25. I increase the air conditioner setting temperature by 1°C			
26. I clean the air conditioner filter once every two weeks.			
27. I check the coolant of the air conditioner once a year.			
28. I take out the plug when I do not use the air conditioner.			
29. I maintain room temperature as 26~28℃ in summer.			
TV			
30. I reduce the TV watching time an hour a day.			
31. I reduce the volume by 20%.			
32. I take out the plug when I do not watch it.			
Computer			
33. I take out the plug when I do not use it.			
34. I turn off the monitor when I do not use it for a long time.			
Washing Machine			
35. I reduce the washing frequency by 20%.			
36. I operate the machine only with full loads.			
Electric blanket			
37. I use proper size electric blanket.			
38. I adjust the temperature setting from High to Mid.			

Microwave oven			
39. I use microwaves oven more frequently than electric stoves.			
40. I take out the plug when I do not use it.			
Iron			
41. I reduce the pre-heating time when I use steam iron.			
42. I reduce the using time by batch/bulk ironing.			
43. I put more water on clothes while ironing.			
Fan			
44. I reduce the strength of the wind by one step.			
Audio			
45. I take out the plug when I do not use it.			
46. I reduce the volume by 20%.			
Charger			
47. I take out the plug when I do not use various chargers.			
Energy stars			
48. I am aware of star rating of products.			
49. I usually look for energy star labeled products in shops/markets.			
50. I compare energy efficient products by looking at the star rating.			

APPENDIX D

ATTITUDE TEST

Student ID:……

Questionnaire- Part B (Learning satisfaction)

Read the statements carefully and **check [√]** in the appropriate box. The numbers for rating are indicated as follows:

5=Highest satisfaction, 4= High satisfaction, 3= Moderate satisfaction, 2= Low Satisfaction, and 1= Least Satisfaction

Sl. No	Questions	Rating				
Interest		**5**	**4**	**3**	**2**	**1**
1	I enjoy physic lessons very much with multimedia technology.					
2	I become more curious and observant in the class when the lesson is integrated with multimedia technology.					
Participation		**5**	**4**	**3**	**2**	**1**
3	I enjoy participating in class activities when the lessons are taught using multimedia.					
4	The lessons using animations, game and simulated activities make me more attentive in the class.					
5	Integration of multimedia in the lesson promotes better interaction amongst friends and teachers.					
Satisfaction		**5**	**4**	**3**	**2**	**1**
6	It is easier for me to understand the content with multimedia technology.					
7	I get learning satisfaction when I learn the lesson with multimedia.					
8	Multimedia technology in the lesson helps me to develop confidence in learning electrical energy calculation.					

9	I found the graphics and multimedia useful in visualizing the concepts.					
10	Multimedia in learning helps me to think and analyze the real things in world.					
11	It helps me to develop the relevance between the course and real world situations.					
12	Multimedia lessons allow me to develop skills needed in the real world.					
13	I like the way the teacher uses multimedia technology to teach energy consumption by various household appliance lesson.					
14	The use of multimedia in the lesson helps me to build confidence in understanding the concept of energy consumption clearly.					
15	I like multimedia in learning electrical energy consumption and conservation sessions because it enables me to learn faster.					
16	I gain confidence when I learn the lesson using multimedia.					
17	I like electrical energy lessons with multimedia because the lessons are interesting, informative and help to visualize the abstract concepts of energy better.					
18	I like multimedia technology integration in all the subjects to help enhance our critical thinking.					

Please response suggestion to improve the multimedia:

……
……
……
……
……

APPENDIX E

LESSON PLAN

LESSON PLAN (Experimental Group)

Subject: Physics **Topic**: Energy Consumption and Conservation.

Level of students: Grade X **Time required**: 90 Minutes **T/L Approach**: 5 E Learning Cycle Approach with developed instructional unit

Teaching/Learning material required: projector, developed multimedia, computers, chalkboard, text book, activity sheets, calculators, etc.

Previous Knowledge: about the lesson:

Students have already learnt the concept of common household electrical appliances, electrical power (wattage) and electrical energy.

Learning Objectives: after completing activity student should be able to:

1. identify factors that determine electrical energy consumption in electrical appliances.
2. calculate the energy consumption and cost for operating daily used household electrical appliances.
3. inculcate better sense of awareness on the energy conservation.
4. encourage their own positive attitude/satisfaction about the multimedia-supplemented instructional unit.

	Time	What teacher is doing?	What students are doing?
Introduction (Motivational Opening)	10 minutes	Ask students to complete the pre-content test to investigate students' concept about electrical energy. (**Pretest** will be conducted – 3-5 minutes) The topic will be introduced with developed multimedia. Then to investigate the degree of awareness on energy conservation in learners. Pre-awareness survey questionnaire will be conducted. *// engagement* The lesson is introduced and will be engaged in a scenario that commonly happens at our home. Example, father gets a monthly power bill claiming Nu. 6,500/-. His monthly salary is just Nu. 10,000/- now he has pay ***more than 50%*** of his income just on power bill. This arise curiosity to investigate the cause of power consumption and eventually it links to the learning units. Shows sample of Power Bill/ Electrical Bill as a referential point for the lesson to begin. Ask students to list down commonly used household electrical appliances. Ask students, "any idea how much energy is been consumed by those devices?"	**complete content test (Pre-test)** they will complete Awareness Test questionnaire *#1. They will list down all those electrical appliances use in their house.* * Students are engaged into the scenario which arise curiosity to investigate the cause of power consumption and eventually it links to the learning units. **Responses "NO"**
Lesson Development	70 minutes	**//exploration** **Activity 1** - *Energy Detective* *Objective*: to identify energy consumption factors in appliances Explain instructions of the activity(case 1) - **(10 minutes)** 1. Sort the students into groups of 3-5 per computer. 2. Each group will be given activity sheet 1 and solve the cases. 3. Compare the energy consumed for each appliance in case 1. 4. Questions: a. Which appliance has consumed maximum energy? b. Why do you think the energy consumption is different though they are used for same duration? **Conclusion: (3 minutes)** Identify the factor that affects the rate of energy consumed.	* Follows the instruction of the activity carefully. * As per the instruction, students solve the Detective cases and in the meantime record their findings during the process of the game. * compare the total cost of energy consumed in each case. - find out which appliance uses the maximum energy from the graph displayed -explore why energy consumption is different though they are used for same duration -analyze other *factor affecting cost of energy consumed* though they are used for same duration. - identify the factor-1 for energy consumption. ***wattage** of appliance.

	Time	What teacher is doing?	What students are doing?
		Explain instructions of the activity(case 2) - **(10 minutes)** 1. Compare the energy consumed for each appliance in case 2. 2. Questions: a. Which appliance has consumed maximum energy? b. Why do you think the energy consumption is different though they have same wattage? **Conclusion: (3 minutes)** Identify the factor that affects the rate of energy consumed. **Follow up: (4 minutes) //evaluation and elaboration** Students examine their findings for energy consumption. If students are satisfied, the lesson is further elaborated, how electrical energy is related to power and time, calculation of electric energy and cost of power bill, etc.	- find out which appliance uses the maximum energy from the graph displayed -explore why energy consumption is different though they are used for same duration -analyze other ***factor affecting cost of energy consumed*** though they are used for same duration. - identify the factor-2 for energy consumption. ***duration** of appliance used. **Follow up:** Students evaluate their findings by taking the test. - If their finding is not correct they can revisit the cases. - Otherwise, concept of factors in calculating energy consumption and cost of power bill.

		Activity 2 (15 minutes) //exploration
		Objective: **Energy Efficiency Game** (monitor you power bills!)
		Explain instructions of the activity: **//exploration**
		* **play the game** and in the meantime,
		• Record the rating and time duration of each appliance in the activity sheet 2.
		• Calculate energy consumed by each appliance.
		• Find total cost for energy consumed.
		
		Follow up: (5 minutes) //explanation
		• Collect the activity sheets and display on the board.
		• Questions:
		1. Find out who has paid maximum and also least money for electrical energy?
		2. Why someone has less saving while others are having more?
		Let stds compare and find out the reasons to save more money in term of energy consumption and conservation with above questios..
			Follow the activity 2 instructions
			*play the game and also
			* record their findings during the activity.
			*compare the total cost of energy consumed in each sheet.
			****calculate the energy consumption by appliance based on the activity by them.***
			****calculate the cost of running electric appliances.***
			- **find out** who has paid maximum and also one who has paid least and compare their saving.
			-explore why someone saving is more/less.
			Present their finding using concept maps; factors affecting cost of energy consumed by appliances.
			*identifies ways to reduce the cost of energy consumption/ save more money by conserving energy using concept of wattage and duration of its usage.

		Activity 3 (10 minutes) //elaboration
		Objective: **Shopping**(know your home electric appliances better)
		Explain instructions of the activity: **//exploration**
		• Shopping game, buy the appliances that are commonly used at home with the objective of energy conservation.
		Follow up: (5 minutes) //explanation
		Explains and elaborate on how can appliances be more energy efficient when they are operated with energy saving tips.
			Select the appliances based upon the idea of energy awareness.
			(inculcates sense of awareness on energy conservation)
			*records the appropriate ways to operate electrical appliances to make more energy efficient.

		Summarization of Activities: (5 minutes) //elaboration **Concept Maps** After completion of the activities. Tr. displays the concept maps of each group and brings discussion of their finding.	Links of energy calculation and conservation concept to our day to day life situations, how can we minimize/ conserve electrical energy usage tips as to save more money in longer period. Eventually relate to saving money/ better home budget.

	Time	What teacher is doing?	What students are doing?
		**Graphical Representative of Electrical Bill*: (Display the real monthly *electrical bill* paid) Relate the concept to our day to day life situations, how can we minimize/ conserve electrical energy usage so as to save money in our household chorus (awareness on energy conservation)	
Conclusion	10 minutes	**Question Answer Session://evaluation** Based upon the students findings; Few numerical questions will be given to solve as to evaluate concept of this lesson. ➢ **Post-test** will be conducted – (3-5 minutes) ➢ Post-Awareness survey will be conducted(2-5 minutes) ➢ ***Attitude survey questionnaire***	Students solve the given questions individually. **complete test and questionnaires (Post-test)**

LESSON PLAN (Control Group)

Subject: Physics **Topic**: Energy Consumption and Conservation.

Level of students: Grade X **Time required**: 90 Minutes **T/L Approach**: 5 E Learning Cycle Approach without multimedia

Teaching/Learning material required: chalkboard, text book, activity sheets, calculators, etc.

Previous Knowledge: about the lesson:

Students have already learnt the concept of common household electrical appliances, electrical power (wattage) and electrical energy.

Learning Objectives: after completing activities student should be able to:

1. identify factors that determine electrical energy consumption in electrical appliances.
2. calculate the energy consumption and cost for operating daily used household electrical appliances.
3. inculcate better sense of awareness on the energy conservation.

	Time	What teacher is doing?	What students are doing?
Introduction (Motivational Opening)	10 minutes	Ask students to complete the pre-content test to investigate students' concept about electrical energy. (**Pretest** will be conducted – 3-5 minutes) *// engagement* The topic will be introduced (Writing on the board) Then to investigate the degree of awareness on energy conservation in learners. Pre-awareness survey questionnaire will be conducted. Ask students to list down commonly used household electrical appliances. Ask students, "any idea how much energy is been consumed by those devices?" Shows sample of Power Bill/ Electrical Bill as a referential point for the lesson to begin.	**complete content test (Pretest)** they will complete Awareness Test questionnaire *#1. They will list down all those electrical appliances use in their house.* **Responses "NO"**

Lesson Developme	**70 Mi**	**Activity 1 (25 minutes) //exploration**
		Objective: calculate cost of energy consumed by given appliances.
		Explain instructions of the activity
		1. Sort the students into groups of 3-5.
		2. Each group will be given activity sheet
		3. Find the energy consumption by each appliance given in sheet. (refer activity sheet 1)
		4. Find cost of energy consumed for each appliance.
		5. Find total cost for energy consumed.
		
		Follow up: (7 minutes) //explanation
		6. Collect the activity sheets and display on the board.
		7. Questions:
		a. Find out who has paid maximum and also least money for electrical energy?
		b. Why someone has to pay more while others are paying less money for energy consumed?
		c. Why someone has to pay differently when they are using *same appliances*?
		
		Conclusion: (3 minutes)
		Identify the factor that affects the rate of energy consumed.
		
		Activity 2 (15 minutes)
		Objective: **Energy Saving Plan** (arrange respectively given duration within the list as to minimize cost of energy as low as possible)
		Explain instructions of the activity: **//exploration**
		• Rearrange the duration given within the list to minimize cost electricity.
		• Find the energy consumption by each appliance in
			*Engage students in reading the instructions of the game.
			* Follows the instruction of the activity and in the meantime record their findings during the process of the game.
			*compare the total cost of energy consumed in each sheet.
			
			- find out who has paid maximum and also one who has paid least and compare their saving.
			-explore why someone has to pay more/ least.
			-compare same appliances, to find out different in cost of energy consumed.
			-analyze the *factor affecting cost of energy consumed.*
			
			*duration of appliance used.
			
			Follow the activity 2 instructions
			
			*Arrange given duration for the given appliances in activity 1 to minimize the cost of energy as low as possible on using the same appliances.(using the

<table>
<tr><th></th><th>Time</th><th>What teacher is doing?</th><th>What students are doing?</th></tr>
<tr><td></td><td></td><td>the activity sheet 2.
• Find cost of energy consumed for each appliance.
• Find total cost for energy consumed.

Follow up: (7 minutes) //explanation
• Collect the activity sheets and display on the board again.
• Questions:
1. Find out who has paid maximum and also least money for electrical energy?
2. Why someone has to pay more while others are paying less money for energy consumed?
3. Let stds compare <u>same duration</u> used but having to pay differently.

Conclusion: (3 minutes)
Identify another factor that affects the rate of energy consumed.

Summarization of Activities: (10 minutes) //explanation
Concept Maps
After completion of the activities. Tr. displays the concept maps of each group and brings discussion of their finding.

*Graphical Representative of Electrical Bill: //evaluation
- Find out the Appliances that are commonly used at home.
<table><tr><th>Sl. No.</th><th>Appliance</th><th>Wattage</th><th>Duration</th></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr></table>• view the monthly electrical bill paid for this appliances.(real example)
• let students decide how they want to reduce cost of energy in the bill?

// elaboration
Relate the concept to our day to day life situations, how can we minimize/ conserve electrical energy usage so as to save money in our household chorus (awareness on energy conservation)
• Allow students to scientifically argue their results.
Tips:
✓ use appliances that are energy efficiency.
✓ use as and when you need electricity.
✓ get awareness of latest energy saving technology and etc.
✓</td><td>concept derived from activity 1)

* record their findings during the activity.
*compare the total cost of energy consumed in each sheet.

- find out who has paid maximum and also one who has paid least and compare their saving.

-explore why someone still has to pay more/ least.

-compare same duration of use, to find out different in cost of energy consumed.

-analyze other factor affecting cost of energy consumed though they are used for same duration.

*wattage of appliance.

Present their finding using concept maps; factors affecting cost of energy consumed by appliances.

(inculcates sense of awareness on energy conservation)

Links of energy calculation and conservation concept to our day to day life situations, how can we minimize/ conserve electrical energy usage tips as to save more money in longer period.</td></tr>
<tr><td>Conclusion</td><td>10 minutes</td><td>Question Answer Session://evaluation
Based upon the students findings;
Few numerical questions will be given to solve as to evaluate concept of this lesson.

➢ Post-test will be conducted – (3-5 minutes)
➢ Post-Awareness survey will be conducted(2-5 minutes)</td><td>Students solve the given questions individually.

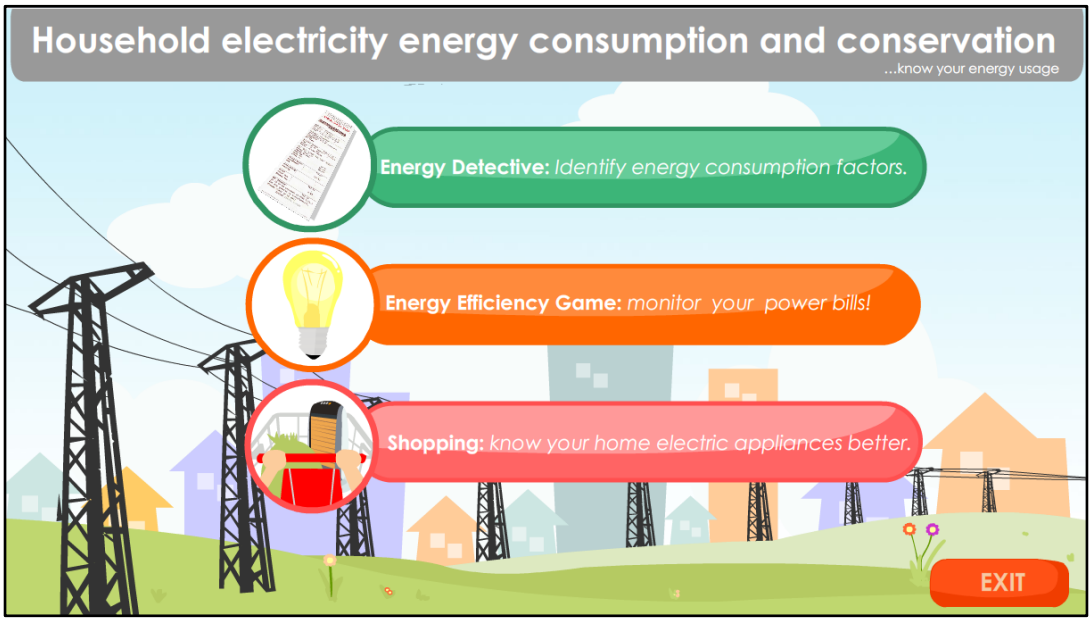
Complete test and questionnaire (Post-test)</td></tr>
</table>

APPENDIX F

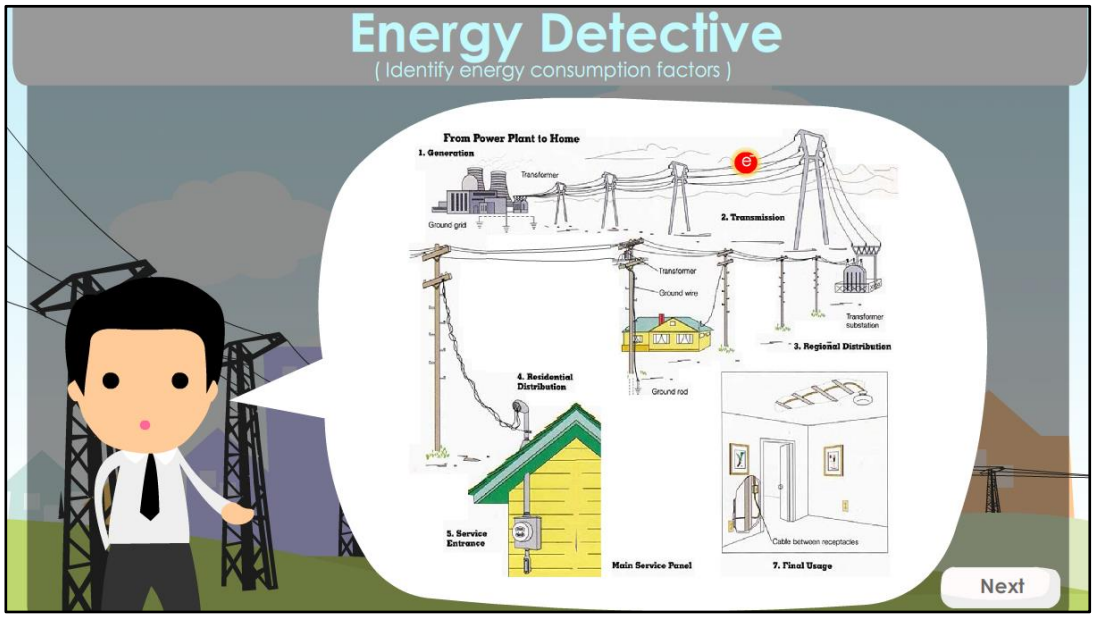
SNAP SHOTS OF MULTIMEDIA-SUPPLEMENTED INSTRUCTIONAL UNIT FOR LEARNING HOUSEHOLD ELECTRICAL ENERGY CONSUMPTION AND CONSERVATION

Main Screen

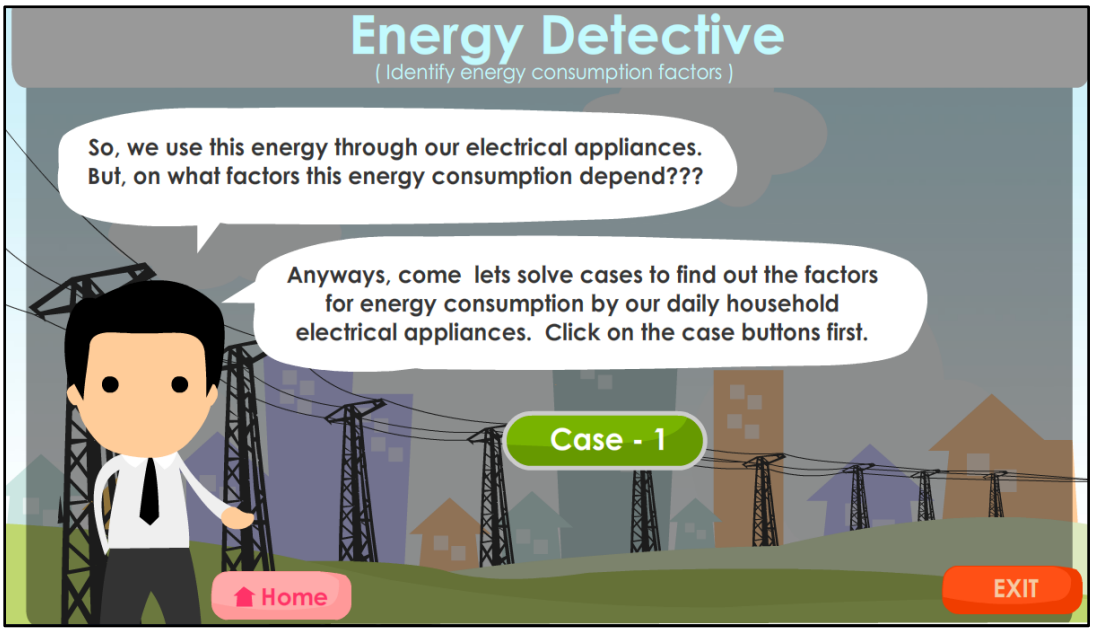
Introduction scene of lesson



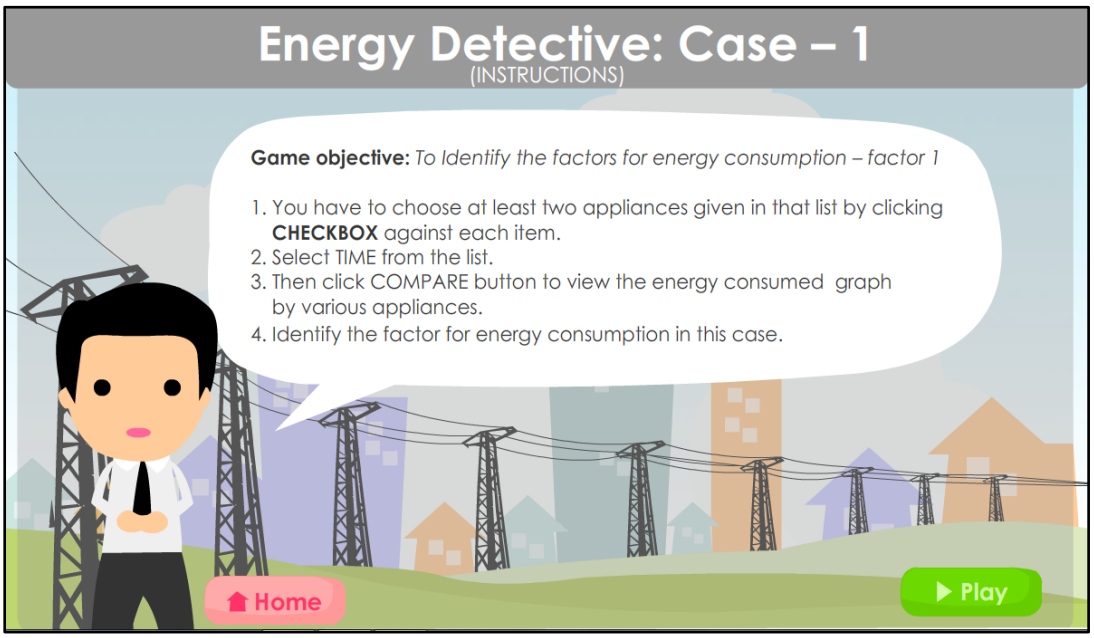
Three interactive learning modules



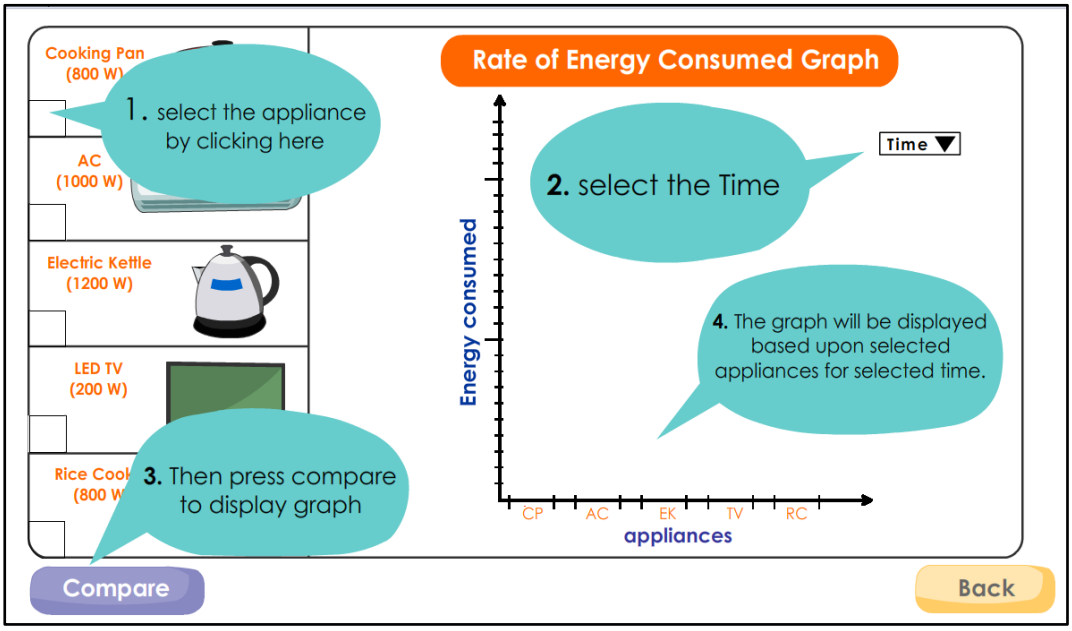
Learning module 1: Energy Detective: Identify the energy consumption factors



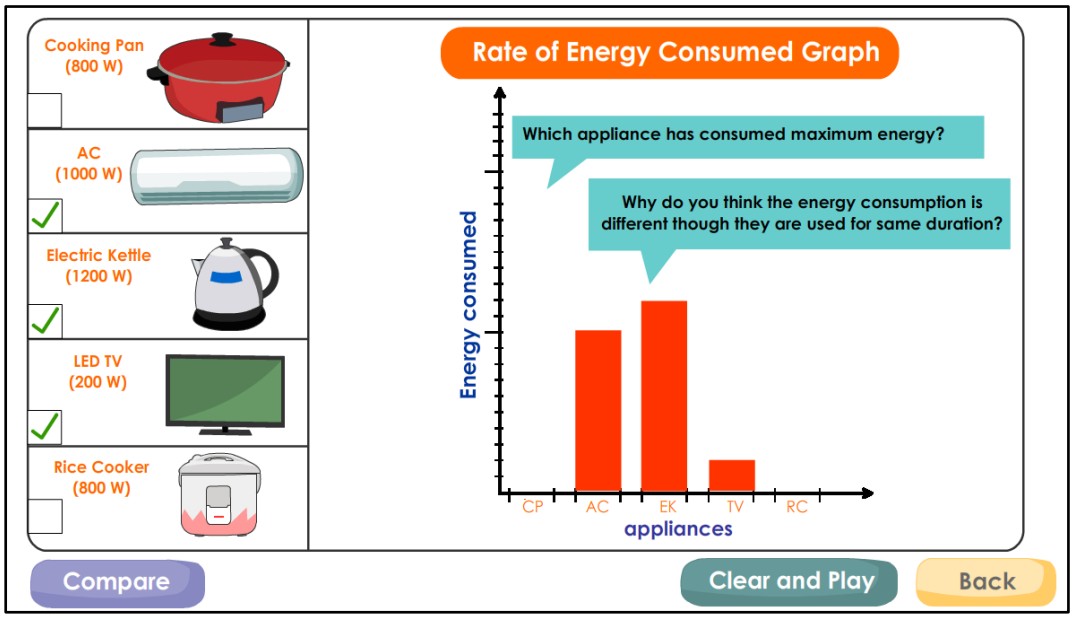
Energy Detective: Case 1



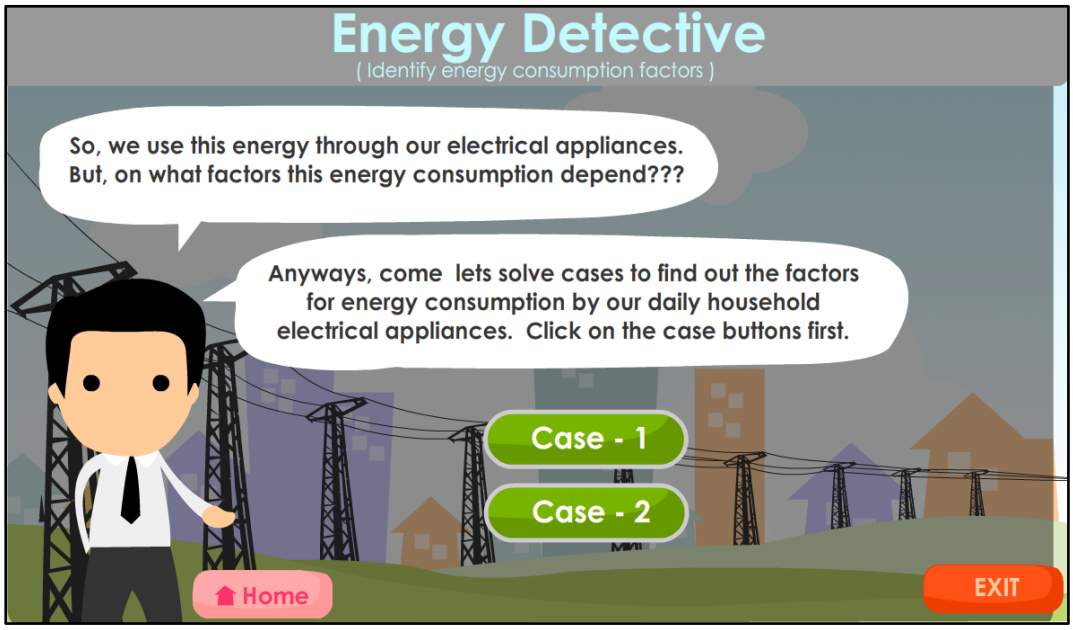
Energy Detective: Case 1-Instructions1



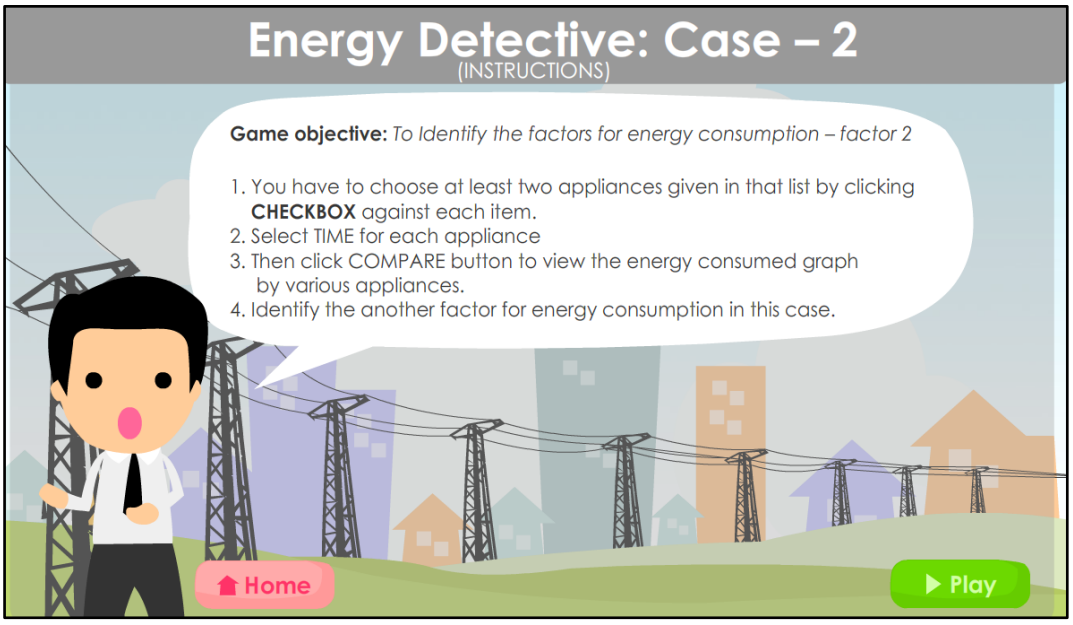
Energy Detective: Case 1-Instruction 2



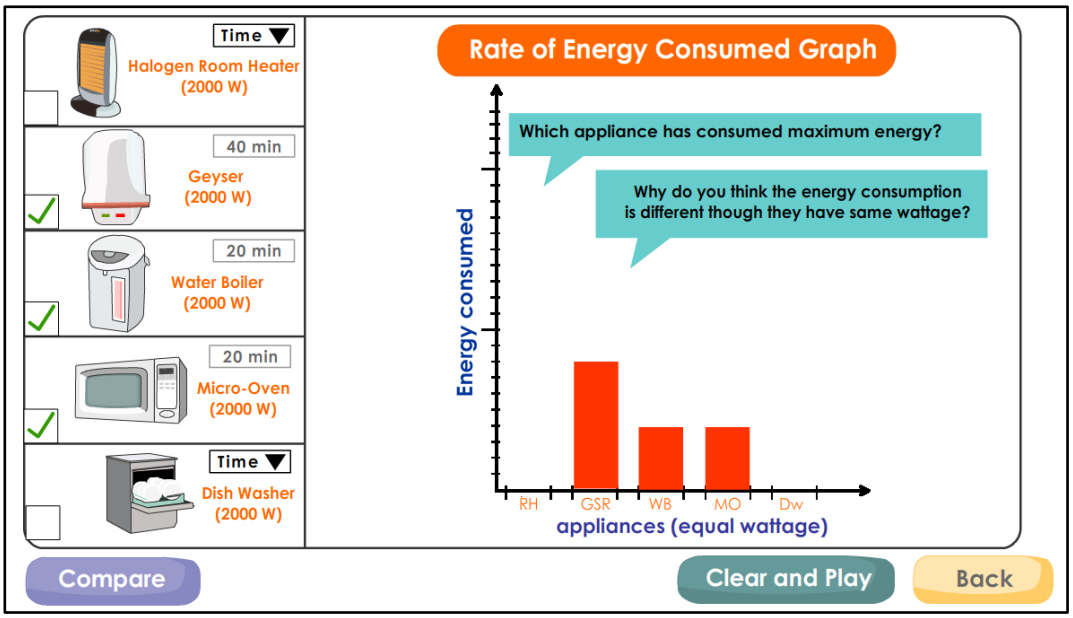
Energy Detective: Case 1-Learning Unit



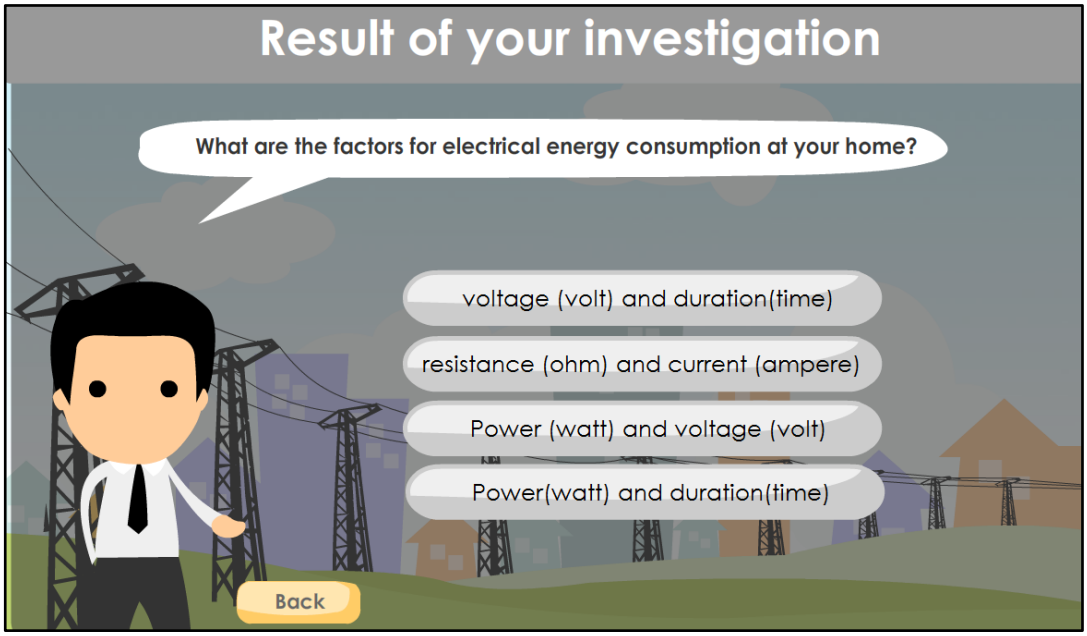
Energy Detective: Case 2



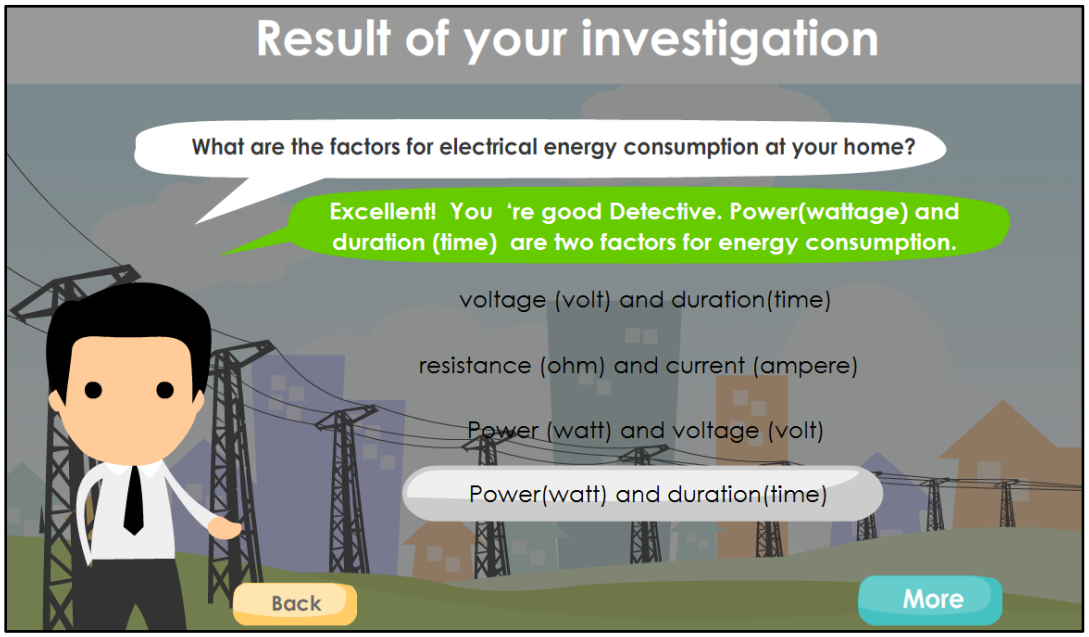
Energy Detective: Case 2-Instructions



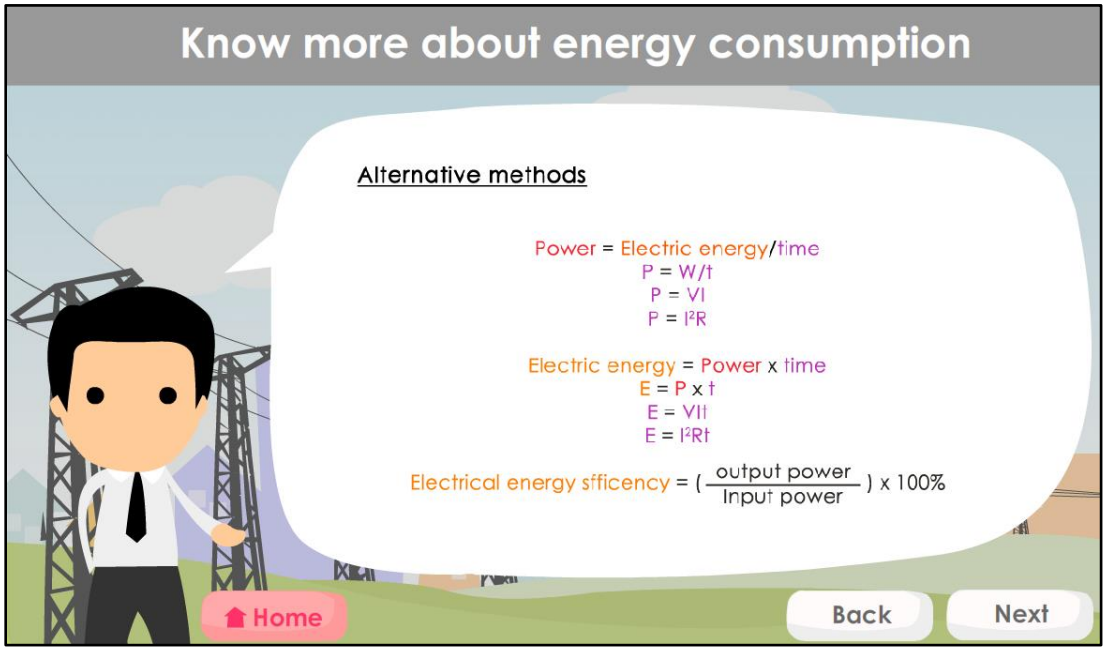
Energy Detective: Case 2-Learning Unit



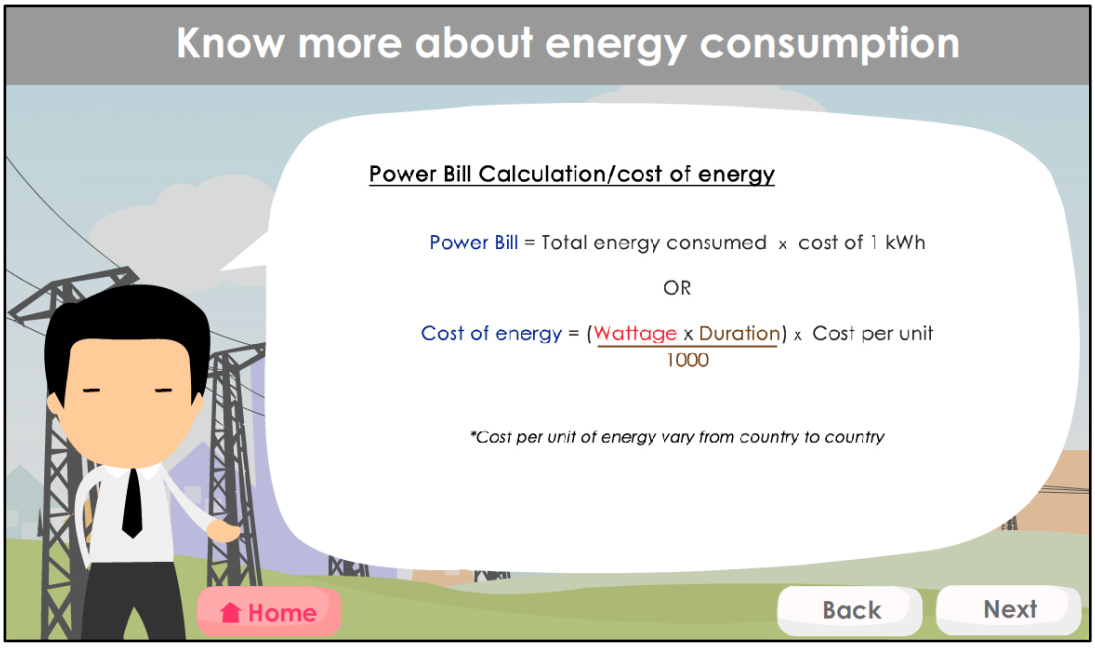
Energy Detective: Self- evaluation/test



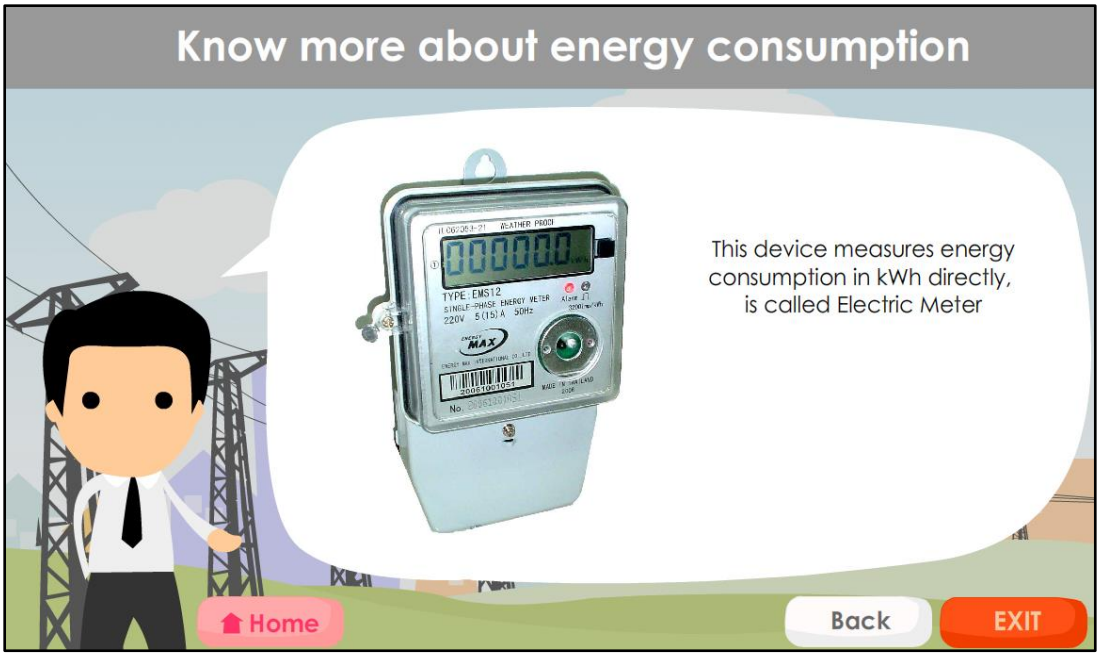
Energy Detective: Evaluation Result



Energy Detective: Lesson extension 1



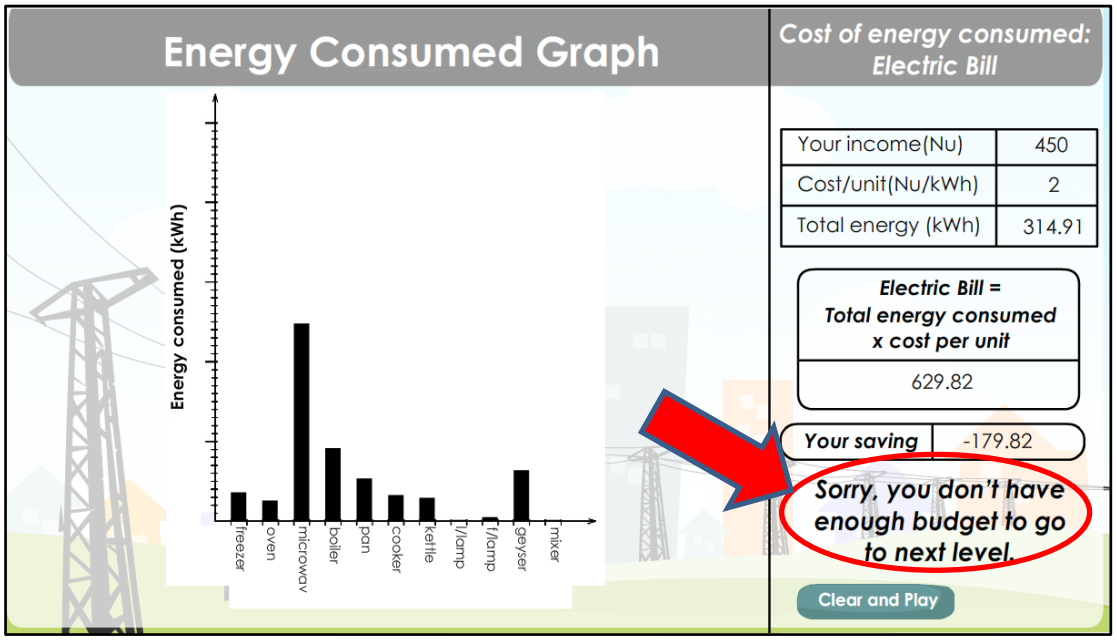
Energy Detective: Lesson extension 2



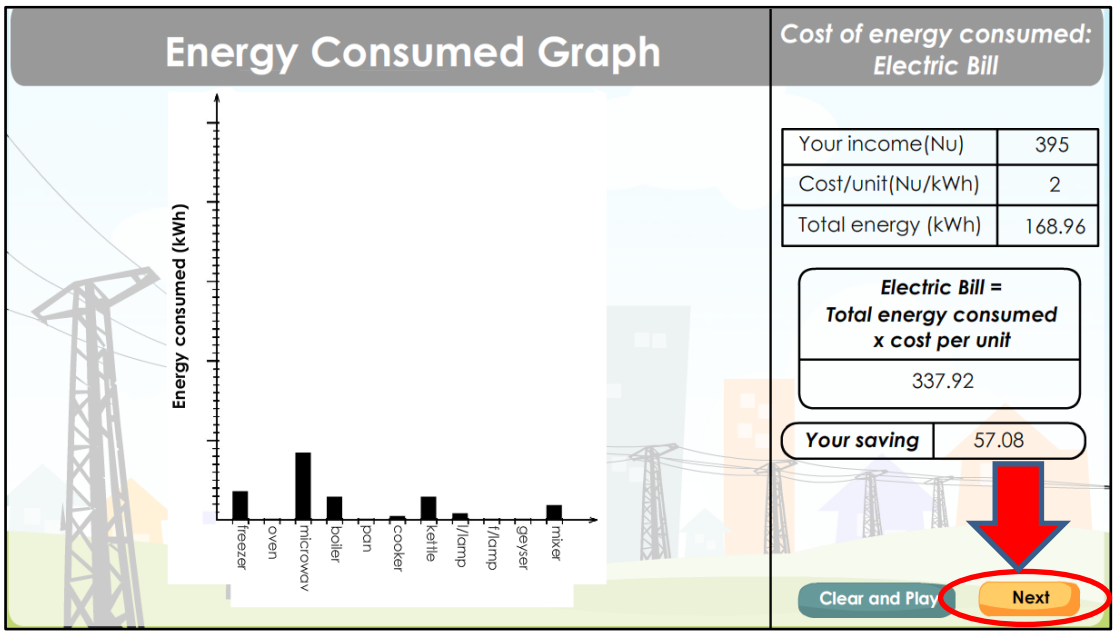
Energy Detective: Lesson extension 3

Learning module 2: Energy Efficiency Game: Monitor your power bill (Instruction)

Energy Efficiency Game: Learning unit

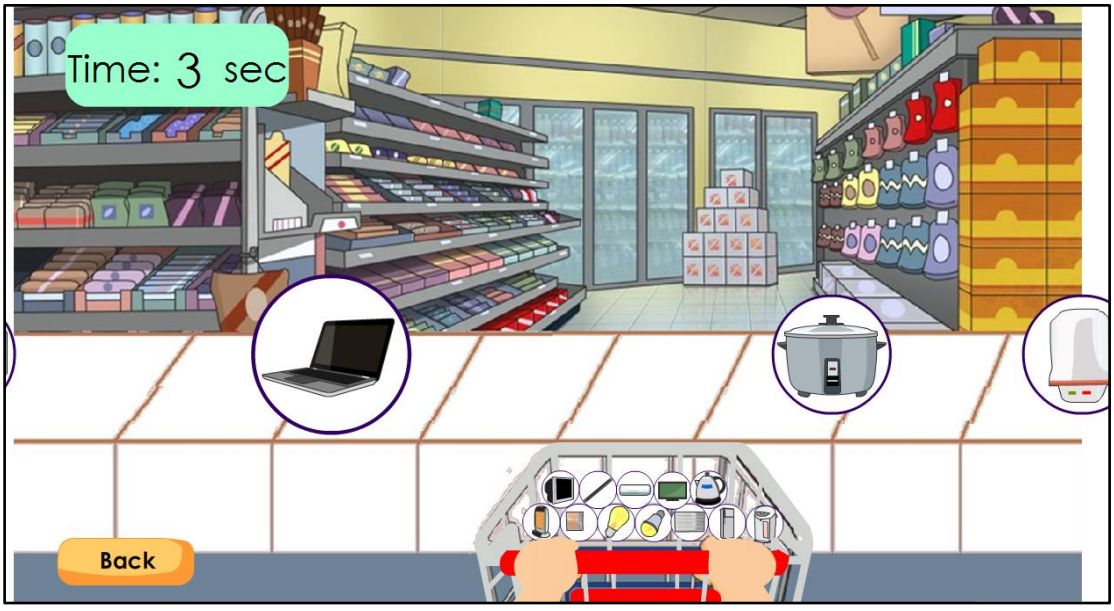


Energy Efficiency Game: Lesson Evaluation 1

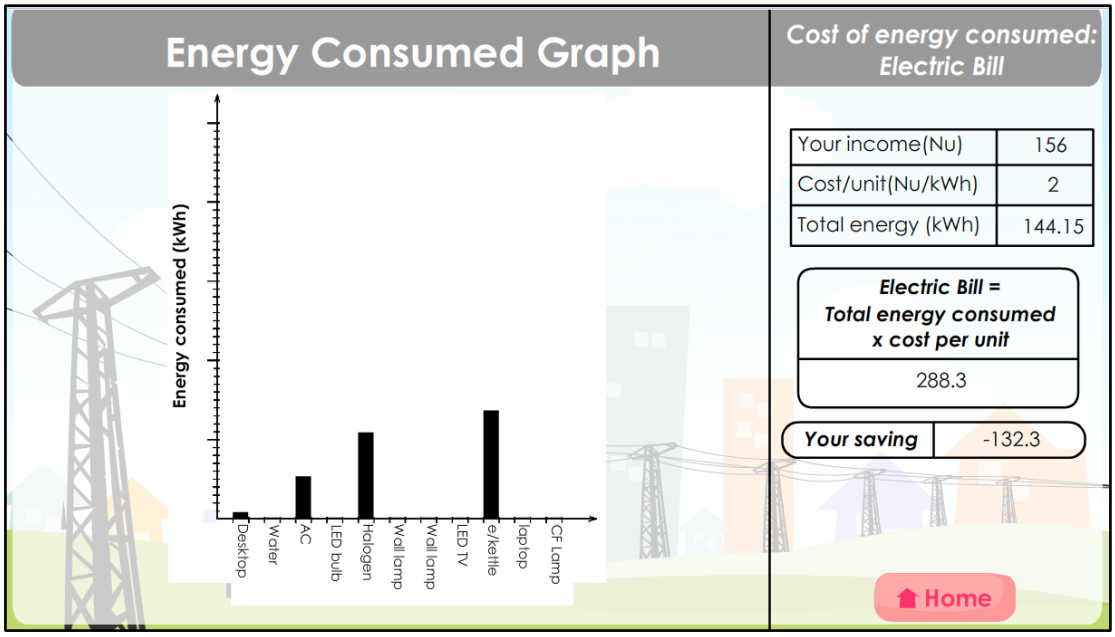


Energy Efficiency Game: Lesson Evaluation 2

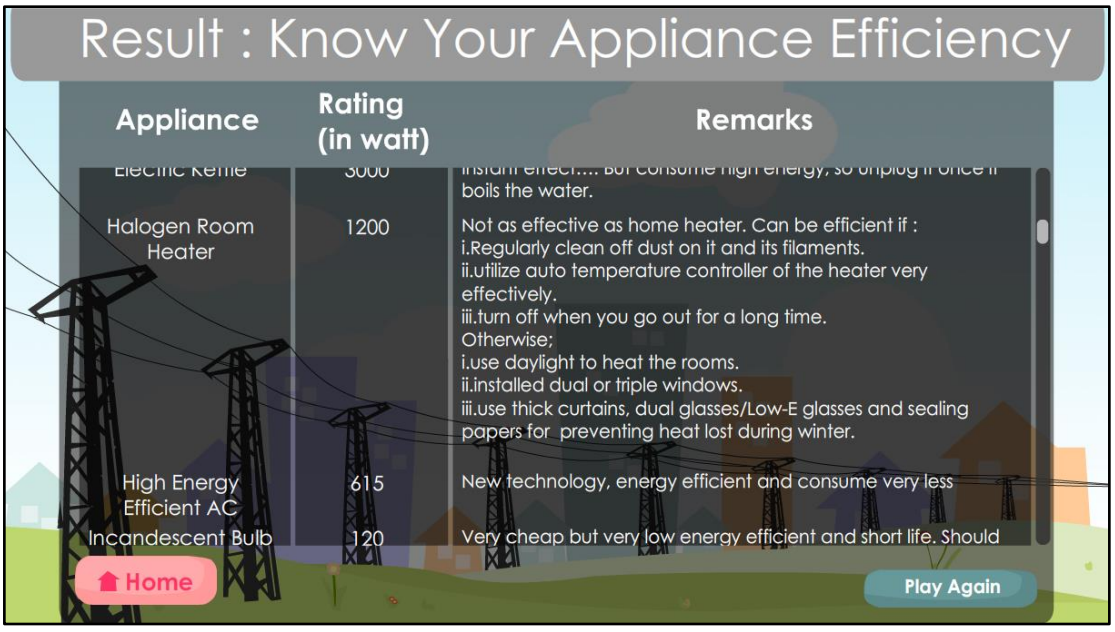
Learning module 3: Shopping Game: Know your home electric appliance better!



Shopping Game: Learning unit



Shopping Game: Lesson Evaluation



Shopping Game: Lesson Elaboration

BIOGRAPHY

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DATE OF BIRTH	25th July 1980
PLACE OF BIRTH	Phuentsholing, Chukha, Bhutan
INSTITUTIONS ATTENDED	National Institute of Education, Samtse, Bhutan Bachelor in Education (2001-2004) Sherubtse College, Royal University of Bhutan, Bhutan Post Graduate Certificate in Teaching of Information Subjects (2006-2008) Master of Science (Science and Technology Education) (International Postgraduate Program) (2012-2014)
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PUBLICATIONS

Dorji, U., & Panjaburee, P. A Learning Cycle Approach to Developing Educational Computer Game for Improving Students' Learning and Awareness in Electric Energy Consumption and Conservation, *Educational Technology & Society*. [submitted]

PRESENTATIONS

Dorji, U., & Panjaburee, P. (2013, 13-15 November). Multimedia-Supplemented Instructional Unit for Learning Household Electrical Energy Consumption and Conservation. In Proceedings of the *4th International Conference on Teaching and Learning*. p. 224-231. Held at Bangkok, Thailand, on 13 – 15 November, 2013.