EFFECTS OF BRAIN-BASED LEARNING ON PHYSICS ACADEMIC ACHIEVEMENT AND LEARNING ATMOSPHERE OF THE NINTH GRADE STUDENTS, BHUTAN

BY

YANGZOM

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This study was carried out to study the effects of brain-based learning on the physics academic achievement and learning atmosphere of the ninth grade students in Bhutan. The research design used was 2 groups, pretest-posttest experimental design. The subjects were randomly assigned to the experimental and control groups based on their pretest ranked scores. Achievement test and observation forms were used to collect the data. The experiment was carried out for six consecutive weeks.

Prior to the experimentation, validity and reliability of research instruments were established. The instruments were found to be valid with an IOC range of 1.00. The reliability of the instruments using KR-20 was 0.89.

Descriptive statistics and independent-samples t-test were used to analyze the data. When applying independent-samples t-test, the academic achievement and the learning atmosphere of the students experiencing BBL when compared to that of conventional teaching method was found statistically significant at 0.05 levels. It could be concluded that BBL was effective in increasing the academic achievement as well as enhancing the learning atmosphere.

Student's Signature:..... Thesis Advisor's Signature:.....

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LIST OF ABBREVIATIONS

BBL	Brain-based learning
CAPSD	Curriculum and Professional Support Division
DCRD	Department of Curriculum and Research Development
HSS	Higher Secondary School
IOC	Item Objective Congruency

CHAPTER 1

INTRODUCTION

This chapter describes the rationale of the study and outlines research questions, research objectives and hypotheses. It also provides the operational definition of the keywords used in the study.

1.1 Rationale

Physics is a field of study which connects the past with the present, and the traditional with the modern. It penetrates the different thoughts of mankind to mend it into one beautiful principle: its uses in the daily lives of mankind. In his book, "Physics and Philosophy", Werner Karl Heisenberg, one of the greatest physicist and Nobel Prize laureate, presents the various ways in which physics is used in daily life and its implications in shaping the thinking of mankind (Heisenberg, 1958: 129-144). However, physics is considered as one of the difficult subjects in the Bhutanese context. Tenzin, Johnson, Childs and Ramachandran (2008) found out that science subjects in the higher classes [ix-xii] were taught using conventional teaching method which lacked activities (p. 16). It is also clearly stated in the "Science Curriculum Framework of Bhutan" (2011) that the revised science curriculum should be activity based through "inquiry", "constructivist" and "investigative" approach (p. iii) which indicated that physics (science) was taught like any other subject.

Not only in Bhutan, Karim et al. (2006, as cited in Saleh, 2011) also found out that "students generally lack interest towards the subject of physics" (p. 63). It may be because the teaching and learning of physics lacked what it required: inquiry, hands-on

activity, investigation and constructivism. Physics is taught in the conventional method. Rehman, Malik, Hussain, Iqbal and Rauf (2012) point out that "[t]he conventional teaching method transfers only knowledge (Caine and Caine, 1995); promotes one way communication (McIntosh, 1996); lacks in interaction between students and teachers (Munson, 1992); makes learners passive (Steinhorst and Keeler, 1995); works by presenting content formally (Vella, 1992); and orally (Ruyle, 1995)" (pp. 113-114). Students often have difficulty relating science concepts taught in the class to real life. For instance, it is difficult to actually say what a wave is or what is the meaning of Kelvin or degree Celsius unless they are taught the concepts.

Therefore, to fulfill the needs of making learning optimum, instructional design needs to address the ways in which learning takes place. One such field which takes care of the overall learning process is the brain-based learning (BBL). Gulpinar (2005), Tileston (2005) and Zadina (2004) (as cited in Duman, 2010) claims that BBL has all the components to an effective teaching and learning (p. 2080). The educational use of BBL is mainly based on the principles of BBL put forward by Renate Nummela Caine and Geofferey Caine in 1991. Chipongian (2006) says that the BBL principles are a result of interdisciplinary research and that is why it has more to offer (p. 2). Reddish & Steinberg (1999) found out that in order to make learning optimum, we need to listen to the students and find ways to learn what they are thinking (p. 2). Moon and Leach (2008), in their book, "The Power of Pedagogy", reports of an increased "mutual trust" between the teachers and students when teachers listened to and consulted the students on the learning process (p. 146). BBL expects teachers to 'listen' to the students and focus on their needs as this will increase the 'mutual trust' which will result in genuine and fear-free learning. Teaching and learning has been found to be effective when the teachers catered to learners' unique learning style and abilities by several researchers namely Akyurek and Afacan (2013), Mary and Shefali (2012), Rehman, Malik, Hussain, Iqbal and Rauf (2012), Awolola (2011), Saleh (2011), Bas (2010) and Ozden and Gultekin (2008). This

study aimed to deliver the concepts of teaching force in a physics class by addressing the various factors as addressed by the BBL principles.

1.2 Research questions

This study intended to address the following two questions:

1.2.1 What is the effect of BBL on academic achievement of students learning ninth grade physics?

1.2.2 What is the effect of BBL on the learning atmosphere of students learning ninth grade physics?

1.3 Research objectives

The objectives of this study were:

1.3.1 To study the effect of BBL on the academic achievement of ninth grade students studying physics

1.3.2 To study the effect of BBL on the learning atmosphere of the ninth grade students studying physics.

1.4 Hypotheses

1.4.1 There will be significant difference between the mean scores in the academic achievement between the control and experimental groups.

1.4.2 There will be enhancement in the learning atmosphere when BBL is integrated in teaching and learning physics when compared to conventional teaching method.

1.5 Scope of the study

1.5.1 Location of the study

The study was conducted at Sherubling Higher Secondary School in Trongsa district, Bhutan. The researcher took a total of 7 periods to teach the entire chapter over a period of 6 weeks.

1.5.2 Content of the lesson

The study was carried out on the fifth chapter, force, of physics of the ninth grade curriculum. The researcher planned five lessons on the chapter on the following topics:

i. Definition of force
ii. Units of force
iii. Types of force
iv. Friction as a contact force
v. Advantages/disadvantages of friction; increasing/decreasing friction

1.5.3 Sample and subject

Sample: the sample of the study comprised 160 students of the four sections of grade 9 students of Sherubling Higher Secondary School, Trongsa, Bhutan.

Subject: random sampling was done to select two sections of 38 students each; one section as the experimental group and one section as the control group.

1.5.4 Variables

The independent variable used in the study was BBL and the dependent variables were academic achievement of the students and learning atmosphere.

1.6 Benefits of the study

The concept of education today has become learner-centered. BBL enhances the teaching-learning process by engaging the students in an enriching experience. McNamee (2011) believes that education today demands teachers to not only teach the content but to engage the students in meaningful learning as well by catering to the individual needs (p. 21). This requires making learning safe, trusting, secure, exploratory, real and as meaningful as possible. BBL is a learning approach which seems to address these things more prominently than the various other educational theories. Therefore it will prove beneficial for the teachers if they have the knowledge in the field. The following will be the contributions of the study:

1. This study will help bring forward the concept of BBL in the Bhutanese teaching environment.
2. It will disseminate the knowledge of how the brain learns and the ways to cater instruction as per the needs of the learners.
3. The importance of the organization of learning environment and the need for the teachers to manage the learning atmosphere will also be revealed.
4. It will help remind the teacher of his ability and art in making learning meaningful and enjoyable.

1.7 Operational definition

Brain-based learning

It is the use of brain's natural way of learning to design instruction on the chapter force and the learning atmosphere in the experimental group.

Effect

It refers to the outcome in the learners' achievement level in the posttest when compared with the pretest after BBL had been used as a mode of instructional strategy.

Learning atmosphere

It is the teacher's art of creating a safe, conducive, positive, respectful and fear-free climate in accordance with BBL in the experimental group.

Academic achievement of students

It is the learners' score earned in the achievement tests before and after the experiment.

Physics

It is one of the branches of science which the ninth graders in the study learn.

CHAPTER 2

REVIEW OF LITERATURE

This chapter discusses the concept of BBL and its applications to education. This is done based on the principles of BBL as proposed by the foremost authors in the field. Next, it presents the theories which support BBL. It includes some of the most prominent theories in education such as cognitive learning theory, constructivism and multiple intelligence theory. In order to optimize the use of BBL approach, the relation between the theories and the concept of BBL has been highlighted. The reviews of some related literature are also presented which supported the effectiveness of BBL in teaching and learning.

2.1 Education system in Bhutan

Bhutanese education system was mainly monastic until the 1950s from its inception in the early 1900s. From 1950s, it underwent a lot of change under the leadership of the second and the third king. With the advent of the modern education system, the curriculum was borrowed from India. However, the trend of education in Bhutan still lays in its roots- the monastic education system. Children are taught mostly through rote learning, and they are required to 'regurgitate' what they have learnt in exams to get promoted to the next class. Assessments were mostly summative until a few years back when formative assessments were made a part of it. However, even at present, children are required to obtain 80% in the summative assessments.

A need for shift in the ways of educating children became a conscience and a challenge for the educators. Owing to the advancements in the learning of science, the

authorities of science in the present day claimed that the educators in Bhutan need to shift their paradigm of teaching. Thus the need for a student-centered learning took its root. Teaching and learning focused on the students. They were considered the main driving force in the school. New ways and strategies of educating them became every teacher's priority.

2.2 Brain-based learning

Learning is a complex process and even more complex is the way individuals learn. It will not be wise to say one learner is more intelligent than the other simply by comparing the grades, a concept which we have long taken for granted. Bowen (2011) observes that in an ever challenging educational world, teachers are often faced with the confusion of which is the best way to deliver effective instruction and to bring out the best learners (p. 4). With such challenge, every educator should be prepared to be responsible for the stakeholders. It is at times like this when BBL emerged as an answer to such confusion. Brain-based learning (BBL) is a new paradigm which focuses on how the brain learns. It is important to know how the brain functions since it controls human thinking and all other related activities. The concept of BBL is in its initial stage. But the unprecedented rate at which neuroscientists are learning and discovering about the functioning of the brain is alarming. A lot of studies done in the field have helped explore its "anatomy, circulation, electrical activity, glucose metabolism and neuronal growth" (Cercone, 2006: 293). The ever-advancing technologies will be a boon to the field. We discover more about the brain through brain imaging devices, lab experiments with animals, computerized electrodes, clinical studies, positron emission tomography (PET), autopsies and spectrometers (Jensen, 1998: 2-3).

With BBL, every individual is taken care. It caters to many components which are known to maximize and enrich learning namely, "hands-on discovery, cooperative learning, integrating curriculum to build connections, creating a safe, comfortable

learning environment and encouraging students to construct knowledge rather than memorize facts" (McNamee, 2011: 13). Mary and Shefali (2012) describe BBL as a means of simplifying difficult lessons which will make learning meaningful and cooperative (p. 369). Greenleaf (2003, as cited in Duman, 2006) defines BBL as the brain's natural way of learning (p. 17). It includes accepting the rules of brain processing and organizing the teaching according to these rules in the mind for meaningful learning (Awolola, 2011: 94). These rules of the brain are made accessible to the educators through the ever-advancing field of neuroscience in the form of adaptable principles (Ozden and Gultekin, 2008: 2). Educators incorporate these findings from neuroscience and integrate the knowledge of how the brain processes to the way different individuals learn. David A. Sousa, an international consultant in educational neuroscience, says that the teachers' knowledge in the field of neuroscience is directly proportional to the effectiveness of his teaching (Sousa, 2011: 5). In his book, "How the Brain Learns", he provides priceless information on how the findings from neuroscience can be incorporated into everyday classroom teaching. BBL caters to individual learning styles and needs; therefore it caters to the concept of learner-centered education (Awolola, 2011: 93) which is the focus of education in the modern world. The BBL is incorporated into the field of education mainly through the works of Caine and Caine in the form of 12 principles.

2.2.1 The principles of brain-based learning

The 12 principles of BBL are used to organize the lessons and the learning environment. Since the teachers have the knowledge of how the brain learns naturally, they also know up to a certain level, that the students are human with emotions. This knowledge helps them to manage and supervise the learning atmosphere which is the most vital of the learning components. Perrin (2012) notes that "[t]he 12 principles of brain-based learning are an avenue for teachers to connect theory to practice and begin to bridge the gap between the art and science of teaching" (p. 17). Renate and Geoffrey

Caines' 12 principles are cited as a model of brain-based theories when it comes to the application of neuroscience in education. These principles integrate neuroscience and education (Wachob, 2012: 17). Its many benefits impacting the daily classroom teaching can be taken care if the teacher simply incorporates some of these principles. Not all principles need to be incorporated at once in a single lesson. Many studies conducted in teaching and learning incorporating the 12 principles found that students became motivated during and after the lessons. Since motivation in learning comes from different factors such as the lesson itself, friends, peer and teachers' constructive feedback, by a sense of achievement and the students' "preferred" environment (Reid, 2007: 15-17), the principles of BBL must have been successful in addressing these factors so as to motivate the learners. Extrinsic motivation is necessary for intrinsic motivation, and it is motivation that keeps the learners on track even if they 'fall down' at times.

Figure 2.1 shows the 12 principles as proposed by Renate Nummela Caine and Geoffrey Caine.

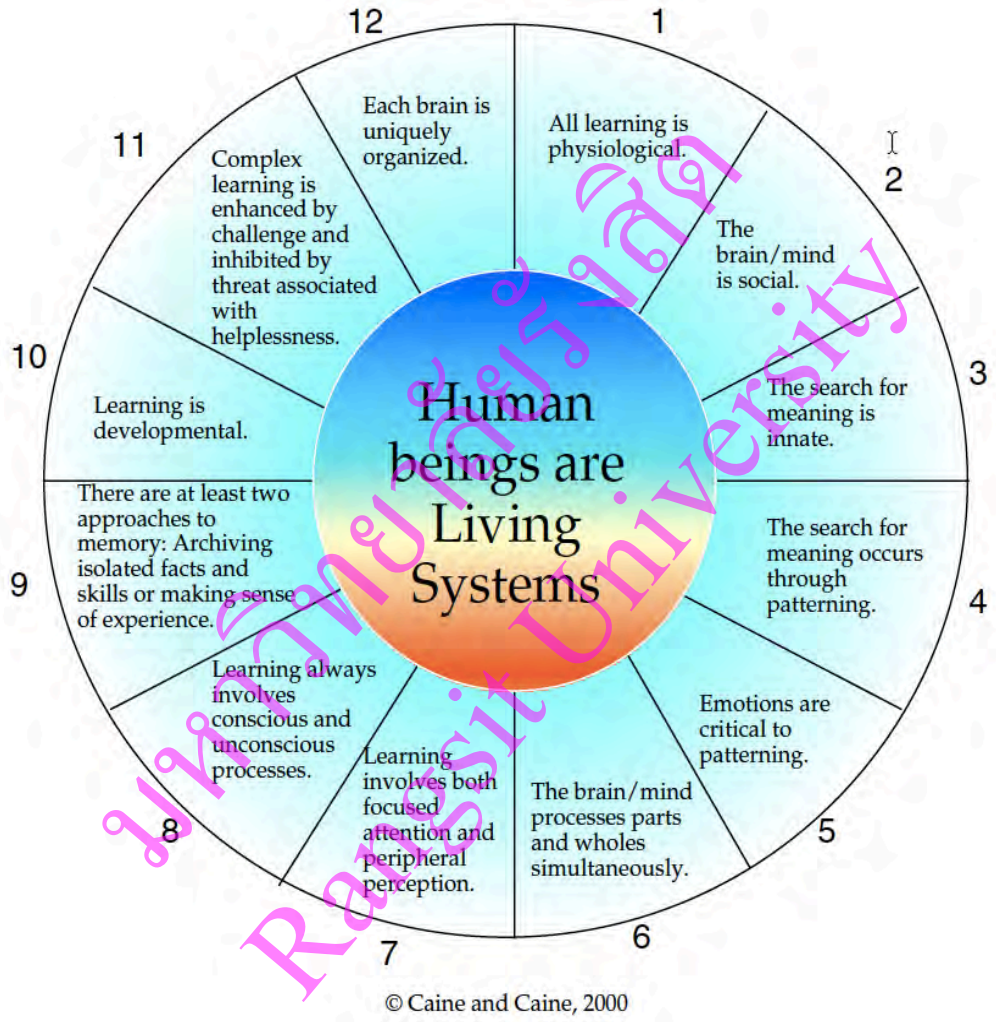


Figure 2.1 The 12 principles of BBL

Source: http://www.cainelearning.com/research-basis/brain-mind-principles/

Table 2.1 BBL principles and their implications in education (Wachob, 2012)

BBL principles	Implications in education
All learning is physiological	The brain changes with new experiences, which is often known as neural plasticity (Groen et al., 2007). Students need sensory input through action and physical movement (Sanes and Lichtman, 2001), and sitting at desks hinders the brain's ability to restructure neural connections (Levin et al., 2008; Ratey, 2008).
The brain is social	Human brain is a social entity that learns from working with others and building connections (Caine et al., 2005; Erlauer, 2003; Jensen, 2005; Kennedy, 2006; Roberts, 2002; Tileston, 2005). The brain develops better in concert with other brains – intelligence is valued in the context of the society in which we live (Lackney, 2007).
The search for meaning is innate	Human beings seek meaning and purpose during topics of interest through an instinctual drive (Frankl, 2006). Teachers need to relate the content to student interests in order for deep cognition to occur.
The search for meaning occurs through patterning	The mind naturally connects material by grouping information into categories (Gilhooly et al., 2007). Teachers should encourage the grouping of information through common threads of student experiences (e.g. asking questions, problem solving, projects) (Ratey, 2008).

Table 2.1 BBL principles and their implications in education (Wachob, 2012) (Cont.)

Emotions are critical to patterning	Emotions are involved in every thought process (Immordino-Yang and Damasio, 2007; Newquist, 2004; Sousa, 2006) therefore; feelings around a certain topic determine the depth of understanding and mastery (Caine and Caine, 1994). Teachers should present information to students in a way that encourages a positive emotional connection to the material.
The brain processes parts and whole simultaneously	The brain has the ability to integrate steps of a task when given the skill as a whole (Fuster, 2008). In other words, the brain can work backwards to develop strategies for completion when faced with the task as a whole. This principle can be integrated through projects, scenarios, and big ideas (Smith and Girod, 2003).
Learning involves focused attention and peripheral perception	Attention is needed in order for learning to occur (Almarode and Almarode, 2008), which is dictated by stimulus selection (Ratey, 2008). Furthermore, learning also occurs through background stimuli, as shown in mirror-neural research on children displaying behaviors acquired from non-direct environmental triggers (Feeney, Howard, and Howard, 2002; Rizzolatti and Fabbri-Destro, 2008). Teachers should find ways to keep students engaged in learning, as well as, create a physical environment that indirectly conveys the message of the content being taught.

Table 2.1 BBL principles and their implications in education (Wachob, 2012) (Cont.)

Learning involves conscious and unconscious processes	Besides intentional learning, the mind also has the ability to process information unintentionally, or through "cognitive unconscious" (Lakoff and Johnson, 1999). This process promotes metacognition, or awareness of learning, which encourages a higher order of thinking (Curwen et al., 2010). Teachers can promote higher-levels of thinking in students by incorporating reflection of learning and questioning results.
We have two ways of organizing memory: spatial memory system and a set of systems for rote learning	Science has discovered that the brain has both short and long-term memories (Fuster, 2006; Schacter, 1996). Teachers can use activities that encourage natural thinking (e.g. projects, problem solving), and organize activities that address different learning styles to encourage higher retention and meaning of the content.
Learning is developmental	It includes theories about the development of identity and general capacities such as the shift from concrete to abstract thinking, and the rough progression in the mastery of a discipline, from novice to expert. Professional development, and learning in the classroom, should both be scaffolded to take into consideration the capacities of learners and their current state of knowledge and competence. And there should be many opportunities to reflect on experience, and deal with regular feedback, so that insight and understanding can develop over time.

Table 2.1 BBL principles and their implications in education (Wachob, 2012) (Cont.)

Learning is enhanced by challenge and inhibited by threat	The brain slows in its ability to process information during times of stress (Barkley, 2010; Roberts, 2002), through the process called primitive response, or preparing the body to respond to fear without having to think about it. Teachers can focus on student-centered, hands-on activities that foster positive peer-social interactions, and ensure that students succeed throughout the learning process (Ratey, 2008).
Each brain is uniquely organized	Each individual has a unique brain with experiences and the ability to make meaning very different from others. It is very difficult to let people truly see things as one sees. Alexander (2009-2013) states that at the same time each person's brain is different in the sense that it is what Caine and Caine call '…a unique blend of experience and genetics.'

2.2.2 Implementation of BBL in the classroom

2.2.2.1 Lesson

Implementation of BBL principles in the classroom context has been discussed in two ways: in the lessons and in the environmental set up. It depends on each teacher's unique art to create the learning atmosphere. The BBL used in this study is an "integration of 'brain-based learning principles' (Caine and Caine, 1991, Sousa, 1995; Jensen, 1996) through seven brain compatible instructional phases (Sousa, 1995; Smith, 2003)" (Saleh, 2011: 94-96). They are:

1. Activation
2. Clarifying the outcomes and painting the big picture
3. Making connection and developing meaning

4. Doing the learning activity
5. Applying and integrating/ demonstrating students' understanding
6. Reviewing for students' retention/closure
7. Previewing the next topic

For an instruction to be effective, the teachers must design prior to delivery. The seven phases of BBL which is used in this study befits the components for an effective instruction. In order to enhance any lesson, the activation of students' prior knowledge is necessary in order to know what the students already know and make meaning. Smilkstein (2011) believes that "[t]his causal sequence through levels of learning must be seamless" (p. 134). Knowledge can only be constructed on the existing one. In order to make students clear of the expectations, it is also necessary to make the objectives of the lesson explicit.

Learning is not considered complete if the students do not get to participate in the learning after the teacher's input. In BBL, learners are required to participate in active learning which goes beyond carrying out the usual activities in the class. Watkins, Carnell and Lodge (2007) define active learning as engaging students "behaviorally, cognitively [and] socially" (p. 71). Activities in BBL classroom demands collaboration, thinking, construction and creation. It requires working together, focusing on cooperation rather than competition. Cooperative learning enhances motivation among the learners and makes all learners academically successful (Ornstein, Levine and Gutek, 2011: 425). In a study carried out by Flook, Repetti and Ullman (2005), it was found that "social experiences play……[a vital role in] children's psychological and academic functioning" (p. 326). BBL offers many platforms in which learners are required to work socially. BBL also allows the use of constructive and alternative assessment rather than simply grading. It requires the teachers to set a ground for the next learning to take place by paving its way through the present lesson. Put simply, it allows the learners to view a

connected, sequenced series of meaningful learning rather than chunks of new information that need to be memorized in every class.

In this study, the researcher has combined the first two phases and the last two phases together and fitted it in accordance to the lesson planning procedure which is valid in the context. Table 2.2 presents the outlines of how the lessons were aligned to the phases of instructional design and BBL principles.

Table 2.2 Instructional phases (Saleh, 2011)

Lesson components	Phases	Features	BBL principles
Introduction	Activate	Activate the memory processor system and students' prior knowledge to stimulate the transfer process	i. Brain learns best in its optimal state ii. Learning is enhanced by challenge/ inhibited by threat. iii. Brain processor works in wholes and parts simultaneously
	Paint the big picture	Have the students affirm for themselves personal performance target. Alleviate anxieties over the accessibility and relevance of the material. (Smith, 2003; Sousa, 1995)	i. The brain is unique and a parallel processor (able to perform several activities at the same time). ii. Brain processor works in wholes and parts simultaneously

Table 2.2 Instructional phases (Saleh, 2011) (Cont.)

Lesson develop-ment	Make connection and develop meaning	Lesson is connected to the prior knowledge and presented. It builds on what the learners already know and understand and helps them assimilate and integrate new information. (Caine and Caine, 1991; Smith, 2003)	i. Learning involves both focused attention and peripheral perception. ii. Learning involves both conscious and unconscious processes. iii. Learning always takes place in two memory approaches, retaining facts, skills and procedures or making sense of experience. iv. Brain can easily grasp and remember facts and skills embedded in its memory space.

Table 2.2 Instructional phases (Saleh, 2011) (Cont.)

	Do the learning activity	The stage for digesting, thinking about, reflecting on and making sense of experience, utilizing visualization, auditory, kinesthetic in multiple contexts. Access the multiple intelligences. (Jensen, 1996; Smith, 2003)	i. The brain is unique and a parallel processor (able to perform several activities at the same time). ii. The search for meaning comes through brain patterning process. iii. Brain processor works in wholes and parts simultaneously iv. Learning involves both conscious and unconscious processes. v. Complex and active experience involving movement stimulate brain development. vi. Learning engages whole physiology.
	Apply/demonstrate	The stage for brain active processing-apply/demonstrate the learning. (Caine and Caine, 1991; Smith, 2003)	i. The brain is unique and a parallel processor (able to perform several activities at the same time). ii. Learning always takes place in two memory approaches, retaining facts, skills and procedures or making sense of experience

Table 2.2 Instructional phases (Saleh, 2011) (Cont.)

	Review for students' retention	The activity stimulates working memory to summarize the lesson (Sousa, 1995)	Learning involves both conscious and unconscious processes.
Closure	Preview the next topic	The experience helps brain preprocessor to focus on the new lesson (Shaw and Hawes, 1998)	Learning involves both focused attention and peripheral perception.

2.2.2.2 Optimal learning state

The optimal learning state should not only include the environment but the way the teacher creates the learning atmosphere as well. It should include the physical, emotional, social and pedagogical settings (Lackney, 2007: 5) which are deemed necessary to make the students emotionally stable (McNamee, 2011: 13) for optimum learning to take place. The setting of appropriate learning environment is valuable because it can stimulate the learners' senses which in turn will result in effective learning. Nelson et al. (2006, as cited in McAteer, 2010) believes that "[t]he more a teacher creates a learning environment…..[that provides] emotional support, the greater the students' attention" (p. 75). This is because learners are creatures of emotion before being creatures of logic. Kottler, Zehm and Kottler (2005) view every child as a human being wanting to be connected intimately with others and that the most successful of the teachers are the ones who treat their students so (p. 48). Every teacher has a greater job to do than teaching- connecting lives. Indeed, it is a well-thought, safe learning environment that gives the initial impression that learners are valued. In that sense, not only should

schools and teachers be concerned about the physical environment within but beyond as well like issues pertaining to student safety, accessibility to the latest technologies etc… (MacGilchrist, Myers and Reed, 2004: 68). A BBL classroom makes the learners feel safe by ensuring a safe atmosphere and a safe environment.

In her study, "Using Action Research to Evaluate the use of Brain Based Teaching Strategies in the Classroom", Smith (2007) describes the ways in which the seven teachers of Charleston School in South Carolina used the brain-based approach to organize their teaching. She found out that teaching and learning seemed effective with the use of brain-based teaching strategies [to organize the learning environment] than without them (pp. 121-126).

To bring about optimal learning, the researcher will include the following strategies in the lesson:

Table 2.3 Classroom strategies and BBL principles (Saleh, 2011)

Strategy	BBL principles
The use of appropriate aroma and music (Jensen, 1996)	i. Positive climate stimulates brain function. ii. Appropriate environment, music and aroma excite brain activity. iii. Emotions are critical to brain patterning process.

Table 2.3 Classroom strategies and BBL principles (Saleh, 2011)

Active learning and student-centred strategies (Caine and Caine, 1991, 2003; Jensen, 1996; Sousa, 1995)	i. Learning involves both focused attention and peripheral perception. ii. Learning involves both conscious and unconscious processes. iii. Learning always takes place in two memory approaches, retaining facts, skills and procedures or making sense of experience. iv. Brain can easily grasp and remember facts and skills embedded in its memory space.
Emotion in learning experience (Caine and Caine, 1991, 2003; Jensen, 1996; Sousa, 1995)	i. Positive climate stimulates brain function. ii. Learning is enhanced by challenge and inhibited by threat.
Real-life experience (Caine and Caine, 1991; Jensen, 1996; Sousa, 1995)	i. Learning involves both focused attention and peripheral perception. ii. Learning involves both conscious and unconscious processes. iii. Learning always takes place in two memory approaches, retaining facts, skills and procedures or making sense of experience. iv. Search for meaning comes through brain patterning process. v. Brain processor works in wholes and parts simultaneously.

2.2.2.3 Assessment in brain-based learning

Standardized assessments are not deemed necessary for BBL. Assessment in a BBL classroom is more than awarding grades and positions. It should aid the learning process and not judge it. When assessments mean simply grading, teaching and learning can be detrimental. “Research on high-stakes accountability and the implications for education have generally concluded that striving for higher test scores without a balanced approach to teaching can be detrimental to learning” (Kohn, 2000; Perlstein, 2010; Rabkin and Redmond, 2004; Sutton, 2004 as cited in McNamee, 2011: 12). In their research based book “What Successful Teachers Do”, Glasgow and Hicks (2003) emphasize that students should not be threatened with the idea of grades during the process of learning as this will “sink” their zeal to learn (p. 84). Watkins, Carnell and Lodge (2007) also support the same idea that assessment should be a part of learning activities and not different from it (p. 151). This means that students should not have the stigma of fear of failure while in the process of learning. Martin (2010) believes that fear is directly related to students’ self-esteem (p. 35). He says that if the students fail, they feel that they are “not worthwhile” (p. 36). Indeed, assessment should altogether be a guide for them to lead to a hallmark of good grades. Cave, Ludwar and Williams acknowledge that it should be the teachers who should find appropriate ways to assess the students’ work (p. 2).

Research has found out that immediate, constructive feedback increases motivation and makes students aware of how to improve their work. Students can choose to present their work through a skill they find most appropriate and interesting. This caters to the individual’s learning style preference. However, since teachers have to be accountable for standardized testing, they can find a balance between the alternate assessment and the traditional assessment and adjust the assessments as per the classroom situation. New advancements in the field allow exactly that. Teachers can

let students maintain portfolios, let them present their work through art, presentations, demonstrations and writings. They can also participate in interdisciplinary projects.

2.2.3 Related learning theories

Learning is an abstract concept. It means different to different people. Some define learning as the change in behavior whilst others take it as a change in the cognitive processing. Still others explain it as an ability of an individual to construct on the existing knowledge. The concept of learning has evolved over the years as did mankind. Therefore, it became necessary to understand how different people learn and a conceptual framework to do so deemed vital. The learning theories helped educators understand their learners explicitly. It guided them to have a clear knowledge of their teaching and the learners' understanding.

Different learning theories support different instructional strategies. The prominent learning theories which support BBL are:

2.2.3.1 Cognitive learning theory

BBL involves the functioning of the brain and it is much the same as how designing instructions with the knowledge of information processing in the brain. Thus BBL also has many aspects of cognitive learning theory. "Cognitive learning theories explain learning by focusing on changes in mental processes and structures that occur as a result of people's efforts to make sense of the world" (Kauchak and Eggen, 2004: 237). This directly relates to the first principle of BBL that learning is physiological. It means that the learners are active, they construct knowledge depending on the existing knowledge and that all learning changes the mental processes of an individual. Cognitive learning theory posits the various mental processes in information processing during learning and as a result of learning. It involves how the learner

observes, categorizes, forms, and generalizes to make sense of the information provided. Santrock (2011) believes that in order to help students improve their memory teachers should chunk, organize, link and repeat the information (p. 274). It also values the learner's prior experiences since it believes that the learner comes with knowledge, skills and related experiences to the learning situation. The learner needs to actively participate in the learning process to construct their personal understanding of the content to which they are exposed, and the teachers should facilitate for this.

2.2.3.2 Constructivism

Constructivism is a theory about how people learn. It explains how people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences (Richardson, 2003: 1626). It has it's "basis on how people make sense of their experience" (Taber, 2011: 39). Applefield, Huber and Moallem (2001) believe that irrespective of the vastness of each individual's experience, a person's "existing knowledge structure" has an impeccable influence on what is being learned and how meaning is constructed from thence on (p. 4).

Constructivism is another learning theory that supports BBL. Indeed it has many overlapping implications with BBL. Constructivism provides a situation in which the learners construct their own knowledge based on previous experiences, skills and interaction with the environment. Moore (2004) makes it very clear when he said about constructivism that "[r]eality is not 'out there' waiting to be described; it is the descriptions themselves that construct the 'real' of which we claim to have knowledge" (p. 150).

Dunn (2005) refers to it as "a theory of learning……[and] not a theory of teaching" (p. 230). He further emphasizes that many view the theory as "a means to develop thinkers and problem-solvers" (p. 230). This implies constructivism as

a theory extending beyond the classroom scenario and the fact that BBL addresses the aspects of it makes BBL further appreciative and effective. The teachers' role is to facilitate learning by providing the context and arranging the environment in which learning is to take place. This aligns with the principles of BBL where the learning atmosphere needs to be looked into including how the learner interacts with peers, and makes use of the previous knowledge and experiences to construct knowledge.

Wachob (2012) outlined some of the overlapping principles between BBL and constructivist learning approaches as illustrated below:

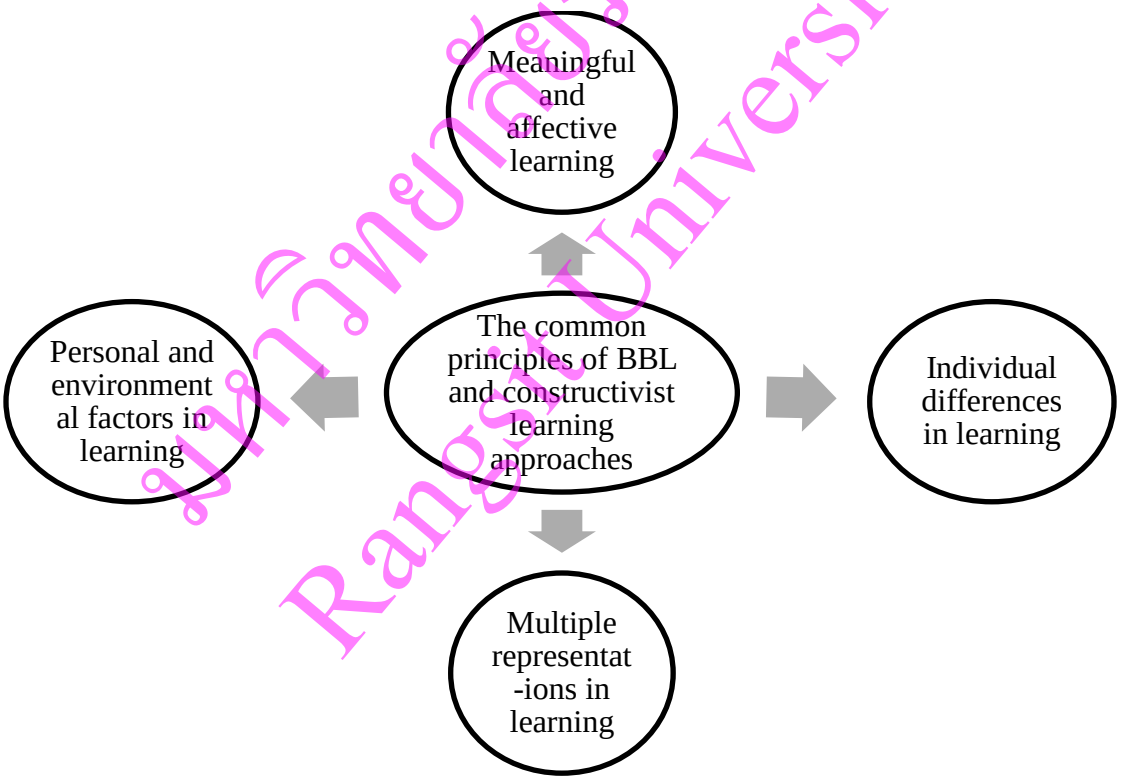


Figure 2.2 Common principles of BBL and constructivism

Source: Wachob, 2012

2.2.3.3 Multiple intelligences theory

Teaching and learning today has come to a profound realization that different individuals learn differently. The theory of multiple intelligences was first introduced by Howard Gardner in 1983 through his book “Frames of Mind”. According to this theory, “there are different ways to be intelligent” (Gardner, 1983, 1993, 1999, 2006, as cited in Krummick, 2009: 26). Gardner and Hatch found out that most of the activities that we carry out rely on the use of more than one type of intelligence (1989: 5). Each individual has his own way of doing things and it is pointless to regard a particular way as the best especially when it comes to learning. Learning catered to an individual’s style is regarded as the most efficient one. It is the duty of every teacher to at least try to recognize those traits if we want to succeed in bringing out the best in a variety of young minds. “Many things go into creating the child we see before us. Learning styles, life experiences, developmental stages, environment, culture, and support systems are just a few components of the puzzle that influence a child’s success” (Boyles and Contandio, 1997 as cited in Mussen, 2007: 27).

Pociask and Settles (2007) carried out a study to observe the effects of incorporating the theory of multiple intelligences into daily lessons and found out that the “[s]tudents appeared to be more focused” in the class and recommend teachers to use it in teaching and assessment (p. iii).

Multiple intelligences theory focuses on instruction that “stimulates thinking, creativity and caring in all students; caters to individual abilities and learning styles; and is based on more equitable access” (Sulaiman et al., 2011: 1146). It is weird and unfair to use the narrowness of the term ‘grade’ in schools to measure a person’s intelligence. This is celebrating only one trait of human intelligence. Not all who scored the highest in schools end up being successful. In fact, the authors of “Teaching and Learning Through Multiple Intelligences”, Campbell, Campbell and Dickinson

(2004) claim that Gardner (1983) himself defines intelligence as the ability to “solve” the challenges to make life meaningful (p. xx). Multiples intelligences theory puts forward eight different kinds of intelligences and teachers can use this knowledge to cater to the different needs of each learner. But it is not as easy for the teachers as to ‘how’ to cater to these needs. Using BBL can be a solution for this. Wachob (2012) posits that there are certain elements common in multiple intelligences theory and BBL (p. 12). Indeed, according to Armstrong (2003 as cited in Klinek, 2009), the various parts of the brain are associated with different types of intelligences Gardner offered (p. 56). This means that if BBL is used in designing instructions, the multiple intelligences of the learners will be naturally focused.

The table below shows how the eight multiple intelligences and brain-based approaches are related.

Table 2.4 Multiple intelligences and BBL principles (Wachob, 2012)

Intelligence	Core operations	Brain-based approach
Linguistic	Syntax, phonology, semantics, pragmatics	Allow students to develop case studies, poetry, or make up stories.
Musical	Pitch, rhythm, timbre	Have students create rhythms or songs for remembering concepts.
Logical-mathematical	Number, categorization, relations	Break problem solving tasks into smaller components, and give students time to systematically test solutions.

Table 2.4 Multiple intelligences and BBL principles (Wachob, 2012) (Cont.)

Spatial	Accurate mental visualization, mental transformation of images	Incorporate graphs and charts into the lesson, and allow students to map out content or “mind map”.
Bodily-kinesthetic	Control of one's own body, control in handling objects	Allow students to create models for class projects, and incorporate movement into lessons.
Interpersonal	Awareness of others' feelings, emotions, goals, motivations	Incorporate small group work into lessons.
Intrapersonal	Awareness of one's own feelings, emotions, goals, motivations	Help students recognize their dominant learning styles and allow time for application of those styles when possible.
Naturalist	Recognition and classification of objects in the environment	Use real life scenarios or allow students to apply the environmental examples to the content.

Gardner suggests that teachers, as educators of a thousand different minds, it is the responsibility of us to integrate educational theories, teaching strategies, and other pedagogic tools in meaningful ways to better address the needs of students. He said he never had a rigid hold on the usage of this theory. It depended on each user how and in which context it will be used (Gardner, 2011: 6). Addressing the multiple intelligences of our students will have a profound effect in addressing their individual abilities and therefore boosting their confidence. Educators should be careful in using MI as a theory in teaching and assessing. When using it, we should not consider

it as a sole purpose of 'doing' it on the students. Rather it should be a combined effort of the stakeholders to discover and focus on the individual's unique strengths and abilities (Shearer, 2006: 24). Using MI makes the students their own assessors as well. This helps them become reflective and thus helps them think and decide critically about their work and thus their life in the long run (Tirri and Nokelainen, 2011: vii).

2.2.4 Related research

Several studies have been carried out to see the effectiveness of BBL in the classrooms.

Akyurek and Afacan (2013) carried out a study titled Effects of Brain-Based Learning Approach on Students' Motivation and Attitudes Levels in Science Class to examine the effect of brain-based learning approach on attitudes and motivation levels in 8th grade students' science classes. The method used for the study was pre/post-test control group research model from the true experimental design. They used attitude questionnaire and motivation questionnaire to collect the data. The research was conducted with one experimental group and two control groups. In total, 57 students, 19 in experimental group, 19 in each control groups participated in the research. The study took place during the teaching of 'cell division and heredity'. They found that the students in the experimental group had significantly higher scores in the posttest on their motivation towards the use of BBL when compared to those in the control group. Therefore they concluded that the use of BBL increases students' motivation towards learning.

Mary and Shefali (2012) carried out a study to study the Effectiveness of Brain-Based Learning on Academic Achievement in Biology, Stress and Study Habits of VIII Standard Students. The research design was a quasi-experimental of pretest and posttest. They carried out the study on a sample of 240 students from 4 schools in which

two were private-aided 120 students and two were private-unaided 120 students. A three-stage random sampling technique was used to select the sample. They found out that BBL is a constructive, domain specific strategy to holistic education, and that it had the potential to stimulate the optimal learning among students in very relaxed and enriched learning environment.

Rehman, Malik, Hussain, Iqbal and Rauf (2012) carried out a study on the Effectiveness of Brain-Based Learning on Secondary Level Students of Urban Areas using a pretest-posttest control group design on 60 ninth grade students. They were randomly divided into experimental and control groups. The researchers used an academic achievement test developed using five in-built faculties of human brain. The test was validated through experts' opinions and pilot testing. The item analysis was carried out to check difficulty level and discrimination power. A 16-items test was finalized stating five innate brain faculties. The reliability of the test was estimated using split-half method. It was concluded that the students who were taught using the BBL approach performed better than the students taught using conventional learning method.

A study by Awolola (2011) on the Effect of Brain-Based Learning Strategy on Students' Achievement in Senior Secondary School Mathematics in Oyo State, Nigeria was conducted on 522 students. The study adopted a pretest-posttest non-equivalent control group design in a quasi-experimental setting. The ANCOVA statistic was used to analyze the data collected from the study. The study found that BBL was more effective in enhancing students' achievement than the conventional lecture method.

Saleh (2011) carried out a study on the Effectiveness of the Brain-Based Learning Approach in Dealing with Problems of Form Four Students' Conceptual Understanding of Newtonian Physics. The research method adopted was quasi-experimental involving 100 students from two Science secondary schools. Data were collected from results, based on the Test of Newtonian Physics Conceptual

Understanding using descriptive and inferential statistic and an independent-samples t-test technique. The findings showed that BBL approach possessed a better conceptual understanding of Newtonian Physics compared to students who were exposed to conventional teaching method.

In a study carried out by Bas (2010) titled Effects of Brain-Based Learning on Students' Achievement Levels and Attitudes towards English Lesson, 60 students in two different classes in the 6th grade of an elementary school was administered a pre-posttest control group research. The data obtained in the study were analyzed by the computer programme SPSS 15.0. The arithmetic mean and standard deviations were calculated for each group. In order to test the significance between the groups, the t-test was used. The significance level was taken as .05. The results of the research showed a significant difference between the attitude scores of the experiment group and the control group. It was found out that the use of BBL method increased the motivation and academic success level of students. The data collected from the research also showed that the use of BBL method developed a positive attitude in students.

Ozden and Gultekin (2008) carried out a study to investigate the Effects of Brain-Based Learning in a 5th Grade Science Course on Academic Achievement and Retention of Previously Acquired Knowledge. The design was a pre-posttest control group model. Two classes of 22 students each were determined as experimental and control groups respectively. The study lasted for 11 days for a total of 18 class hours. The study found out that BBL approach appeared to be more effective than the traditional teaching procedures.

A study to see the Effect of Brain-Based Learning Instruction to Improve on Students' Academic Achievement in Social Studies Instruction was carried out by Duman (2006). The research design was a pretest-posttest one experimental group and one control group. The sample of the study consisted of sixth grade students which were

selected randomly from two separate classes. Data from the dependent variable was collected by Academic Achievement Test of Social Studies and the Interview method of qualitative research. ANCOVA and t-test were used to analyze the data. The study found out that the use of BBL instruction improved the academic achievement of students as well as fostered a positive attitude in the students

2.3 Conclusion

Understanding various educational theories has brought tremendous change in how the educators view education. The shift in the paradigm of teacher-centered to learner-centered has lifted the face of educating the learners. Many theories are in place which contributes its own bits and pieces to better teaching and learning. However, there never has been as effective, as impounding and as wholesome a theory as the BBL, which not only takes care of the academic teaching and learning, but the physical, emotional and social state in which the learning has to happen. Bowen (2011) argues that the effectiveness of BBL is evitable by its increasing use, and that it is the duty of the educators to use the knowledge of neuroscience to enhance teaching and learning (p. 8).

The study of neuroscience is advancing as ever and this fact indicates that it does have benefits to education. Researchers have seen BBL packed with potentials to change the society. Not only does it influence teaching and learning but it is also seen to affect how a person views others as an individual, which affects relations in societies. Worden, Hinton and Fischer (2011) suggest that “teachers and [neuro] scientists….. [should] cooperate to use [brain] research to answer practical problems facing schools and families” (p. 12). Every teacher should have the knowledge of BBL if they are to have ‘successful human beings as the bloom of education’, rather than ‘machines as the product of the school’.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter gives an overview of the research methodology in carrying out the study. It describes the research design, samples and subjects of the study, research instruments used to collect data, validity and reliability of the instruments, data collection procedures and the statistics used to analyze the data collected.

3.1 Research design

The research design was 2 groups pretest-posttest experimental design. Achievement test and observation forms were used to collect data. Achievement test was administered to both groups before and after teaching. Observation forms were used to observe each experimental and control group class to see if the principles of BBL had been included in the design of the learning atmosphere.

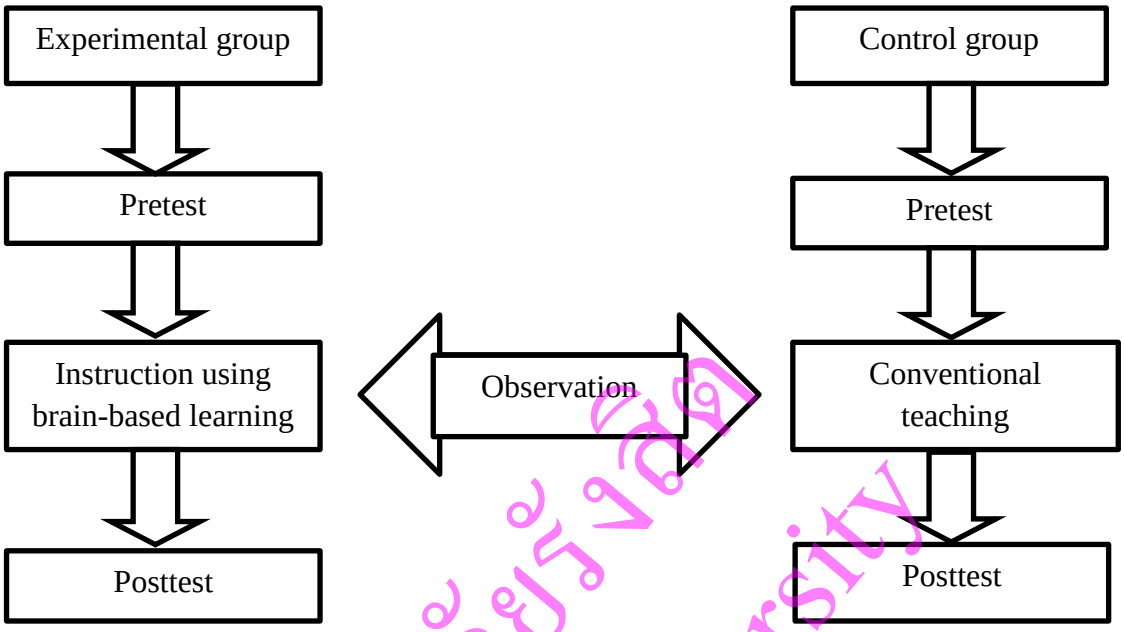


Figure 3.1 Research design

3.2 Sample and subject

3.2.1 Sample: the sample of the study comprised 160 students of the four sections of grade 9 of Sherubling Higher Secondary School, Trongsa, Bhutan.

3.2.2 Subject: the researcher used random sampling to assign 38 students each to the experimental and control group. The selection was done based on the pretest ranked scores.

3.3 Experimental procedures

Prior to teaching, a pretest was administered to both groups. This was done to ensure that they were of the same learning ability. The experimental group was taught with the BBL while the control group was taught using conventional teaching method.

The researcher taught both groups. All classes in both groups were observed by a teacher observer using an observation form. The observation form included 10 indicators of BBL which were grouped under physical and mental atmosphere. The observation was done to see if the researcher used BBL principles in the delivery of the lessons and the design of the learning atmosphere. After teaching both groups for six weeks, the researcher administered a posttest to see if there was any progress from the pretest scores.

3.4 Data collection

3.4.1 Ethical considerations

3.4.1.1 Approval

Before proceeding to the destination school and carrying out the research project, the researcher obtained a letter of approval from the Ministry of Education. Upon reaching Trongsa district, the location of the study, the researcher also sought permission from the principal of the school and the subject teacher of the ninth graders.

3.4.1.2 Confidentiality

The researcher ensured that the participants and their opinions were kept anonymous.

3.4.2 Research instruments

3.4.2.1 Experimental instruments

Lesson plan

Five lesson plans were made on the chapter force. The lesson plans were made using the format provided by the Bhutan Council for School Examinations and Assessment (BCSEA) which divides the whole lesson plan into four parts:

- A section giving a brief account of the topic, the objectives, the teaching/learning materials that will be used and so on.
- Introduction
- Lesson development which is the body of the lesson
- Closure

This was again designed synchronous to the BBL principles. Since BBL had no definite form of assessment, the researcher used different modes of assessment for each lesson, for example, rubrics, checklists, model answers and so on.

The objectives of the lessons tried to include all the three domains of learning; psychomotor, cognitive and affective. The lessons were guided by worksheets. They were also supplemented with fact sheets which were given at the end of every lesson. This helped the students in looking beyond the topic they have learnt and widening their views about the topics learnt.

3.4.2.2 Data collection instruments

Achievement test

To study the effect of BBL on the students' academic achievement, an achievement test was used. The achievement test consisted of 20 objective questions on the chapter force. The questions were framed using Bloom's taxonomy of cognitive domain. The format of the questions was based on the format of the BCSEA. The test was administered once before and once after the experiment to both groups.

Observation forms

A teacher observer observed all the five lessons in the experimental and the control group using an observation form. The purpose of the observation was to see if the researcher used the principles of BBL in the designing of the learning atmosphere. The observation form had 10 indicators sub-grouped under physical and mental atmosphere. These indicators were framed from Caine and Caines' 12 BBL principles.

3.5 Validity and reliability of research instruments

3.5.1 Validity

The research instruments were validated by a team of experts from Rangsit University and a team of experts from Bhutan. IOC of the instruments was calculated to see if the items align with the learning objectives. The items were adapted or revised as per the recommendations from the experts. Indexes of item objective congruency (IOC) were computed for lesson plans, achievement test and observation

forms. The IOC for all the three research instruments were 1.00 which indicated that they were valid.

3.5.2 Reliability

After reaching Bhutan, the achievement test was tried out in a ninth grade class in Taktse Middle Secondary School prior to carrying out the experiment. To find reliability coefficient of the achievement test, Kuder-Richardson Formula (KR-20) was applied. The KR-20 coefficient was 0.89 which indicated that the instruments were reliable.

3.6 Data analysis

In comparing and assessing the effects of BBL and conventional teaching method on the academic achievement of ninth grade students in physics, the comparison between pretest and posttest score was done by t-test. The inferential statistics t-test with $p<0.05$ level of significance was used to compare the pre and post achievement test level of the two groups.

In order to see if the BBL had been included in the lessons and the design of the learning atmosphere, an observation form consisting of 10 indicators of BBL, was used to observe each class in the experimental and the control group by a teacher observer. Descriptive statistics such as mean and standard deviation, and inferential t-test were used to analyze the data collected through these forms.

CHAPTER 4

RESULTS OF DATA ANALYSIS

This chapter presents the results of the data analysis. The results are presented in two parts: test score analysis and lesson observation analysis.

4.1 Test score analysis

The first objective was to study the effect of BBL on the academic achievement of ninth grade students studying physics. This was done by doing a comparative statistical analysis using mean, standard deviation and independent-samples t-test.

Figure 4.1 showed the comparison of the means of pretests and posttests within the groups. The mean of control group in the pretest was 11.68 and in the posttest was 14.92 with a mean gain of 3.18. The mean of experimental group in the pretest was 10.50 and in the posttest was 16.21 with a mean gain of 5.68. Independent-samples t-test was used to compare the means of the two groups (Table 4.1).

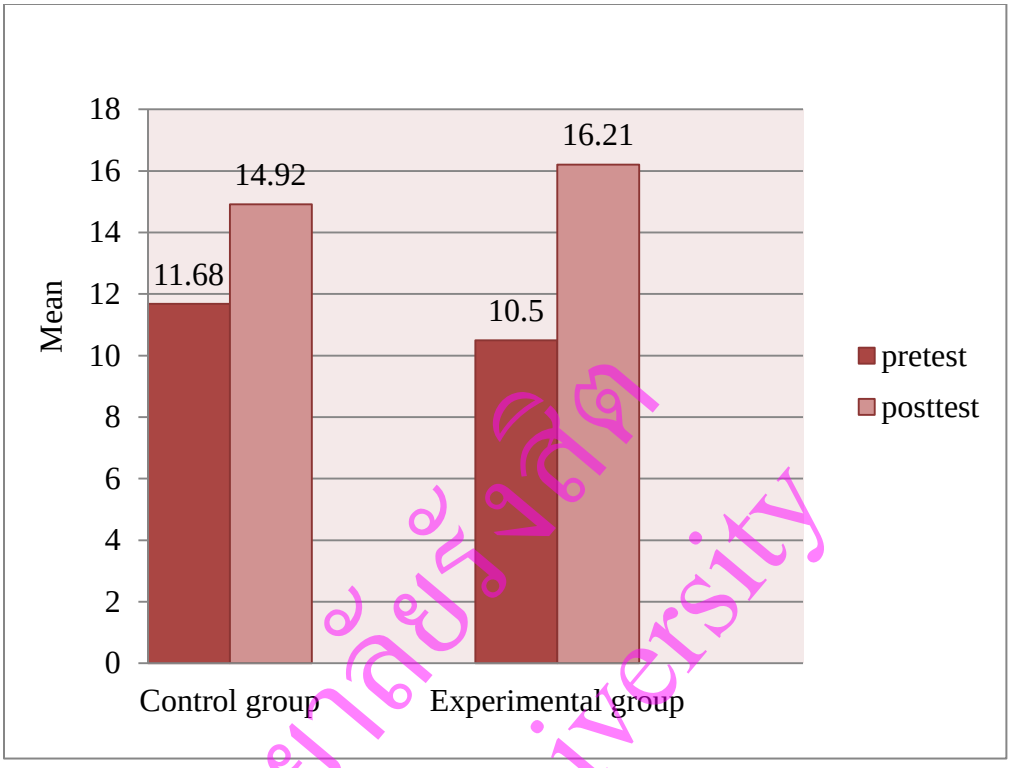


Figure 4.1 Comparison of means within the groups

Table 4.1 showed the result of comparison of the pretest and posttest means of the experimental and control group both within and between the groups.

Table 4.1 Comparison of means and SD of pretest and posttest

Group	Pretest	Posttest	Gain score (mean)	t-value	df	p-value
Experimental	10.50	16.21	5.68	11.17	37	0.00
Control	11.68	14.92	3.18	6.10	37	0.00
t-value	1.88	2.05				
Df	74	74				
p-value	0.06	0.04				

When applying independent-samples t-test to compare the difference of the pretest means of the experimental group with that of the control group, the 2-tailed significance value was 0.06 which indicated that there was no significant difference between the pretest means of the two groups. This indicated that the two groups had relatively equal learning abilities in the beginning of the experiment. When comparing the posttest means of the two groups, the 2-tailed significance value was 0.04 which indicated that the difference was statistically significant at 0.05 level. It could be concluded that the use of BBL increased the academic achievement of the students.

4.2 Lesson observation analysis

The purpose of the teacher's observation was to determine the extent to which the lessons were characterized by the principles of BBL. The 12 BBL principles were incorporated into 10 indicators. These 10 indicators were further classified under physical and mental atmosphere. Table 4.2 presented the result analysis by applying independent-samples t-test. It was found that the difference was statistically significant at 0.05 level. The mean of the experimental group (36.80) was higher than that of the control group (20.40) which showed the enhancement of the learning atmosphere after the inclusion of the BBL.

Table 4.2 Means and SD of lesson observation of the two groups

Group	Mean	SD	N	Mean difference	t-value	df	p-value
Experimental	36.80	2.78	5	16.40	6.59	8	0.00
Control	20.40	4.83	5				

Table 4.3 Comparison of means, SD and level of opinion of the learning atmospheres

Learning atmosphere	Experimental		Control	
	Mean	Opinion	Mean	Opinion
Physical	3.72	Outstanding	1.84	Fair
Mental	3.68	Outstanding	2.12	Fair

Table 4.3 presented the subtotal means and level of opinion of the observation of the physical and mental atmosphere of the two groups. The level of opinion for the experimental group was 'outstanding' for both the learning atmosphere and for the control group was 'fair'.

Tables 4.4 and 4.5 presented the means, standard deviation and level of opinion of each indicator under the physical and mental atmosphere respectively for both groups.

Table 4.4 Means, SD and level of opinion of teacher's observation for physical atmosphere

Physical atmosphere indicators	Experimental			Control		
	Mean	SD	Opinion	Mean	SD	Opinion
1. Teaching/learning materials are displayed in the class.	3.40	0.89	'G'	2.40	1.34	'F'
2. The classroom arrangement is appropriate for group work.	3.80	0.45	'O'	1.00	0.00	'ND'
3. Lesson includes the use of different learning materials.	3.40	0.55	'G'	2.40	0.55	'F'
4. Seating arrangement facilitates interaction.	4.00	0.00	'O'	2.40	0.55	'F'
5. Classroom arrangement	4.00	0.00	'O'	1.00	0.00	'ND'

facilitates free movement.						
Sub total	3.72	0.38	‘O’	1.84	0.49	‘F’

Table 4.5 Means, SD and level of opinion of teacher’s observation for mental atmosphere

Mental atmosphere indicators	Experimental			Control		
	Mean	SD	Opinion	Mean	SD	Opinion
1. Concepts are related to students’ experience.	3.60	0.55	‘O’	2.60	0.55	‘G’
2. Students can choose their own partners in carrying out the activities.	4.00	0.00	‘O’	1.00	0.00	‘ND’
3. Students share their work with others enthusiastically.	3.60	0.55	‘O’	1.80	0.84	‘F’
4. Students are comfortable asking questions/requesting assistance.	3.20	0.45	‘G’	2.20	0.84	‘F’
5. The teacher responds positively to students’ questions and answers.	4.00	0.00	‘O’	3.00	1.22	‘G’
Sub total	3.68	0.31	‘O’	2.12	0.69	‘F’

Note- Level of opinion: 0.00-1.50: Not demonstrated ‘ND’ 1.51-2.50: Fair ‘F’ 2.51-3.50: Good ‘G’ 3.51-4.0: Outstanding ‘O’

In the experimental group, for the physical atmosphere, the subtotal mean was 3.72 and the standard deviation was 0.38. The level of opinion indicated ‘outstanding’ result. Indicators 4 and 5 had the highest means. For the mental atmosphere, the subtotal mean was 3.68 and the standard deviation was 0.31. The level of opinion indicated ‘outstanding’ result. Indicator 2 and 5 had the highest means.

In the control group, for the physical atmosphere, the subtotal mean was 1.84 and the standard deviation was 0.49. The level of opinion indicated ‘fair’ result. Indicators 1, 3 and 4 had the highest means. For the mental atmosphere, the subtotal mean was 2.12 and the standard deviation was 0.69. The level of opinion indicated ‘fair’ result. Indicator 5 had the highest mean.

Figure 4.2 Comparison of means of each indicator for the control and the experimental group

Figure 4.2 presented the comparison of the means of each indicator under physical and mental learning atmosphere for the control and the experimental groups.

4.2.1 Students' perception after the inclusion of BBL

The following figures presented the students' perception when BBL was used as an instructional strategy. It is evident from the students' own reflection that they liked the strategy. They mentioned that they could learn better through group works and peer activities. They felt that learning is more of understanding and less of memorizing.

Figure 4.3 Students' sketch of the seating arrangement

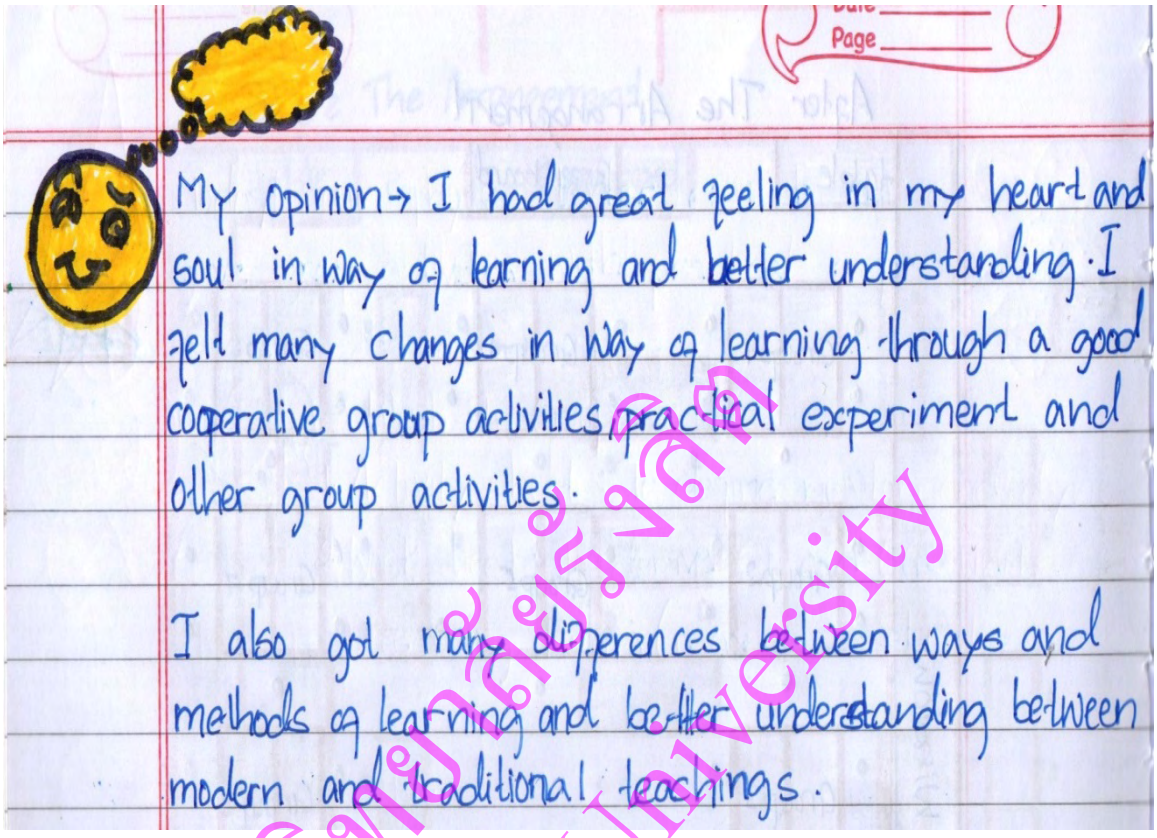
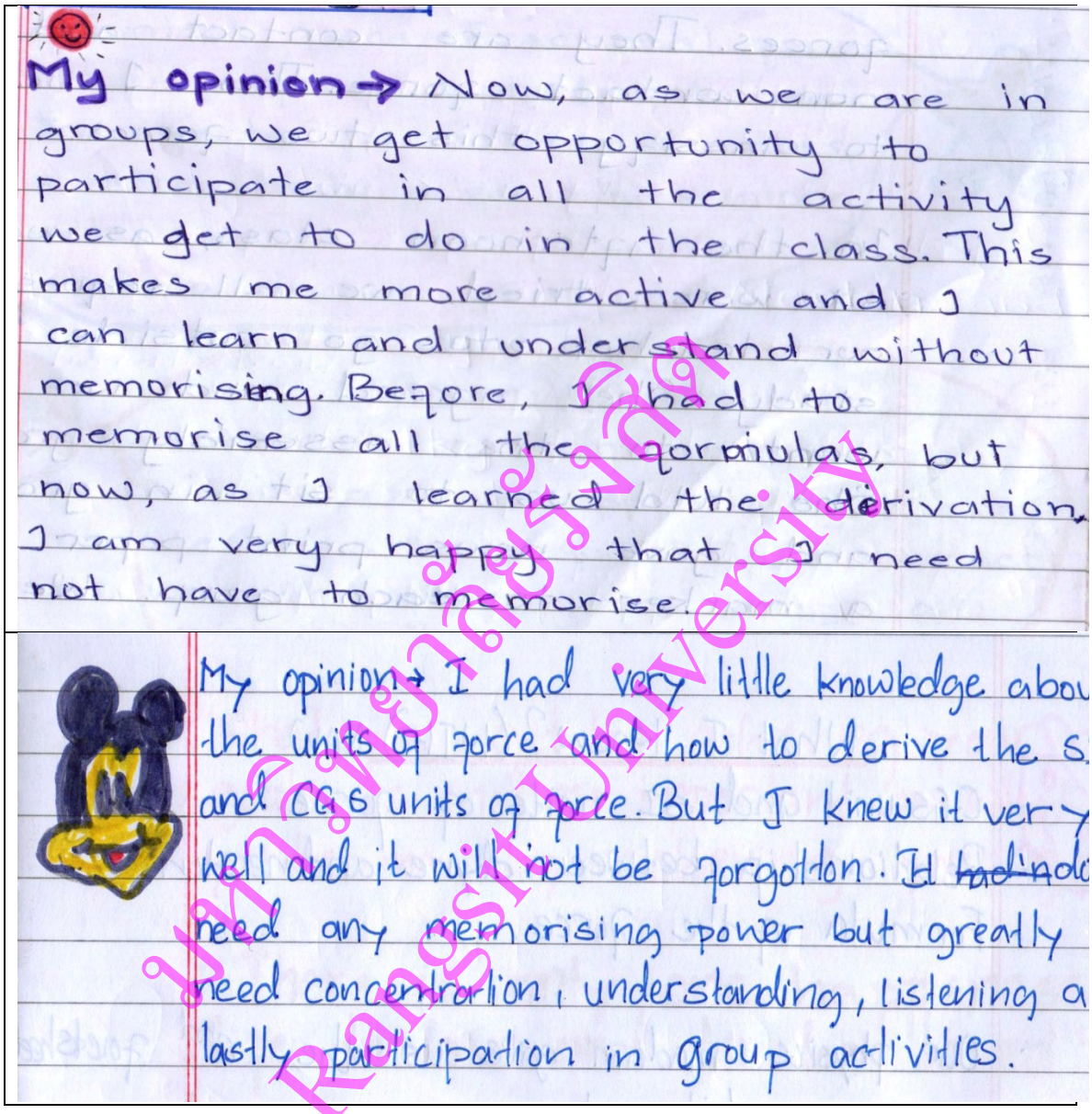


Figure 4.4 Student's opinion (1)


My opinion → Now, as we are in groups, we get opportunity to participate in all the activity we get to do in the class. This makes me more active and I can learn and understand without memorising. Before, I had to memorise all the formulas, but now, as I learned the derivation, I am very happy that I need not have to memorise.

My opinion → I had very little knowledge abou the units of force and how to derive the S. and CGS units of force. But I knew it very well and it will not be forgotten. It ~~had no~~ need any memorising power but greatly need concentration, understanding, listening a lastly participation in group activities.

Figure 4.5 Students' opinion (2)

5.2 Discussion

5.2.1. Objective 1

The first objective was to study the effect of BBL on the academic achievement of the ninth grade students studying physics.

From table 4.1, it can be concluded that the performance of the students in the experimental group and the control group increased significantly. However the results showed that the experimental group after the treatment with BBL performed better than the control group which did not receive the treatment. The results of the experimental group was significant ($p=0.04$) when compared to that of the control group. Therefore, the first hypothesis, there will be significant difference between the mean scores in the academic achievement among students experiencing conventional teaching method compared to BBL was accepted. Many other studies supported this finding. Rehman, Malik, Hussain, Iqbal and Rauf (2012), Awolola (2011), Saleh (2011) and Ozden and Gultekin (2008) all found out that the academic achievement of students increased significantly with the use of BBL.

The academic achievement of the students after the use of BBL might have improved because the lessons were based on the students' experiences and emotions. The use of BBL allows for the consideration and inclusion of the students' experiences in their learning from where they can construct meaning. The experiences carried with them some emotions. If not, the learning based on these experiences was made memorable. They were filled with emotions. "Our most powerful memories are laden with emotions" (Erlauer, 2003: 12). She continues that the information which is constructed from our previous experiences is remembered easily by the brain (p. 53). She also provides interesting classroom instructional strategies to aid learning (p. 54) which were incorporated by the researcher in the lessons. "The development of the human brain

cannot be separated from life experience, as life experiences changes the brains psychological structure and operation" (Degan, 2011: 6). He further goes on explaining that individuals learn by processing experience. This is in line with the principles of constructivism learning theory which explains that learning is not about building knowledge from nothing, indeed it is building upon the "cognitive and conceptual resources already available" (Taber, 2011: 48). Constructivism allows the lessons to be integrated with hands-on experience, lab activities, co-operative and inquiry learning (Applefield, Huber and Moallem, 2001). Students could learn through trial and error which accounted for excellence in their learning. They were allowed to experiment their learning until the concept became clear. This did not require students to memorize the facts rather they could construct the meaning after the things they have learnt have been understood (Figure 4.5). They could write down their own understanding on the topics (Appendix VIII). Indeed, Sjoberg (2007) noted that "constructivism is a dominant perspective in fields like science education" (p. 8).

Jensen (1998) also found out that students' attentiveness and alertness increases when they are involved in a variety of activities. This involved "rotating mini-lectures, group work, reflection, individual work, and team project time" (p. 49). Lessons were not only held inside the four walls of the classroom. Students were taken outside for group works and presentations. They were taken to the science labs for want of extra space and materials. Ackerman (1992, as cited in Jensen, 1998) revealed that "a change in location is one of the easiest ways to get attention" (p. 50). Students' achievement might have improved because they were attentive during the lesson and the learning.

Another reason for students' better performance may be because the lessons focused on the students' diverse abilities. This was supported by the theory of multiple intelligences. The researcher tried to bring out the innate abilities of the students during individual as well as group works. The freedom in the choice of choosing their co-workers and presenting their work was seen as an effective strategy to instill a positive

attitude for learning. The media and style of presentations and assessments were based on the students' own interest. They were allowed to 'opt' for any strategy they deemed suitable as long as the lesson objectives were fulfilled. The part they took in preparing the activities and the presentations was also kept to their preferences. Some chose to prepare the charts by writing or drawing, while some wanted to present. The others did the demonstrations. The activities merely focused on the students' ability to do different things. During the presentations, some students chose to present their work through writing while some others preferred demonstration, yet others found it appropriate to do it through question-answer sessions and some preferred to organize mini-lectures in the class. Each of them had their own interests and preference of doing things. And it so happened that students always wanted to do the things which they are best at. While this allowed them to better their best, their other abilities were also focused as well. They took turn to carry out the activities with their peers' assistance.

Through these activities, students realized the variety in the ways of learning (Figure 4.4) and this in turn made them reflect on their studying and learning habits as well. Some felt the need to work with others while others felt the need to learn through figures and symbols. They could see that each of them could contribute 'something' towards the group's success. The freedom to choose 'their' way of preparation and presentation allowed them to demonstrate their creativity. This made them work hard and to explore their creativeness. It helped them in valuing and appreciating their unique talents. "[B]eliefs and perceptions of self constitute the most central cognitive feature or determinant behind students' personal understandings, interpretations, and self-regulation" (Malmivuori, 2001 as cited in Tirri and Nokelainen, 2011: vii). This further enhanced their confidence in handling learning disparities. Gangi (2011) reported Gardner's (1983) beliefs that the individuals make use of the knowledge of their "intelligent strengths" to enhance their "educational opportunities and options" (p. 33). It was also found to increase the students' expectation of themselves (Gangi, 2011: 28).

A lot of studies found out that it is detrimental to label students according to the marks they score in the tests as educational institutions usually do. Infact, Shearer in her study “Using a Multiple Intelligences Assessment to Facilitate Teacher Development” (2006) found out that students “sort themselves” into different ability groups (high ability, average ability and below average ability) owing to which students are “labeled as smart” by the teacher in the classroom (p. 19). This is a very strong point to think about. Is it nature or nurture that is changing the students’ perspective in terms of viewing themselves? Can we, as educators, change that? It is very important for the educators to be very mindful of what we let students do during learning. Everything we do is either going to heal or harm them, mend or mar them.

5.2.2 Objective 2

The second objective was to study the effect of BBL on the learning atmosphere of the ninth grade students studying physics.

All the lessons in both groups were observed using a lesson observation form. The lesson observation form had 10 indicators framed based on the principles of BBL. They were classified under physical and mental atmospheres.

Table 4.2 presented the comparison of the observation of the learning atmosphere in the experimental and the control group. The result was statistically significant at 0.05 level. It showed that the BBL enhanced the learning atmosphere when compared to learning atmosphere in the conventional class. Tables 4.4 and 4.5 showed the mean, standard deviation and level of opinion of each indicator under physical and mental atmosphere respectively of the experimental and control group. In the experimental group, for the physical atmosphere, the subtotal mean was 3.72 and the standard deviation was 0.38. The level of opinion indicated ‘outstanding’ result. For the mental atmosphere, the subtotal mean was 3.68 and the standard deviation was 0.31. The

level of opinion indicated ‘outstanding’ result. In the control group, for the physical atmosphere, the subtotal mean was 1.84 and the standard deviation was 0.49. The level of opinion indicated ‘fair’ result. For the mental atmosphere, the subtotal mean was 2.12 and the standard deviation was 0.69. The level of opinion indicated ‘fair’ result. It was concluded that the inclusion of BBL enhanced the learning atmosphere. Therefore, the second hypothesis, there will be enhancement in the learning atmosphere when BBL is integrated in teaching and learning physics when compared to conventional teaching method was accepted. Similar studies done by Akyurek and Afacan (2013), Mary and Shefali (2012), Bas (2010) and Duman (2006) also revealed that the inclusion of BBL in teaching and learning not only increased the academic achievement but that it also fostered a positive learning atmosphere and therefore a positive attitude in students.

BBL is known for the flexibility it involves in designing the learning atmosphere. Students were allowed to work with the person they felt most comfortable with. They were allowed to work in groups or independently. They had the freedom of movement in the class. The learning atmosphere was co-operative rather than competitive, but it was challenging. Degan (2011) found out that when the learning atmosphere was challenging, the brain produced new cells which “improved memory and learning” (p. 7). Many studies found out that the “brain changes as a result of the environment” (Hebb, 2002, original published in 1949; Bennett, Diamond, Krech, and Rosenzweig, 1964; Rosenzweig, Love, and Bennett, 1968 as cited in Degan, 2011: 7). The visual displays in the classroom also aided the students in learning. Jensen (1998) found out that such classroom “can be a source of inspiration, affirmation, and content” (p. 39). “They can help learners feel safe, comfortable, or keep up with the learning” (Debes, 1974 as cited in Jensen, 1998: 39). Although a decorative classroom provides platform for an enriched learning, Jensen found out that “challenge” and “feedback” were the actual “ingredients” of enrichment.

During the teaching/learning period, students experienced less threat and more support. The teacher was friendly and the learning was a peaceful one. The students moved on their own pace and they were given time to adjust to the teaching/learning process. Students worked in groups which provided them the opportunity for sharing ideas and clearing their doubts. They could refine and define their ideas while they associated with their friends. The author of "The Brain-Compatible Classroom", Erlauer (2003) highlighted that learners with higher "emotional security" possessed a better ability to think and learn when compared to those who experience insecurity, fear and stress (p. 14). She further added that this is enhanced and nurtured by socialization with others. This is supported by the constructivism theory as well the multiple intelligences theory. Since the learning is learner-centered, the classroom environment facilitates for interaction which will bring about the sharing various experiences which will enrich the learning (Collins, 2008: 1-2). This was also seen to reduce insecurity. It concealed the fragile expositions of the learners. This type of atmosphere was never there in the conventional classes. This change might have made the learning easier and also may have triggered the students to be responsible for their learning. Armstrong (2000) highlighted the same findings in his paper "Using Multiple Intelligences to Design a Classroom Environment" (pp. 1-4). He discussed how a classroom environment can be designed using the theory of multiple intelligences and how this affected the students' learning and attitude. This was found as a boon to the BBL classroom as MI theory is one of the founding theories of BBL.

Students liked the group work and the experiments as evidenced from their own reflections from Figures 4.4 and 4.5. They loved the seating arrangement (Figure 4.3) done after the inclusion of BBL to design the learning atmosphere.

While the results of the study indicated an improvement in the academic achievement and the learning atmosphere, the researcher also did face some challenges in the course of the experiment. BBL required lots of space for individual/group works,

presentations and display of students' works. Interaction is a key factor of BBL. The small size of classroom in the Bhutanese context hindered the movement of the students and all the works of the students could not be displayed simultaneously due to the small space available for a subject corner. To overcome this, the researcher took some classes outside or in the physics lab.

The Bhutanese students are used to learning in the teacher-centered environment. It involves the teacher to lecture the lessons and the students to passively listen or take down notes. While on the other hand, BBL required students to work in groups and prepare for presentations by discussing and making their own teaching aids. They were required to follow the instructions given in the worksheets. They also evaluated their and others' works using checklists and rubrics. They were not used to such methods and the researcher had difficulty in acquainting them with the materials and the processes in the first lessons. It was also challenging to acquire all the materials for the specific lesson. But the students got used to the process and their performance improved as the lessons progressed.

5.3 Recommendations

5.3.1 To the teachers

BBL is an effective instructional approach which takes into consideration the wholesome development of the students. Teachers must be mindful of the physical atmosphere as well as the emotions of the students to bring about better teaching and learning. Students should be seen as individuals with emotions. Factors such as prior experiences, individual learning styles and abilities and internal and external motivation should be considered.

5.3.2 To the curriculum developers

It would be interesting to use the BBL in other subjects to see how the manipulation of the physical and the mental atmosphere impacted the learners' academic achievement and attitude towards learning. Further researches may be carried out to compare BBL with other prominent teaching strategies such as co-operative learning, inquiry method or 4MAT model.

Further explorations can also be done through studies pertaining to the effectiveness of the assessment procedures in the Bhutanese context, and the inclusion of the assessment practices in BBL to improve learning.

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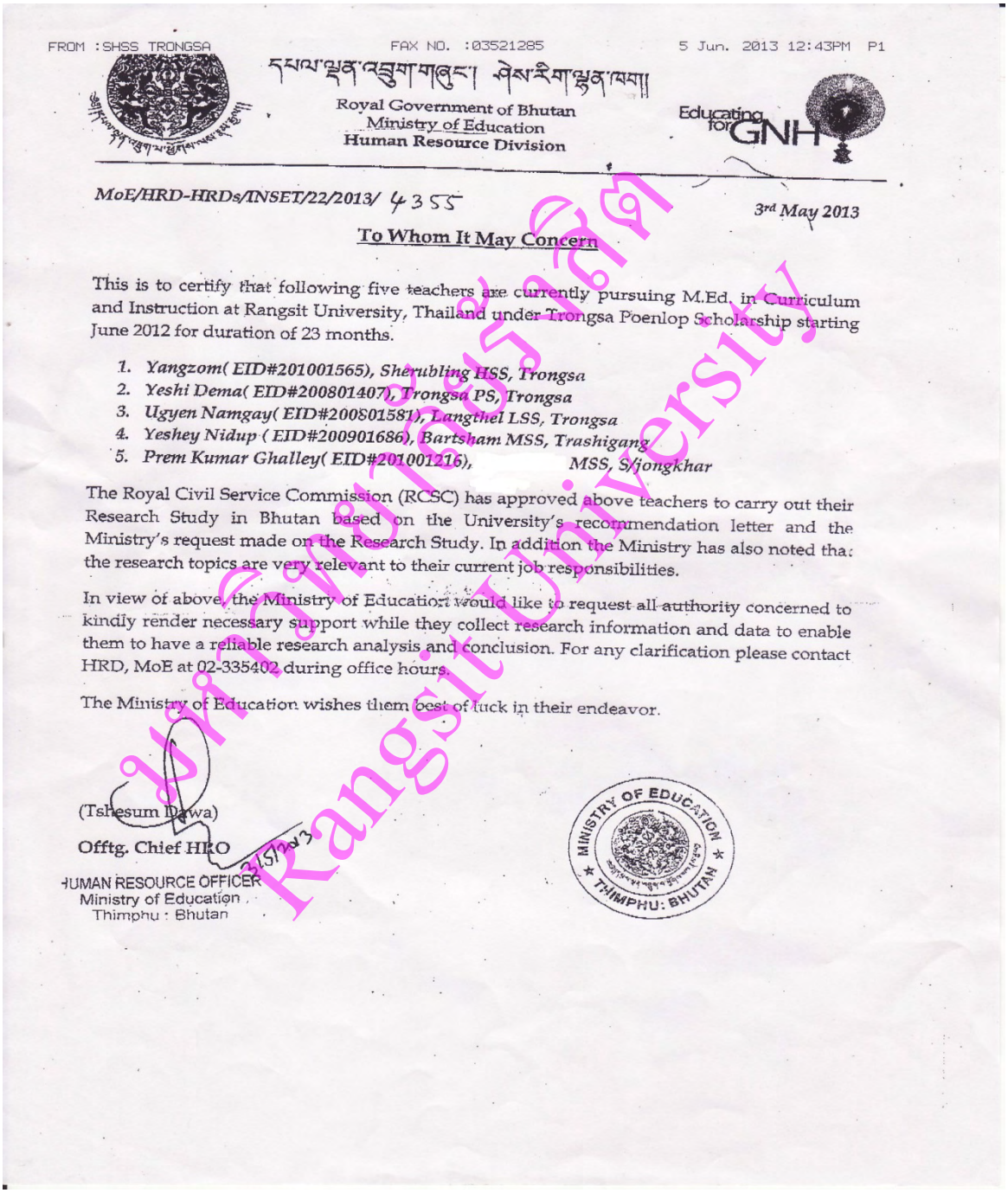
APPENDICES

Appendix I

Letter of approval, Ministry of Education, Bhutan



FROM :SHSS TRONGSA FAX NO. :03521285 5 Jun. 2013 12:43PM P1

དཔལ་ལྡན་འབྲུག་གཞུང་། ཤེས་རིག་སྡེབ་ཁག།

Royal Government of Bhutan
Ministry of Education
Human Resource Division

Educating for GNH

MoE/HRD-HRDs/INSET/22/2013/ 4355

3rd May 2013

To Whom It May Concern

This is to certify that following five teachers are currently pursuing M.Ed. in Curriculum and Instruction at Rangsit University, Thailand under Trongsa Poenlop Scholarship starting June 2012 for duration of 23 months.

1. *Yangzom(EID#201001565), Sherubling HSS, Trongsa*
2. *Yeshi Dema(EID#200801407), Trongsa PS, Trongsa*
3. *Ugyen Namgay(EID#200801581), Langthel LSS, Trongsa*
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The Royal Civil Service Commission (RCSC) has approved above teachers to carry out their Research Study in Bhutan based on the University's recommendation letter and the Ministry's request made on the Research Study. In addition the Ministry has also noted that the research topics are very relevant to their current job responsibilities.

In view of above, the Ministry of Education would like to request all authority concerned to kindly render necessary support while they collect research information and data to enable them to have a reliable research analysis and conclusion. For any clarification please contact HRD, MoE at 02-335402 during office hours.

The Ministry of Education wishes them best of luck in their endeavor.

(Tshesum Dawa)
Offtg. Chief HRO
HUMAN RESOURCE OFFICER
Ministry of Education
Thimphu : Bhutan

MINISTRY OF EDUCATION ★ THIMPHU: BHUTAN ★

Appendix II

IOC of achievement test questions

Question	Expert 1	Expert 2	Expert 3	IOC
1	+1	+1	+1	1
2	+1	+1	+1	1
3	+1	+1	+1	1
4	+1	+1	+1	1
5	+1	+1	+1	1
6	+1	+1	+1	1
7	+1	+1	+1	1
8	+1	+1	+1	1
9	+1	+1	+1	1
10	+1	+1	+1	1
11	+1	+1	+1	1
12	+1	+1	+1	1
13	+1	+1	+1	1
14	+1	+1	+1	1
15	+1	+1	+1	1
16	+1	+1	+1	1
17	+1	+1	+1	1
18	+1	+1	+1	1
19	+1	+1	+1	1
20	+1	+1	+1	1

Appendix III

Achievement test

Unit objectives:

1. The students will be able to classify forces into two major types, contact and non-contact and provide various examples of it.
2. The students will be able to examine the cause of friction, evaluate its presence in daily life to come up with different solutions to either increase or decrease it.

Blueprint

Lesson Topics	Rem.	Und.	App.	Ana.	Eva.	Cre.	Marks
Definition and effects of force	1	2					**2**
Units of force	3 4		5				**3**
Types of Forces	6 7			8 9	10		**5**
Friction		11 12	13	14 15			**5**
Advantages and disadvantages of friction/increasing and decreasing friction			16 19	17 18 20			**5**
Total	**5**	**3**	**4**	**7**	**1**		**20**

Achievement test questions

Full marks: 20 Time: 30 minutes

Attention: The paper is not an exam. It will be used purely for my study. Please answer it as much correctly as you can.

Instructions: This questionnaire consists of 2 parts:

Part A: Demographic information

Part B: Test questions

Part A: Demographic information

Please fill in the information below by putting a tick mark in the bracket [ ].

1. Name: ……
2. Gender: [ ] Male [ ] Female
3. Age: [ ] Between 13-15 [ ] Between 16-18 [ ] Above 18

Part B: Test questions

Direction: This paper contains 20 multiple choice questions. Each question has four alternative answers. Choose the best possible answer by circling it. (1 X 20= 20 marks)

1. The physical cause which changes or tends to change the state of rest or of uniform motion of a body in a straight line is called _____.

a) Energy
b) Push
c) Force
d) Pressure

2. Which pair best describes the effects of force?

I. A force can change the dimensions of a non-rigid body.

II. A force can make an object move or stop a moving object.

III. A force can change the speed but not the direction of a moving body.

IV. A force can only speed up the motion of a body.

a) I & II

b) III & IV

c) I & III

d) II & IV

3. It is a cold winter and your car will not start. Two friends help you by pushing it. After the push, it accelerates at a rate of 2 meters per second per second. What is the magnitude of the net force exerted on the car by your friends? The mass of the car is 800 kg.

a) 0.0025 N

b) 400 N

c) 1600 N

d) 640000 N

Mass of car = 800 kg

4. Which are the best examples of contact force?

a) Frictional force and electric force

b) Tension force and magnetic force

c) Push and gravitational force

d) Collision force and pull

4. Choose the odd one out:

a) 

b) 

c) 

d) 

6. Sonam runs her toy car on dry marble floor, wet marble floor, newspaper and towel spread on the floor. The force of friction acting on the car on different surfaces in increasing order will be:

a) Wet marble floor, dry marble floor, newspaper and towel
b) Newspaper, towel, dry marble floor, wet marble floor
c) Towel, newspaper, dry marble floor, wet marble floor
d) Wet marble floor, dry marble floor, towel, newspaper

Appendix IV

IOC of observation form

Indicator		Expert 1	Expert 2	Expert 3	IOC
Physical atmosphere					
1	Teaching/learning materials are displayed in the class.	+1	+1	+1	1
2	The classroom arrangement is appropriate for group work.	+1	+1	+1	1
3	Lesson includes the use of different learning materials.	+1	+1	+1	1
4	Seating arrangement facilitates interaction.	+1	+1	+1	1
5	Classroom arrangement facilitates free movement.	+1	+1	+1	1
Mental atmosphere					
6	Concepts are related to students' experience	+1	+1	+1	1
7	Students can choose their own partners in carrying out the activities.	+1	+1	+1	1
8	Students share their work with others enthusiastically.	+1	+1	+1	1
9	Students are comfortable asking questions/requesting assistance.	+1	+1	+1	1
10	The teacher responds positively to students' questions and answers.	+1	+1	+1	1

Appendix V

Lesson observation form

Observation Form: ……..

Class: ……

Lesson topic: …….

4= Outstanding	3= Good	2= Fair	1= Not demonstrated

A. Physical atmosphere

Sl.No.	Indicators	4	3	2	1
1.	Teaching/learning materials are displayed in the class.				
2.	The classroom arrangement is appropriate for group work.				
3.	Lesson includes the use of different learning materials.				
4.	Seating arrangement facilitates interaction.				
5.	Classroom arrangement facilitates free movement.				

B. Mental atmosphere

Sl.No.	Indicators	4	3	2	1
6.	Concepts are related to students' experience				
7.	Students can choose their own partners in carrying out the activities.				
8.	Students share their work with others enthusiastically.				
9.	Students are comfortable asking questions/requesting assistance.				
10.	The teacher responds positively to students' questions and answers.				

Appendix VI

IOC of lesson plans

Lesson number	Expert 1	Expert 2	Expert 3	IOC
1	+1	+1	+1	1
2	+1	+1	+1	1
3	+1	+1	+1	1
4	+1	+1	+1	1
5	+1	+1	+1	1

Appendix VII

Lesson plan

Lesson plan 02

Unit of learning/chapter: Force

Topic: Units of force

Grade: IX

Time: 50 minutes

Period: 1

Content: The SI unit of force is Newton and the CGS unit of force is dyne.

1 N is that force which acts on a body of mass 1 kg and produces an acceleration of 1 m s^{-2} in the direction of force.

1 dyne is that force which acts of a body of mass 1 g and produces an acceleration of 1 cm s^{-2} in the direction of force.

1 N = 10^5 dyne

Objectives

Each student should be able to:

1. Define newton.
2. Define dyne.
3. Make 'educated' inferences from their observation.
4. Tabulate their findings neatly.
5. Work cooperatively with their friends to derive the SI and CGS units of force using F=ma.
6. Solve a numerical problem using F=ma.
7. Highlight the importance of the units in the measurement of a physical quantity (force, in this case).

Previous knowledge: They can define force and figure out that force needs to be measured in different situations. They can also tell that force is the product of mass and acceleration.

Teaching/learning material: Some potatoes of different sizes, a packet of biscuit, a bottle of water, a stop watch, a ruler, activity sheet, work sheet and fact sheet.

Learning activity

Lesson component/ time	**Teacher activity**	**Student activity**
Activate	Demonstrate buying-selling of potatoes involving two students. Show the packet of biscuit, the bottle of water, the stop watch and the ruler and ask students how they are measured. Ask students if force too need to be measured.	Tell that measurement needs to be same everywhere. Point out that things are measured in the same way using specific values/quantities/units. Hypothesize that force needs to be measured and that it has its own units.
Do the learning activity	Divide the students into 8 groups of 5 members of their choice. Ask students to carry out the activity as assigned in activity sheet. Facilitate and monitor the activity.	Conduct the activity in groups of their choice following the procedures given in the activity sheet. Make a conclusion on the definitions of newton and dyne.

Make connection and develop meaning	Initiate class discussion and give feedback.	Share their definition with the class and make necessary corrections after the teacher's feedback.
Apply/demonstrate	Ask students to work with two friends of their choice on the worksheet provided. Use model answer sheet to assess the work.	Work on the worksheet and do the necessary corrections after the teacher's assessment.
Review	Provide a fact sheet. Write a reflection about the lesson.	Make an entry in their portfolio.

Assessment

Model answer sheet

i. What net force is required to accelerate a car at a rate of 2 m/s^2 if the car has a mass of 3,000 kg?

Answer and marking scheme:

F=?
A=2 m/s^2
M=3,000 kg
½

F=ma → ½

F=3,000 X 2
F=6,000 kg m/s^2
1

ii. How much horizontal net force is required to accelerate a 1000 kg car at 2 m/s^2? Express your answer in dyne.

F=?
M=1,000 kg
A=2 m/s^2 } ½

F=ma → ½

F=1,000 X 2
F=2,000 kg m/s^2 } 1

Appendix

Activity sheet: To define newton and dyne

Date: …….

Name: …… Grade: ……

Materials required

Each group will need:

- An object weighing 1 kg and 1 g
- A platform measuring 1 m (divided into 100 cm) and 1 cm (divided into 10 mm) [can be a table surface measuring 1 m and 1 cm]
- A stop clock
- Two pieces of wood [different sizes]

Complete the table below by carrying out the activities as instructed.

Activities	Observation and discussion
➢ Place the object weighing 1 kg at the 0 mark of the 1 m platform. ➢ Set the stop clock to start. ➢ As soon as you start the stop clock, push the weight the larger piece of wood. [You should push it in such a way that the weight reaches the 100th mark of the platform when the stop clock measures 2 seconds. Stop the clock at that instant, and stop the experiment too.] Did you use force to push the weight?	The force you used in this experiment is 1 newton. Newton (N) is the SI unit of force. How can you define 1 N? …….. …….. …….. …….. ……..
➢ Place the object weighing 1 g at the 0 mark of the 1 cm platform. ➢ Set the stop clock to start. ➢ As soon as you start the stop clock, push the weight with the smaller piece of wood. [You should push it in such a way that the weight reaches the 10th mark of the platform when the stop clock measures 2 seconds. Stop the clock at that instant, and stop the experiment too.] Did you use force to push the weight?	The force you used in this experiment is 1 dyne. Dyne is the CGS unit of force. How can you define 1 dyne? …….. …….. …….. …….. ……..

Compare the two experiments. List down the similarities and differences between them.

Comparison	**1st Experiment**	**2nd Experiment**
Similarity(ies)		
Difference(s)		

Worksheet: To derive the SI and CGS units of force using F=ma

Direction: You are familiar with the equation F=ma. From the above activity, you know that the SI unit of force is newton and the CGS unit of force is dyne. Use the details from the above activity to derive the SI and CGS units of force in terms of its mass and acceleration.

SI unit	**CGS unit**
****Note: 1 N = 10^5 dyne*	

Questions

1. Choose one numerical problem from the following and solve it. Use the units you derived to express your final answers in.

iii. What net force is required to accelerate a car at a rate of 2 m/s2 if the car has a mass of 3,000 kg?

iv. How much horizontal net force is required to accelerate a 1000 kg car at 2 m/s^2? Express your answer in dyne.

2.Do you think it is necessary to have units to measure force? Support your answer with two examples.

Fact sheet

Force is a quantity on which many other quantities such as torque, thrust and pressure are based. Accurate force measurements are required in many applications. These include the determination of the strength of materials, quality control during production, weighing, and consumer safety. For example, force measurement systems are used to determine when a missile has developed sufficient thrust to be released for takeoff and in auto safety tests.

In the aircraft industry, force measurements are required to test the structural integrity of aircraft components and structures (force sensors are used to test the structural integrity of the wings, fuselage, and fasteners used in aircraft production).

Similarly, accurate force measurements are required to determine the weight of vehicles, tanks, bins, ladles and hoppers. Automated industrial processes such as rolling mills require accurate force measurement to control roll pressure on bar steel, sheet metal, paper, etc. Other applications include measurement of engine thrust, torque on dynamometer stands, cable tension on winches and elevators, and checking structures for weight, lift, drag and balance. Force sensors are used in electronic balances to measure weight. Such balances include those used to weigh trucks on highways, freight cars on railroads, babies in the doctor's office, puppies at the vet, and the flow of materials in a production process.

Different instruments can be used to measure force. Some of the instruments are:

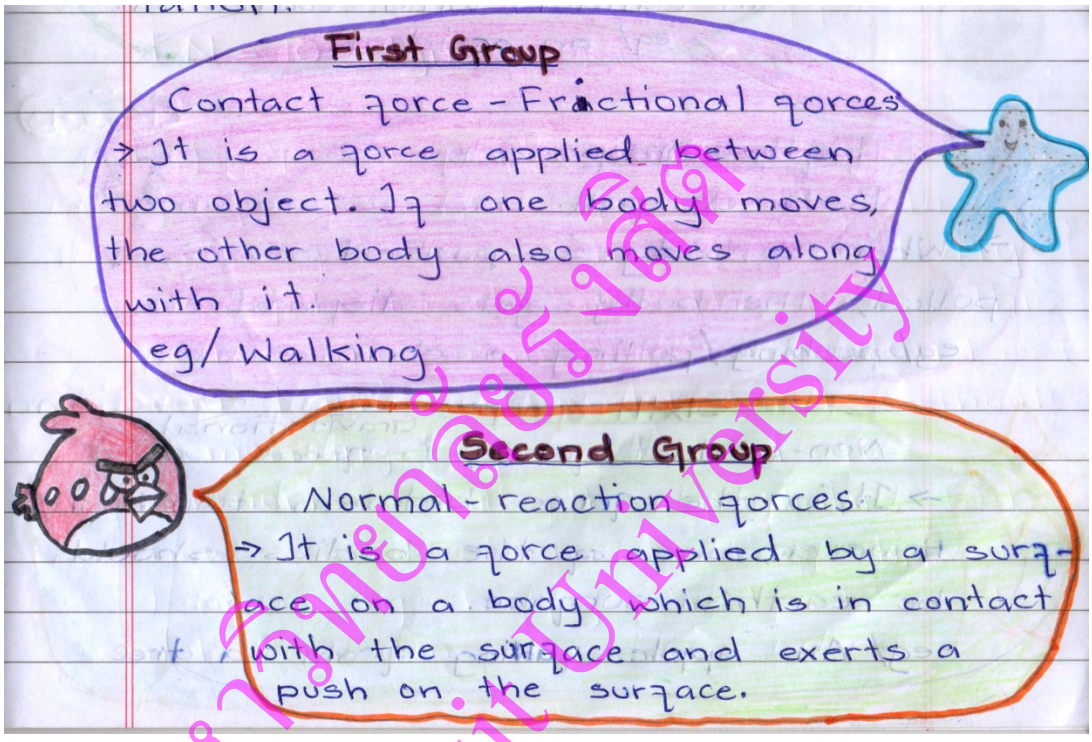
- Force-meter (also known as newton-meter)
- Dynamometer (also known as force gauge; the most important tool to measure force)
- Spring balance (also known as spring scale)
- Manometer

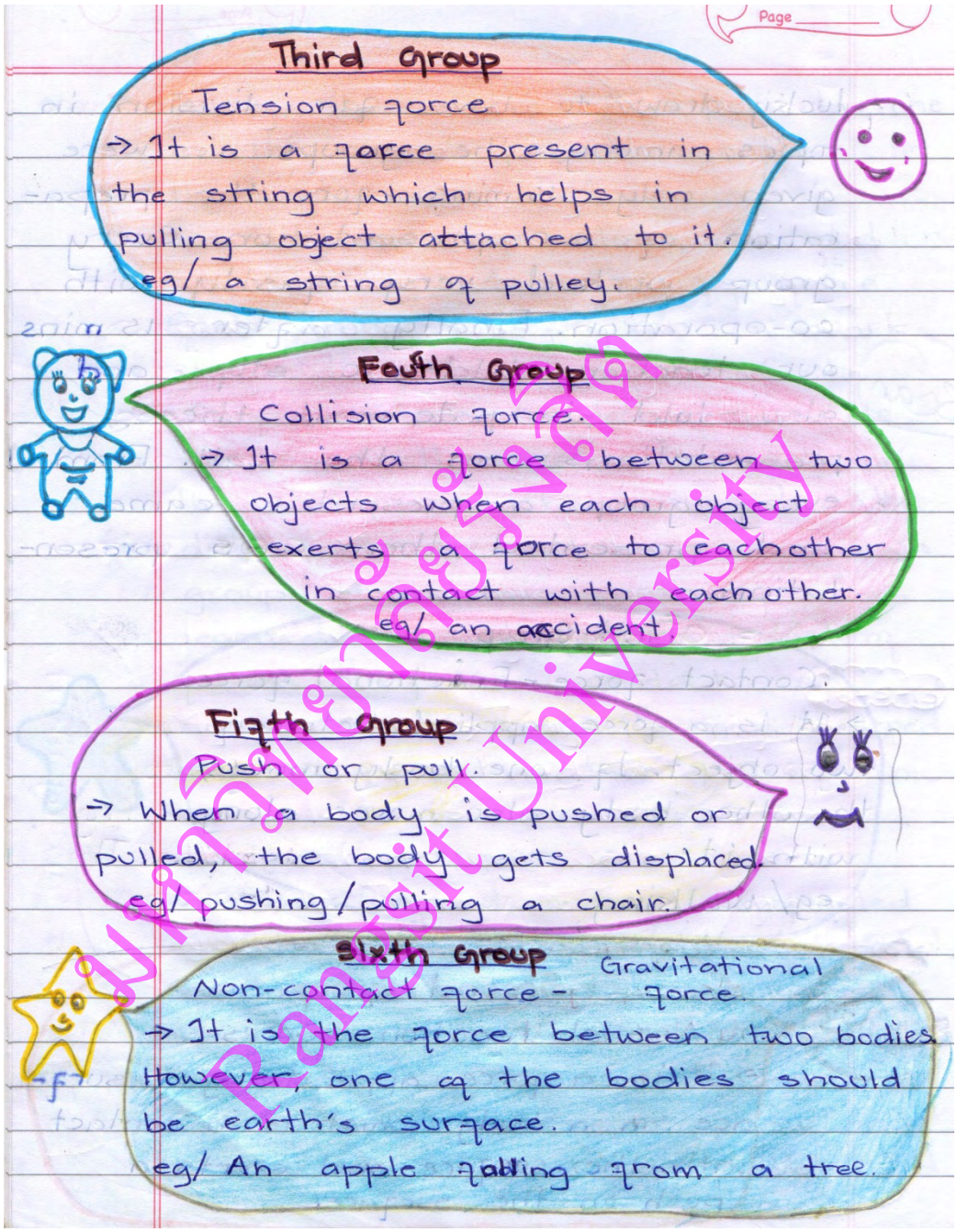
In order to measure, we use units. Units determine the standard of measurement. Newton is the SI unit of force and dyne is the CGS unit of force.

- One newton is that force which acts on a body of mass 1 kg and produce acceleration of 1 m s^{-2} in the direction of the force.
- One dyne is that force which acts on a body of mass 1 g and produces an acceleration of 1 cm s^{-2} in the direction of force.
- 1 N = 10^5 dyne

Appendix VIII

Students' Work





Third Group

Tension force

→ It is a force present in the string which helps in pulling object attached to it.
eg/ a string of pulley.

Fourth Group

Collision force.

→ It is a force between two objects when each object exerts a force to each other in contact with each other.
eg/ an accident.

Fifth Group

Push or pull.

→ When a body is pushed or pulled, the body gets displaced.
eg/ pushing/pulling a chair.

Sixth Group

Non-contact force - Gravitational force.

→ It is the force between two bodies. However, one of the bodies should be earth's surface.
eg/ An apple falling from a tree.

VITAE

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CHAPTER 5

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

The study was carried out to see the effects of BBL on the academic achievement and learning atmosphere of the ninth grade students in Sherubling HSS in Bhutan on the chapter force. The research design was 2 groups, pretest-posttest experimental design. The sample of the study was done using random sampling. Five lessons designed on force were used for the experiment. The research instruments used were achievement test and observation forms. The data were analyzed using differential statistics and inferential t-test. The results of the study indicated that the academic achievement of the students increased and the learning atmosphere enhanced after the inclusion of BBL as the instructional strategy.

This chapter presents the conclusion from the results of the data analysis in chapter four followed by discussion of the findings and recommendations for the teachers and curriculum developers.

5.1 Conclusion

This study was carried out to investigate if the use of BBL as an instructional strategy improved the students' academic achievement and enhanced the learning atmosphere. The results of the data analysis indicated that BBL is an effective instructional strategy to improve the academic achievement and enhance the learning atmosphere.

5.2 Discussion

5.2.1. Objective 1

The first objective was to study the effect of BBL on the academic achievement of the ninth grade students studying physics.

From table 4.1, it can be concluded that the performance of the students in the experimental group and the control group increased significantly. However the results showed that the experimental group after the treatment with BBL performed better than the control group which did not receive the treatment. The results of the experimental group was significant ($p=0.04$) when compared to that of the control group. Therefore, the first hypothesis, there will be significant difference between the mean scores in the academic achievement among students experiencing conventional teaching method compared to BBL was accepted. Many other studies supported this finding. Rehman, Malik, Hussain, Iqbal and Rauf (2012), Awolola (2011), Saleh (2011) and Ozden and Gultekin (2008) all found out that the academic achievement of students increased significantly with the use of BBL.

The academic achievement of the students after the use of BBL might have improved because the lessons were based on the students' experiences and emotions. The use of BBL allows for the consideration and inclusion of the students' experiences in their learning from where they can construct meaning. The experiences carried with them some emotions. If not, the learning based on these experiences was made memorable. They were filled with emotions. "Our most powerful memories are laden with emotions" (Erlauer, 2003: 12). She continues that the information which is constructed from our previous experiences is remembered easily by the brain (p. 53). She also provides interesting classroom instructional strategies to aid learning (p. 54) which were incorporated by the researcher in the lessons. "The development of the human brain

cannot be separated from life experience, as life experiences changes the brains psychological structure and operation" (Degan, 2011: 6). He further goes on explaining that individuals learn by processing experience. This is in line with the principles of constructivism learning theory which explains that learning is not about building knowledge from nothing, indeed it is building upon the "cognitive and conceptual resources already available" (Taber, 2011: 48). Constructivism allows the lessons to be integrated with hands-on experience, lab activities, co-operative and inquiry learning (Applefield, Huber and Moallem, 2001). Students could learn through trial and error which accounted for excellence in their learning. They were allowed to experiment their learning until the concept became clear. This did not require students to memorize the facts rather they could construct the meaning after the things they have learnt have been understood (Figure 4.5). They could write down their own understanding on the topics (Appendix VIII). Indeed, Sjoberg (2007) noted that "constructivism is a dominant perspective in fields like science education" (p. 8).

Jensen (1998) also found out that students' attentiveness and alertness increases when they are involved in a variety of activities. This involved "rotating mini-lectures, group work, reflection, individual work, and team project time" (p. 49). Lessons were not only held inside the four walls of the classroom. Students were taken outside for group works and presentations. They were taken to the science labs for want of extra space and materials. Ackerman (1992, as cited in Jensen, 1998) revealed that "a change in location is one of the easiest ways to get attention" (p. 50). Students' achievement might have improved because they were attentive during the lesson and the learning.

Another reason for students' better performance may be because the lessons focused on the students' diverse abilities. This was supported by the theory of multiple intelligences. The researcher tried to bring out the innate abilities of the students during individual as well as group works. The freedom in the choice of choosing their co-workers and presenting their work was seen as an effective strategy to instill a positive

attitude for learning. The media and style of presentations and assessments were based on the students' own interest. They were allowed to 'opt' for any strategy they deemed suitable as long as the lesson objectives were fulfilled. The part they took in preparing the activities and the presentations was also kept to their preferences. Some chose to prepare the charts by writing or drawing, while some wanted to present. The others did the demonstrations. The activities merely focused on the students' ability to do different things. During the presentations, some students chose to present their work through writing while some others preferred demonstration, yet others found it appropriate to do it through question-answer sessions and some preferred to organize mini-lectures in the class. Each of them had their own interests and preference of doing things. And it so happened that students always wanted to do the things which they are best at. While this allowed them to better their best, their other abilities were also focused as well. They took turn to carry out the activities with their peers' assistance.

Through these activities, students realized the variety in the ways of learning (Figure 4.4) and this in turn made them reflect on their studying and learning habits as well. Some felt the need to work with others while others felt the need to learn through figures and symbols. They could see that each of them could contribute 'something' towards the group's success. The freedom to choose 'their' way of preparation and presentation allowed them to demonstrate their creativity. This made them work hard and to explore their creativeness. It helped them in valuing and appreciating their unique talents. "[B]eliefs and perceptions of self constitute the most central cognitive feature or determinant behind students' personal understandings, interpretations, and self-regulation" (Malmivuori, 2001 as cited in Tirri and Nokelainen, 2011: vii). This further enhanced their confidence in handling learning disparities. Gangi (2011) reported Gardner's (1983) beliefs that the individuals make use of the knowledge of their "intelligent strengths" to enhance their "educational opportunities and options" (p. 33). It was also found to increase the students' expectation of themselves (Gangi, 2011: 28).

A lot of studies found out that it is detrimental to label students according to the marks they score in the tests as educational institutions usually do. Infact, Shearer in her study “Using a Multiple Intelligences Assessment to Facilitate Teacher Development” (2006) found out that students “sort themselves” into different ability groups (high ability, average ability and below average ability) owing to which students are “labeled as smart” by the teacher in the classroom (p. 19). This is a very strong point to think about. Is it nature or nurture that is changing the students’ perspective in terms of viewing themselves? Can we, as educators, change that? It is very important for the educators to be very mindful of what we let students do during learning. Everything we do is either going to heal or harm them, mend or mar them.

5.2.2 Objective 2

The second objective was to study the effect of BBL on the learning atmosphere of the ninth grade students studying physics.

All the lessons in both groups were observed using a lesson observation form. The lesson observation form had 10 indicators framed based on the principles of BBL. They were classified under physical and mental atmospheres.

Table 4.2 presented the comparison of the observation of the learning atmosphere in the experimental and the control group. The result was statistically significant at 0.05 level. It showed that the BBL enhanced the learning atmosphere when compared to learning atmosphere in the conventional class. Tables 4.4 and 4.5 showed the mean, standard deviation and level of opinion of each indicator under physical and mental atmosphere respectively of the experimental and control group. In the experimental group, for the physical atmosphere, the subtotal mean was 3.72 and the standard deviation was 0.38. The level of opinion indicated ‘outstanding’ result. For the mental atmosphere, the subtotal mean was 3.68 and the standard deviation was 0.31. The

level of opinion indicated ‘outstanding’ result. In the control group, for the physical atmosphere, the subtotal mean was 1.84 and the standard deviation was 0.49. The level of opinion indicated ‘fair’ result. For the mental atmosphere, the subtotal mean was 2.12 and the standard deviation was 0.69. The level of opinion indicated ‘fair’ result. It was concluded that the inclusion of BBL enhanced the learning atmosphere. Therefore, the second hypothesis, there will be enhancement in the learning atmosphere when BBL is integrated in teaching and learning physics when compared to conventional teaching method was accepted. Similar studies done by Akyurek and Afacan (2013), Mary and Shefali (2012), Bas (2010) and Duman (2006) also revealed that the inclusion of BBL in teaching and learning not only increased the academic achievement but that it also fostered a positive learning atmosphere and therefore a positive attitude in students.

BBL is known for the flexibility it involves in designing the learning atmosphere. Students were allowed to work with the person they felt most comfortable with. They were allowed to work in groups or independently. They had the freedom of movement in the class. The learning atmosphere was co-operative rather than competitive, but it was challenging. Degan (2011) found out that when the learning atmosphere was challenging, the brain produced new cells which “improved memory and learning” (p. 7). Many studies found out that the “brain changes as a result of the environment” (Hebb, 2002, original published in 1949; Bennett, Diamond, Krech, and Rosenzweig, 1964; Rosenzweig, Love, and Bennett, 1968 as cited in Degan, 2011: 7). The visual displays in the classroom also aided the students in learning. Jensen (1998) found out that such classroom “can be a source of inspiration, affirmation, and content” (p. 39). “They can help learners feel safe, comfortable, or keep up with the learning” (Debes, 1974 as cited in Jensen, 1998: 39). Although a decorative classroom provides platform for an enriched learning, Jensen found out that “challenge” and “feedback” were the actual “ingredients” of enrichment.

During the teaching/learning period, students experienced less threat and more support. The teacher was friendly and the learning was a peaceful one. The students moved on their own pace and they were given time to adjust to the teaching/learning process. Students worked in groups which provided them the opportunity for sharing ideas and clearing their doubts. They could refine and define their ideas while they associated with their friends. The author of "The Brain-Compatible Classroom", Erlauer (2003) highlighted that learners with higher "emotional security" possessed a better ability to think and learn when compared to those who experience insecurity, fear and stress (p. 14). She further added that this is enhanced and nurtured by socialization with others. This is supported by the constructivism theory as well the multiple intelligences theory. Since the learning is learner-centered, the classroom environment facilitates for interaction which will bring about the sharing various experiences which will enrich the learning (Collins, 2008: 1-2). This was also seen to reduce insecurity. It concealed the fragile expositions of the learners. This type of atmosphere was never there in the conventional classes. This change might have made the learning easier and also may have triggered the students to be responsible for their learning. Armstrong (2000) highlighted the same findings in his paper "Using Multiple Intelligences to Design a Classroom Environment" (pp. 1-4). He discussed how a classroom environment can be designed using the theory of multiple intelligences and how this affected the students' learning and attitude. This was found as a boon to the BBL classroom as MI theory is one of the founding theories of BBL.

Students liked the group work and the experiments as evidenced from their own reflections from Figures 4.4 and 4.5. They loved the seating arrangement (Figure 4.3) done after the inclusion of BBL to design the learning atmosphere.

While the results of the study indicated an improvement in the academic achievement and the learning atmosphere, the researcher also did face some challenges in the course of the experiment. BBL required lots of space for individual/group works,

presentations and display of students' works. Interaction is a key factor of BBL. The small size of classroom in the Bhutanese context hindered the movement of the students and all the works of the students could not be displayed simultaneously due to the small space available for a subject corner. To overcome this, the researcher took some classes outside or in the physics lab.

The Bhutanese students are used to learning in the teacher-centered environment. It involves the teacher to lecture the lessons and the students to passively listen or take down notes. While on the other hand, BBL required students to work in groups and prepare for presentations by discussing and making their own teaching aids. They were required to follow the instructions given in the worksheets. They also evaluated their and others' works using checklists and rubrics. They were not used to such methods and the researcher had difficulty in acquainting them with the materials and the processes in the first lessons. It was also challenging to acquire all the materials for the specific lesson. But the students got used to the process and their performance improved as the lessons progressed.

5.3 Recommendations

5.3.1 To the teachers

BBL is an effective instructional approach which takes into consideration the wholesome development of the students. Teachers must be mindful of the physical atmosphere as well as the emotions of the students to bring about better teaching and learning. Students should be seen as individuals with emotions. Factors such as prior experiences, individual learning styles and abilities and internal and external motivation should be considered.

5.3.2 To the curriculum developers

It would be interesting to use the BBL in other subjects to see how the manipulation of the physical and the mental atmosphere impacted the learners' academic achievement and attitude towards learning. Further researches may be carried out to compare BBL with other prominent teaching strategies such as co-operative learning, inquiry method or 4MAT model.

Further explorations can also be done through studies pertaining to the effectiveness of the assessment procedures in the Bhutanese context, and the inclusion of the assessment practices in BBL to improve learning.

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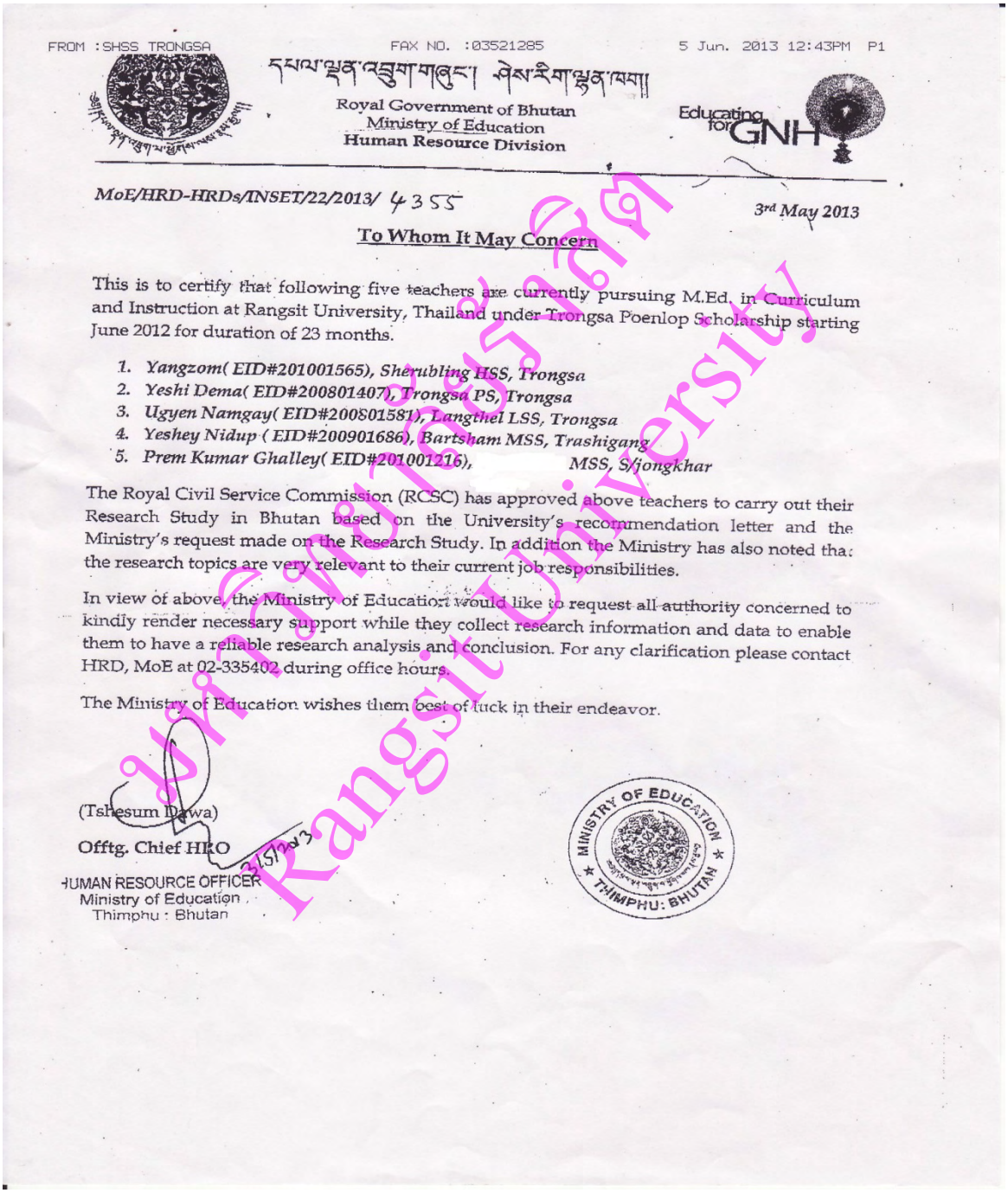
APPENDICES

Appendix I

Letter of approval, Ministry of Education, Bhutan



FROM :SHSS TRONGSA FAX NO. :03521285 5 Jun. 2013 12:43PM P1

དཔལ་ལྡན་འབྲུག་གཞུང་། ཤེས་རིག་སྡེབ་ཁག།

Royal Government of Bhutan
Ministry of Education
Human Resource Division

Educating for GNH

MoE/HRD-HRDs/INSET/22/2013/ 4355

3rd May 2013

To Whom It May Concern

This is to certify that following five teachers are currently pursuing M.Ed. in Curriculum and Instruction at Rangsit University, Thailand under Trongsa Poenlop Scholarship starting June 2012 for duration of 23 months.

1. *Yangzom(EID#201001565), Sherubling HSS, Trongsa*
2. *Yeshi Dema(EID#200801407), Trongsa PS, Trongsa*
3. *Ugyen Namgay(EID#200801581), Langthel LSS, Trongsa*
4. *Yeshey Nidup (EID#200901686), Bartsham MSS, Trashigang*
5. *Prem Kumar Ghalley(EID#201001216), MSS, Sjongkhar*

The Royal Civil Service Commission (RCSC) has approved above teachers to carry out their Research Study in Bhutan based on the University's recommendation letter and the Ministry's request made on the Research Study. In addition the Ministry has also noted that the research topics are very relevant to their current job responsibilities.

In view of above, the Ministry of Education would like to request all authority concerned to kindly render necessary support while they collect research information and data to enable them to have a reliable research analysis and conclusion. For any clarification please contact HRD, MoE at 02-335402 during office hours.

The Ministry of Education wishes them best of luck in their endeavor.

(Tshesum Dawa)
Offtg. Chief HRO
HUMAN RESOURCE OFFICER
Ministry of Education
Thimphu : Bhutan

MINISTRY OF EDUCATION ★ THIMPHU: BHUTAN ★

Appendix II

IOC of achievement test questions

Question	Expert 1	Expert 2	Expert 3	IOC
1	+1	+1	+1	1
2	+1	+1	+1	1
3	+1	+1	+1	1
4	+1	+1	+1	1
5	+1	+1	+1	1
6	+1	+1	+1	1
7	+1	+1	+1	1
8	+1	+1	+1	1
9	+1	+1	+1	1
10	+1	+1	+1	1
11	+1	+1	+1	1
12	+1	+1	+1	1
13	+1	+1	+1	1
14	+1	+1	+1	1
15	+1	+1	+1	1
16	+1	+1	+1	1
17	+1	+1	+1	1
18	+1	+1	+1	1
19	+1	+1	+1	1
20	+1	+1	+1	1

Appendix III

Achievement test

Unit objectives:

1. The students will be able to classify forces into two major types, contact and non-contact and provide various examples of it.
2. The students will be able to examine the cause of friction, evaluate its presence in daily life to come up with different solutions to either increase or decrease it.

Blueprint

Lesson Topics	Rem.	Und.	App.	Ana.	Eva.	Cre.	Marks
Definition and effects of force	1	2					**2**
Units of force	3 4		5				**3**
Types of Forces	6 7			8 9	10		**5**
Friction		11 12	13	14 15			**5**
Advantages and disadvantages of friction/increasing and decreasing friction			16 19	17 18 20			**5**
Total	**5**	**3**	**4**	**7**	**1**		**20**

Achievement test questions

Full marks: 20 Time: 30 minutes

Attention: The paper is not an exam. It will be used purely for my study. Please answer it as much correctly as you can.

Instructions: This questionnaire consists of 2 parts:

Part A: Demographic information

Part B: Test questions

Part A: Demographic information

Please fill in the information below by putting a tick mark in the bracket [ ].

1. Name: ……
2. Gender: [ ] Male [ ] Female
3. Age: [ ] Between 13-15 [ ] Between 16-18 [ ] Above 18

Part B: Test questions

Direction: This paper contains 20 multiple choice questions. Each question has four alternative answers. Choose the best possible answer by circling it. (1 X 20= 20 marks)

1. The physical cause which changes or tends to change the state of rest or of uniform motion of a body in a straight line is called _____.

a) Energy
b) Push
c) Force
d) Pressure

2. Which pair best describes the effects of force?

I. A force can change the dimensions of a non-rigid body.

II. A force can make an object move or stop a moving object.

III. A force can change the speed but not the direction of a moving body.

IV. A force can only speed up the motion of a body.

a) I & II

b) III & IV

c) I & III

d) II & IV

3. It is a cold winter and your car will not start. Two friends help you by pushing it. After the push, it accelerates at a rate of 2 meters per second per second. What is the magnitude of the net force exerted on the car by your friends? The mass of the car is 800 kg.

a) 0.0025 N

b) 400 N

c) 1600 N

d) 640000 N

Mass of car = 800 kg

4. Which are the best examples of contact force?

a) Frictional force and electric force

b) Tension force and magnetic force

c) Push and gravitational force

d) Collision force and pull

4. Choose the odd one out:

a) 

b) 

c) 

d) 

6. Sonam runs her toy car on dry marble floor, wet marble floor, newspaper and towel spread on the floor. The force of friction acting on the car on different surfaces in increasing order will be:

a) Wet marble floor, dry marble floor, newspaper and towel
b) Newspaper, towel, dry marble floor, wet marble floor
c) Towel, newspaper, dry marble floor, wet marble floor
d) Wet marble floor, dry marble floor, towel, newspaper

Appendix IV

IOC of observation form

Indicator		Expert 1	Expert 2	Expert 3	IOC
Physical atmosphere					
1	Teaching/learning materials are displayed in the class.	+1	+1	+1	1
2	The classroom arrangement is appropriate for group work.	+1	+1	+1	1
3	Lesson includes the use of different learning materials.	+1	+1	+1	1
4	Seating arrangement facilitates interaction.	+1	+1	+1	1
5	Classroom arrangement facilitates free movement.	+1	+1	+1	1
Mental atmosphere					
6	Concepts are related to students' experience	+1	+1	+1	1
7	Students can choose their own partners in carrying out the activities.	+1	+1	+1	1
8	Students share their work with others enthusiastically.	+1	+1	+1	1
9	Students are comfortable asking questions/requesting assistance.	+1	+1	+1	1
10	The teacher responds positively to students' questions and answers.	+1	+1	+1	1

Appendix V

Lesson observation form

Observation Form: ……..

Class: ……

Lesson topic: …….

4= Outstanding	3= Good	2= Fair	1= Not demonstrated

A. Physical atmosphere

Sl.No.	Indicators	4	3	2	1
1.	Teaching/learning materials are displayed in the class.				
2.	The classroom arrangement is appropriate for group work.				
3.	Lesson includes the use of different learning materials.				
4.	Seating arrangement facilitates interaction.				
5.	Classroom arrangement facilitates free movement.				

B. Mental atmosphere

Sl.No.	Indicators	4	3	2	1
6.	Concepts are related to students' experience				
7.	Students can choose their own partners in carrying out the activities.				
8.	Students share their work with others enthusiastically.				
9.	Students are comfortable asking questions/requesting assistance.				
10.	The teacher responds positively to students' questions and answers.				

Appendix VI

IOC of lesson plans

Lesson number	Expert 1	Expert 2	Expert 3	IOC
1	+1	+1	+1	1
2	+1	+1	+1	1
3	+1	+1	+1	1
4	+1	+1	+1	1
5	+1	+1	+1	1

Appendix VII

Lesson plan

Lesson plan 02

Unit of learning/chapter: Force

Topic: Units of force

Grade: IX

Time: 50 minutes

Period: 1

Content: The SI unit of force is Newton and the CGS unit of force is dyne.

1 N is that force which acts on a body of mass 1 kg and produces an acceleration of 1 m s^{-2} in the direction of force.

1 dyne is that force which acts of a body of mass 1 g and produces an acceleration of 1 cm s^{-2} in the direction of force.

1 N = 10^5 dyne

Objectives

Each student should be able to:

1. Define newton.
2. Define dyne.
3. Make 'educated' inferences from their observation.
4. Tabulate their findings neatly.
5. Work cooperatively with their friends to derive the SI and CGS units of force using F=ma.
6. Solve a numerical problem using F=ma.
7. Highlight the importance of the units in the measurement of a physical quantity (force, in this case).

Previous knowledge: They can define force and figure out that force needs to be measured in different situations. They can also tell that force is the product of mass and acceleration.

Teaching/learning material: Some potatoes of different sizes, a packet of biscuit, a bottle of water, a stop watch, a ruler, activity sheet, work sheet and fact sheet.

Learning activity

Lesson component/ time	**Teacher activity**	**Student activity**
Activate	Demonstrate buying-selling of potatoes involving two students. Show the packet of biscuit, the bottle of water, the stop watch and the ruler and ask students how they are measured. Ask students if force too need to be measured.	Tell that measurement needs to be same everywhere. Point out that things are measured in the same way using specific values/quantities/units. Hypothesize that force needs to be measured and that it has its own units.
Do the learning activity	Divide the students into 8 groups of 5 members of their choice. Ask students to carry out the activity as assigned in activity sheet. Facilitate and monitor the activity.	Conduct the activity in groups of their choice following the procedures given in the activity sheet. Make a conclusion on the definitions of newton and dyne.

Make connection and develop meaning	Initiate class discussion and give feedback.	Share their definition with the class and make necessary corrections after the teacher's feedback.
Apply/demonstrate	Ask students to work with two friends of their choice on the worksheet provided. Use model answer sheet to assess the work.	Work on the worksheet and do the necessary corrections after the teacher's assessment.
Review	Provide a fact sheet. Write a reflection about the lesson.	Make an entry in their portfolio.

Assessment

Model answer sheet

i. What net force is required to accelerate a car at a rate of 2 m/s^2 if the car has a mass of 3,000 kg?

Answer and marking scheme:

F=?
A=2 m/s^2
M=3,000 kg
½

F=ma → ½

F=3,000 X 2
F=6,000 kg m/s^2
1

ii. How much horizontal net force is required to accelerate a 1000 kg car at 2 m/s^2? Express your answer in dyne.

F=?
M=1,000 kg
A=2 m/s^2 } ½

F=ma → ½

F=1,000 X 2
F=2,000 kg m/s^2 } 1

Appendix

Activity sheet: To define newton and dyne

Date: …….

Name: …… Grade: ……

Materials required

Each group will need:

- An object weighing 1 kg and 1 g
- A platform measuring 1 m (divided into 100 cm) and 1 cm (divided into 10 mm) [can be a table surface measuring 1 m and 1 cm]
- A stop clock
- Two pieces of wood [different sizes]

Complete the table below by carrying out the activities as instructed.

Activities	Observation and discussion
➢ Place the object weighing 1 kg at the 0 mark of the 1 m platform. ➢ Set the stop clock to start. ➢ As soon as you start the stop clock, push the weight the larger piece of wood. [You should push it in such a way that the weight reaches the 100th mark of the platform when the stop clock measures 2 seconds. Stop the clock at that instant, and stop the experiment too.] Did you use force to push the weight?	The force you used in this experiment is 1 newton. Newton (N) is the SI unit of force. How can you define 1 N? …….. …….. …….. …….. ……..
➢ Place the object weighing 1 g at the 0 mark of the 1 cm platform. ➢ Set the stop clock to start. ➢ As soon as you start the stop clock, push the weight with the smaller piece of wood. [You should push it in such a way that the weight reaches the 10th mark of the platform when the stop clock measures 2 seconds. Stop the clock at that instant, and stop the experiment too.] Did you use force to push the weight?	The force you used in this experiment is 1 dyne. Dyne is the CGS unit of force. How can you define 1 dyne? …….. …….. …….. …….. ……..

Compare the two experiments. List down the similarities and differences between them.

Comparison	**1st Experiment**	**2nd Experiment**
Similarity(ies)		
Difference(s)		

Worksheet: To derive the SI and CGS units of force using F=ma

Direction: You are familiar with the equation F=ma. From the above activity, you know that the SI unit of force is newton and the CGS unit of force is dyne. Use the details from the above activity to derive the SI and CGS units of force in terms of its mass and acceleration.

SI unit	**CGS unit**
****Note: 1 N = 10^5 dyne*	

Questions

1. Choose one numerical problem from the following and solve it. Use the units you derived to express your final answers in.

iii. What net force is required to accelerate a car at a rate of 2 m/s2 if the car has a mass of 3,000 kg?

iv. How much horizontal net force is required to accelerate a 1000 kg car at 2 m/s^2? Express your answer in dyne.

2.Do you think it is necessary to have units to measure force? Support your answer with two examples.

Fact sheet

Force is a quantity on which many other quantities such as torque, thrust and pressure are based. Accurate force measurements are required in many applications. These include the determination of the strength of materials, quality control during production, weighing, and consumer safety. For example, force measurement systems are used to determine when a missile has developed sufficient thrust to be released for takeoff and in auto safety tests.

In the aircraft industry, force measurements are required to test the structural integrity of aircraft components and structures (force sensors are used to test the structural integrity of the wings, fuselage, and fasteners used in aircraft production).

Similarly, accurate force measurements are required to determine the weight of vehicles, tanks, bins, ladles and hoppers. Automated industrial processes such as rolling mills require accurate force measurement to control roll pressure on bar steel, sheet metal, paper, etc. Other applications include measurement of engine thrust, torque on dynamometer stands, cable tension on winches and elevators, and checking structures for weight, lift, drag and balance. Force sensors are used in electronic balances to measure weight. Such balances include those used to weigh trucks on highways, freight cars on railroads, babies in the doctor's office, puppies at the vet, and the flow of materials in a production process.

Different instruments can be used to measure force. Some of the instruments are:

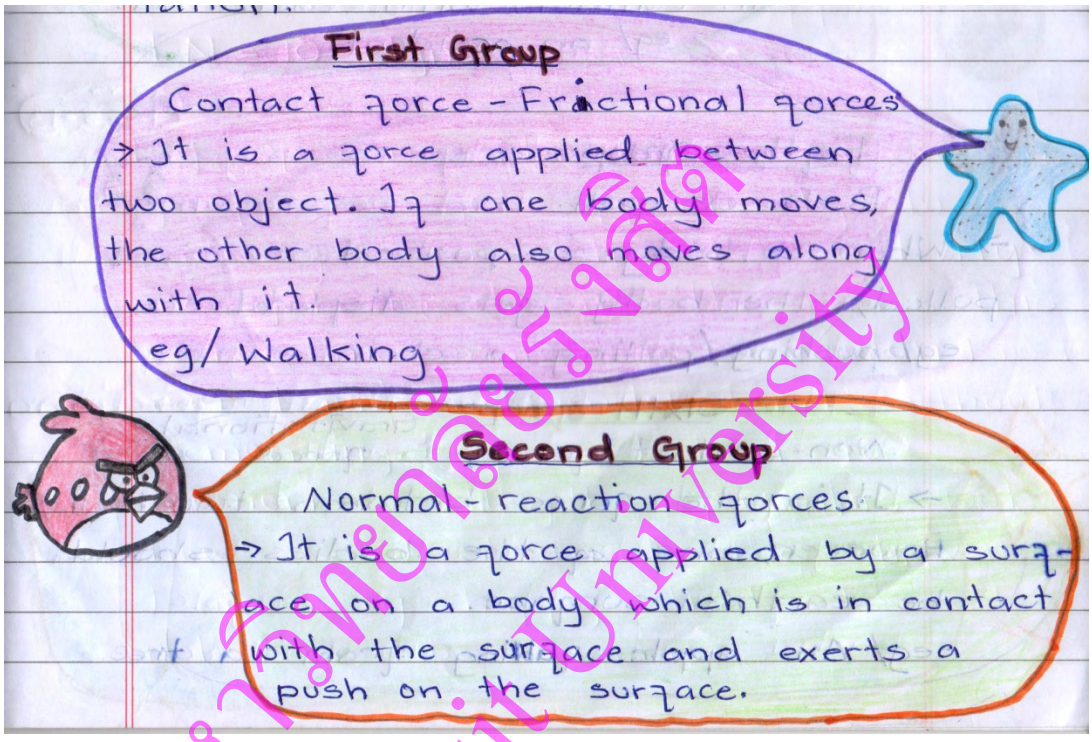
- Force-meter (also known as newton-meter)
- Dynamometer (also known as force gauge; the most important tool to measure force)
- Spring balance (also known as spring scale)
- Manometer

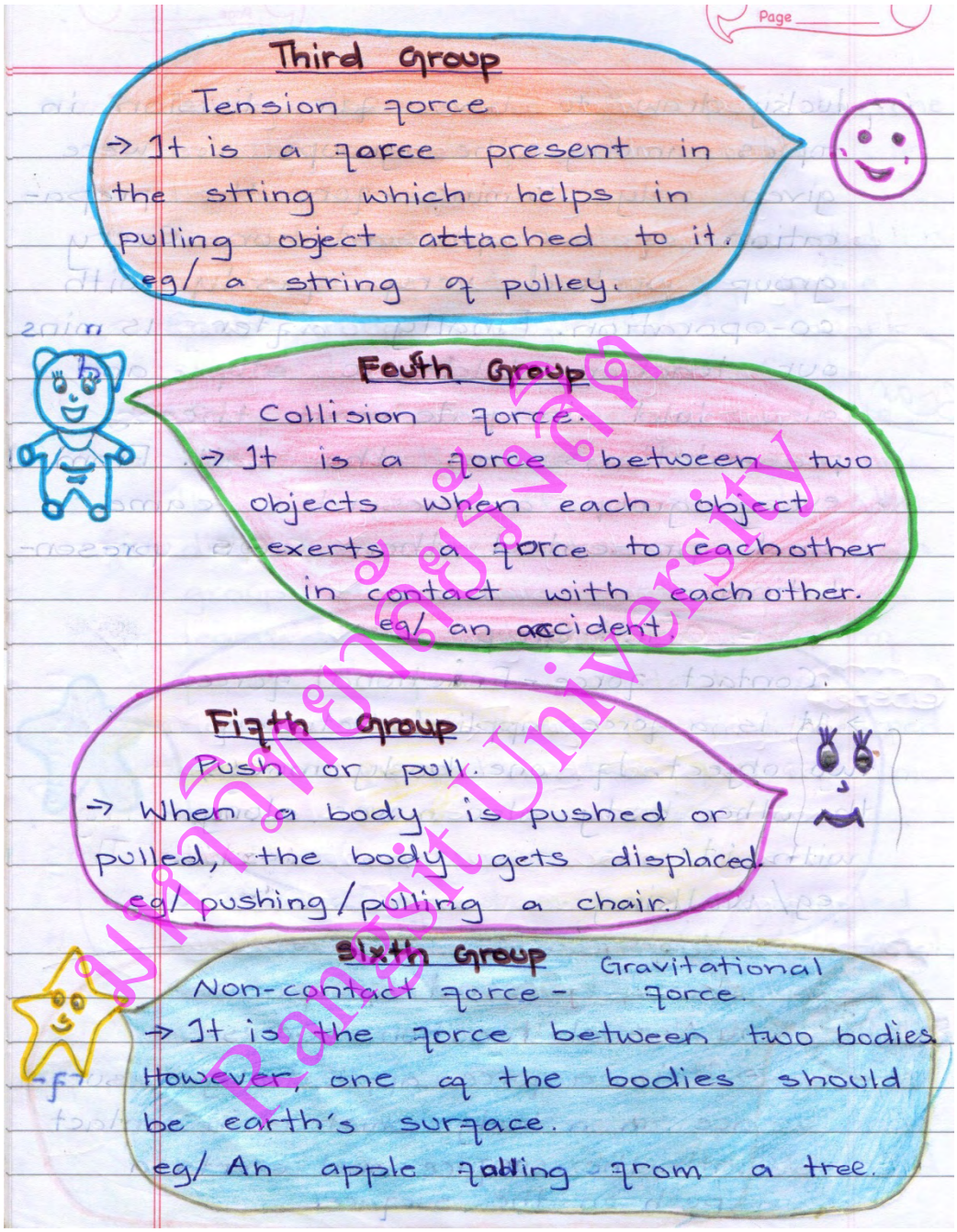
In order to measure, we use units. Units determine the standard of measurement. Newton is the SI unit of force and dyne is the CGS unit of force.

- One newton is that force which acts on a body of mass 1 kg and produce acceleration of 1 m s^{-2} in the direction of the force.
- One dyne is that force which acts on a body of mass 1 g and produces an acceleration of 1 cm s^{-2} in the direction of force.
- 1 N = 10^5 dyne

Appendix VIII

Students' Work





Third Group

Tension force

→ It is a force present in the string which helps in pulling object attached to it.
eg/ a string of pulley.

Fourth Group

Collision force.

→ It is a force between two objects when each object exerts a force to each other in contact with each other.
eg/ an accident.

Fifth Group

Push or pull.

→ When a body is pushed or pulled, the body gets displaced.
eg/ pushing/pulling a chair.

Sixth Group

Non-contact force - Gravitational force.

→ It is the force between two bodies. However, one of the bodies should be earth's surface.
eg/ An apple falling from a tree.

VITAE

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