EFFECTS OF INSTRUCTION USING THE 4MAT SYSTEM ON CHEMISTRY ACADEMIC ACHIEVEMENT AND REASONING ABILITY OF THE TENTH GRADE STUDENTS, BHUTAN

BY

PREM KUMAR GHALLEY

มหาวิทยาลัยรังสิต
Rangsit University

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PREM KUMAR GHALLEY

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Assoc. Prof. Pimpan Dachakupt, Ph.D.	Srisamorn Pumsa-ard, Ed.D.
Examination Committee Chairperson	Member
	Manit Boonprasert, Ed.D.
	Member and Advisor

Approved by Graduate School

(Asst.Prof.Plt.Off.Vannee Sooksatra, D.Eng.)
Dean of Graduate School
October 17, 2013

มหาวิทยาลัยรังสิต
Rangsit University

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Researcher

มหาวิทยาลัยรังสิต Rangsit University

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The objectives of this research were to investigate the effects of instruction using the 4MAT System on "Acids, Bases, and Salts" in Chemistry on the tenth grade students' academic achievement and reasoning ability. One group experiment with pretest and posttest design was adopted to study the effects. The subjects of the study were 31 students from one the four sections of the tenth grade which was selected purposively with the assumption that the subjects had relatively varied learning abilities. The research instruments were academic achievement test, reasoning ability test and lesson plans. The statistics used for data analysis were mean, standard deviation, and dependent paired sample t-test. By applying the paired sample t-test on the means of academic achievement tests, it showed a significant increase in the mean gain at .05 levels. Similarly, result of paired sample t-test for reasoning ability showed significant difference at .05 of the pretest and posttest means. It was concluded that the 4MAT System was effective in improving the academic achievement and reasoning ability in teaching "Acids, Bases, and Salts" in Chemistry.

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

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CHAPTER 1

INTRODUCTION

This chapter presents the rationale of the study, research objectives, research questions, hypothesis, scope of the study, benefits of the study and operational definitions of the keywords.

1.1 Rationale

Science education in Bhutan is as important as in other countries. Bhutan still requires many graduates in scientific field to meet the need for human resources who can understand and engage in meaningful investigation. In Science Curriculum Framework (2011) Powdyel[1], stated that science is important in instilling the development of the understanding on the world around us. He also urged that science plays the vital medium in disseminating the values and principles of GNH[2] through its myriad concepts and pedagogical tools. Therefore, it is crucial that science teachers accept the views of the children and guide them how to appreciate and think scientifically. Science curriculum in Bhutan aims to inculcate the scientific temper, and scientific thinking, which enables them to think, act and understand the power of science so that they appreciate and live in harmony with the world around them.

The contemporary learning theories (cognitivists) believed that learning is associated with mental activity and we can predict the learning from the action of the person who is engaged in learning. John Dewey (1900) believed that learning takes place when students are actively engaged in problem solving. Gestalt believed that students received the ideas as a whole and fitted like bits of the puzzle. Another

[1] The former education minister of Bhutan
[2] Gross National Happiness; developmental philosophy of Bhutan propounded by 4th King of Bhutan

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cognitivist scientist argued that for learning to take place students must assimilate (take in new ideas into the existing knowledge structure) and accommodate (reorganize the existing knowledge structure to fit in the new knowledge).

Rodger W. Bybee (2002) explained constructivism as set of principles designed for teaching and learning. Therefore, he described the characteristics of constructivism as learning is active, interactive, and procedural; new knowledge dependent upon prior knowledge; learning is reinforced when students are placed in familiar and meaningful context; involves problem solving with multiple solution and learning thrives when students discuss ideas and processes.

Therefore, there is an urgent need of instructional varieties to enhancing the science teaching and learning in Bhutanese curriculum. Science particularly Chemistry is regarded as one of the most difficult subjects. Chemistry deals with many abstract concepts, which forms the backbone for further studying of other science subjects like Biology and Physics. According to pupil's performance report of 2012 academic session, the pass percentage in science is statistically found to be 83.68% which is second last to mathematics (80.45%). The academic achievement in science in the school where study was conducted showed mean score of 53.37, (Pupil Performance Report, 2013).

Many Bhutanese students do not like science subjects. They have negative attitudes toward them. The possible reason could be as Rabgay (2012) argues that the instruction in Bhutan consists of conventional way of teaching using textbooks, rote learning, and spoon-feeding techniques, memorization where learning is limited to textbooks within the four walls of the classroom. Wangchuk (2011) concluded in his research that most students do not like to think on their own but prefer to have ideas bundle-up, ready to use kind of information directly delivered to them by the teacher. These are the very reasons why students feel hard to study science. In such environment, the students become excessively dependent, dull, passive, and lack analytical, critical, and creative thinking, which is the requisite of education in the 21st century.

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The 4MAT System brings changes in three major areas: “in teachers’ attitudes toward diverse kinds of intelligences, in their attitudes about the act of teaching, and in their sense of responsibility for their students’ motivation”, McCarthy (1990: 34). She explained that when teachers know the learning preferences of their learners, teaching begin to be more a dialogue than monologue. Teachers begin to motivate their students by creating curiosity and interest in their students. In addition, the teacher’s attitudes toward their follow teachers become more positive. If teachers know their roles and begin to have positive attitudes toward their professionalism there can be a direct impact on the learner’s achievement.

Therefore, there is a need for change in the teaching methods that can enhance the students’ skills, understanding, thinking, appreciation, and motivation toward learning. Researches have indicated that 4MAT System boost aforementioned abilities. This experimental study will investigate the effects of the 4MAT System in Bhutanese context in teaching Chemistry. Besides, it will also enrich the instructional method by bringing forth the literature to Bhutanese context. This study will also determine whether this strategy be implemented in future in Bhutanese classroom. Finally, the study will help teachers and students alike, identify the teaching and learning preference of the students within the four quadrants of the 4MAT.

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1.2 Research objectives:

1) To find out the effects of instruction using the 4MAT System on learners’ academic achievement.

2) To find out the learners’ reasoning ability in Chemistry on the use of instruction using the 4MAT System.

1.3 Research questions

1) Will implementation of the instruction using the 4MAT System in Bhutanese classroom bring improvement in the learners’ academic achievement in Chemistry?

2) Does the instruction using the 4MAT System improve the reasoning ability of the learners in Chemistry?

1.4 Research hypothesis

To examine the research questions the following hypotheses were formulated;

1) Hypothesis 1: There will be significant improvement in the academic achievement in Chemistry of the tenth grade students after the treatment procedure using instruction using the 4MAT System.

2) Hypothesis 2: There will be improvement in the reasoning ability of the tenth grade students at the end of the treatment procedure using instruction using the 4MAT System.

1.5 Scope of the study

1.5.1 Location of the study

The study was carried out at Mendrelgang Middle Secondary School in Tsirang, Bhutan. The district is located in the central Bhutan. The school is located in rural area of the district.

1.5.2 Population, sample and subject

The population comprised the students of the tenth grade of two higher secondary schools in Tsirang, Bhutan. The sample consisted of tenth grade students studying in Mendrelgang Middle Secondary School. The students were divided into four sections.

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The researcher decided to take students of section B purposively of the four sections for the purpose of the study. The subject consisted of 31 students. The researcher assumed that the section chosen comprised relatively varied learning ability students.

1.5.3 Content of the study

The researcher taught Chemistry subject, chapter 3 “Acids, Bases, and Salts” to the subjects of the study.

Learning outcomes as prescribed by the Department of Curriculum and Research Development, Bhutan of this chapter are:

1) Simple definitions in terms of molecules and their characteristic properties.

2) Ions present in mineral acids, alkalis and salts and their solutions; use of litmus to test for acidity and alkalinity.

3) Explain with suitable examples the formation of Salts.

4) Definition of salt: types of salts with examples.

5) General properties of salts: deliquescence, efflorescence, water of crystallization: definition and examples.

6) Neutralization and its application.

1.5.4 Time frame

The experiment was carried out for six consecutive weeks.

1.5.5 Variables

There were two types of variables in this study, 4MAT System as treatment variable and students’ academic achievement and reasoning ability as dependent variables.

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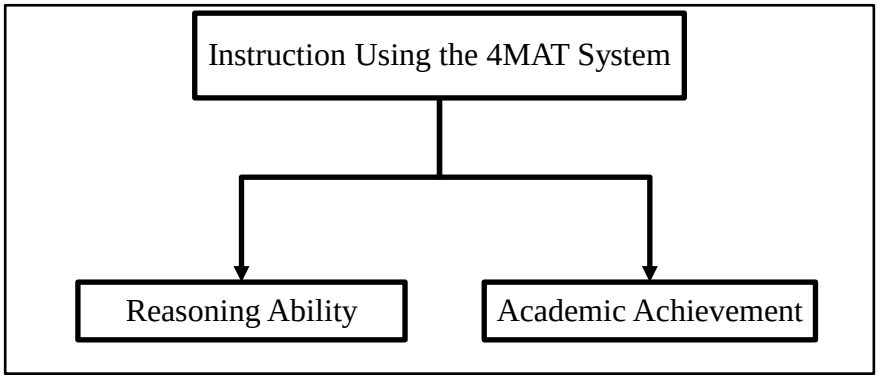

Figure 1.1 Treatment and dependent variables

1.6 Benefits of the study

The study was conducted assuming that it will be of immense benefits to the educator in Bhutan. The study is expected to benefit in following manner;

1) It will be useful to the teacher who would like to change the instructional strategy in teaching science and other subjects alike.

2) It would helpful to the curriculum developer to incorporate and consider the hemispheric dominance and learning style preference in developing the instructional guide for teachers.

1.7 Operational definitions

1.7.1 Instruction Using 4MAT System:

It refers to instruction that engage the students to construct their own idea using left and right mode of the brain. Adapted from McCarthy, the 4MAT System includes the learning styles and hemispheric processing preferences and designing lessons using multiple instructional strategies in systematic framework to teach to these preferences to improve teaching and learning in Chemistry. The 4MAT System consists of eight steps in the lesson which incorporates right and left mode and four instructional strategies as the lesson proceeds.

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1) Connect (Right-Mode): Learners are engaged in concrete experience, search for prior knowledge and experience.

2) Attend (Left-Mode): Learners take judgment on the perception and dialogue generated in step 1.

3) Image (Right-Mode): Learners integrate personal experience into understanding for validation and analysis of ideas.

4) Inform (Left-Mode): Learners verify concepts, facts, generalization and theories.

5) Practice (Left-Mode): Learners Practice the learning and diagnose the learners' ability to apply the concepts.

6) Extend (left-Mode): Learners extend the learning to their personal level to demonstrate the understanding of learning.

7) Refine (Left-Mode): Learners evaluate, assess and review their work of extension and give constructive criticism on their peers' work.

8) Perform (Right-Mode): Learners share, teach and celebrate their learning with fellow students. They display understanding of their work for relevance, originality, connections to big picture, skills and values and how it fits into real world.

1.7.2 Chemistry academic achievement:

It refers to marks obtained by the tenth grade students in Chemistry "Acids, Bases and Salts" unit after the treatment procedure using instruction using the 4MAT System.

1.7.3 Reasoning Ability:

It is a cognitive ability of the learners to support and justify the concepts and ideas with purpose in learning Chemistry unit "Acids, bases and Salts". They can reach the conclusion either inductively or deductively. It is measured by reasoning ability form adapted by researcher.

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CHAPTER 2

REVIEW OF LITERATURE

This chapter presents the review of the related literature and theoretical framework of the study. It includes education system in Bhutan, nature of scientific study, 4MAT System, four different types of learners, principles of 4MAT System, four major learning styles, and steps of 4MAT System, related theories supporting the 4MAT System, hemisphericity and dominance, learning styles, related research on the 4MAT System and reasoning ability.

2.1 Rationale and scope of the science education system in Bhutan

The curriculum framework of Bhutan is based on the developmentally appropriate curriculum that embraces the constructivist learning approaches; how children learn and make meaning of the experiences and how teacher try to bridge the gap between the prior knowledge and new learning situations.

The science curriculum strands is organized around; scientific enquiry, life process, materials and their processes and physical processes. These strands are expected to instill the appreciation in life processes, understand the structure and properties of materials and their uses, use scientific knowledge to make decision and be of useful to self and society and to the sustainability of the environment.

The pedagogy in Bhutanese curriculum includes;

1) Structuring flexible and sufficient learning experience for individual and groups.
2) Creating supportive learning environment.

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3) Constructing relevant learning experiences that connect with the world beyond school.

4) Constructing intellectually challenging learning experiences.

5) Facilitate collaborative learning and assessing and report on student learning.

Assessment in Bhutanese curriculum for tenth grade is divided in two parts; 80 percent consisting of written examination (summative assessment) and 20 percent of continuous assessment (formative assessment) by the teachers which together make 100 percent. Assessment is based on key principles; classroom practice, professional development skills, effective planning, motivating learners, and self and peer assessment.

1) Classroom practice: diagnose what students know and what they need to know and what skills they need to develop. Inform the students, teachers and parents who need to know the progress and achievement of the students to achieve their potentials.

2) Professional development skill: evaluate and enhance the instructional practices. Observe, give feedback to learners, and support learners in self-assessment and reflection.

3) Effective planning: students are assessed through formal and informal approaches and are informed about the criteria and purpose of assessment.

4) Motivating the learners: students are given constructive feedback to continue in their progress and achievement and not on their failure.

5) Self and peer assessment: focusses on how students learn, engaging in self-reflection, identifying the steps to learning and encourage the peer assessment.

2.2 Nature of scientific study

Staver, J. R (2007: 6) defines science as “a way of knowing, a method of learning about nature where scientists systematically approach to collect data from nature, uses the varieties of empirical approaches, techniques, and procedures to

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collect data from nature, observe and analyze to construct the knowledge. There are four forms of knowledge in scientific study; hypotheses, which is the temporary statements about the relationships between variables in nature; facts, which are observations which have been tested and confirmed repeatedly; laws, that describes the behavior of specific aspects under specific condition and theories, are explanations about broad aspects of nature that encompass large numbers of hypotheses, facts, laws, and events.

Research findings have revealed that "science learning relies on a complex synthesis of biological maturation, prior knowledge and experience, reasoning ability, and instruction" Staver, J. R (2007: 13). This implies that prior knowledge and experiences form building block for the new learning to take place, which originates from learner's socioeconomic status, gender, ethnicity, culture, native language, and other factors. In addition, different learners will require various types of instructional support and help to understand the process of science learning to acquire the scientific knowledge. In doing so the learner starts to construct new understanding and new knowledge from the prior experiences individually or along with the co-learners in pairs or in the group process. In the process, the motivation from the teacher to encourage students to start, and continue the learning become important catalyst. Such motivation may include the relevance of the topic, chances to connect to the personal meaning making to satisfy the needs. Finally, teachers set the high expectation of learning and encourage students to establish high expectation for their own learning. Teachers should teach the students to understand the underlying concepts and not believe in whatever they conclude from their prior experience. Dorn (2010) argues that the essential academic learning requirements of the scientific study is not limited to understanding only but it further extends to system thinking, inquiry, and application.

Washington State K-12 Science Learning Standard (2010) put forward that the application of science knowledge is to solve the existing problems, to comprehend influence of science and technology in society, and make aware of the relevant careers in the scientific and technological fields. Indeed people must execute to apply what

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they learn in school to combat the challenges in everyday lives, resolve societal problems involving science and technology, and contribute to the prosperity of their community, state, and nation. System thinking is a process of analyzing and understanding how things, regarded as systems, influence one another within a whole. It is more like an approach to problem solving, which problems as parts of an overall systems rather than reacting to specific part and potentially contribute to the further development of unintended consequences (Wikipedia, 2013).

Like any other developing and developed nations system of education in Bhutanese curriculum also believes in constructivist view as summarized by Hodson (1998) that teaching science education should recognize the ideas and views of the students through creating opportunities to explore their ideas and test phenomena and events and let them predict. Students also need to be reinforced to develop and modify their views and ideas by challenging to rethink and reconstruct their ideas and views.

DCRD[3] (2012: 4) asserted that "the learning activities designed from this curriculum framework should be able to offer opportunities for learners to feel that they are more intelligible, plausible, and fruitful than their own everyday understandings in the development of more complex understandings of the accepted scientific ideas."

2.3 The 4MAT System

The 4MAT stands for 4 Mode Application Techniques, a model which changes the learning style concepts into educational strategies developed by Bernice McCarthy in 1972. The 4MAT teaching model is categorized as four factors model and serves as a conceptual framework for teaching (Mert, 2012). This model has its root in the works of many renowned educationists and psychologists like "John Dewey (experimental learning, 1958), Carl Jung (theory of individual, 1923), and David Kolb (experimental learning theory, 1984)," (as cited in Nicoll-Senft & Seider, 2010: 19). However, it is deep rooted in experiential learning theory of Kolb (1984)

[3] Department of Curriculum and Research Development

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which considers the learning styles and the brain hemisphericity (Mert, 2012). McCarthy & McCarthy (2006) stated, "4MAT provides a systematic model of planning instruction that assumes that individuals learn in different yet identifiable ways and that engagement with a variety of diverse learning activities results in higher levels of motivation and performance. Its premise is that individuals learn primarily in one of four different but complementary ways based on how they perceive and process information" (cited in Nicoll-Senft and Seider, 2010: 19). The 4MAT instruction assumes that "all students can be successful. All will develop the confidence as lifelong learners because of teaching to their learning styles with right and left mode techniques. All students will shine at different places in the learning cycles and they will learn from each other" (Melton, 2009: 5).

2.3.1 Four major types of learners

There are four major types of learner as described by McCarthy (1990) in the 4MAT System depending upon how people perceive and process the information. McCarthy stated people perceive reality differently. Some people respond to new situation by sensing and feeling while others think things through. Those who perceive in a sensing/feeling ways, they project themselves into the reality of now and attend the actual experience. On the other hand, those who think through experiences, they attend more of the abstract dimensions of the reality. They analyze what is happening. They reason experience and approach experience logically. Two kinds perceptions are different, but complement each other. Both are equally important and both have strengths and weaknesses. Learners need both of them to fully understand the experiences. Perception alone does not equal learning.

The second major difference in how people learn is how they process experience and information, how they make new things part of themselves. Some people watch first while others do things first. The watchers reflect on new things; filter them through their own experience to create meaning in a slow, deliberate choosing of perspectives. The doers on the other hand, act on new information immediately and reflect later when things, are tried out. They have to do it, to extend

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them into the world, in order to make it theirs. Therefore processing continuum ranges from the need to internalize to the need to act. Watchers need to refine their reflective gifts while developing the courage to experiment and try. In addition, doers need to refine their experimenting gifts while developing the patience to watch reflectively.

2.3.2 Principles of the 4MAT

Major Premises (McCarthy 1987 as cited in Melton R. 2008: 4)

1) "Human beings perceive and process information in different ways. The combinations formed by our own perceiving and processing techniques form our unique learning styles."

2) "There are four major identifiable learning styles. They are all equally valuable. Students need to be comfortable about their own unique learning style. Type one learners are primarily interested in personal meaning. Teachers need to create a reason. Type two learners are primarily interested in the facts as they lead to conceptual understanding. Teachers need to give them the facts that deepen understanding. Type three learners are primarily interested in how things work. Teachers need to let them try It. Type four learners is primarily interested in self-discovery. Teachers need to let them teach it to themselves and to others."

3) "All students need to be taught in all four ways, in order to be comfortable and successful part of the time while being stretched to develop other learning abilities. All students will "shine" at different places in the learning cycle, so they will learn from each other."

4) "The teacher moves through the learning cycle in sequence, teaching in all four modes and incorporating the four combinations of characteristics. The sequence is a natural learning progression."

5) "Each of the four learning styles needs to be taught with both right and left mode processing techniques. The right mode dominant students will be comfortable half of the time and will learn to adapt to the other half of the time. The left mode dominant students will be comfortable half of the time and will learn to adapt the other half of the time."

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6) “The development and integration of all four styles of learning and the development and integration of both right and left mode processing skills should be a major goal of education.”

7) “Students will come to accept their strengths and learn to capitalize on them, while developing a healthy respect for the uniqueness of others, and furthering their ability to learn in alternative modes without the pressure of “being wrong.””

8) “The more comfortable they are about who they are, the more freely they learn from others.”

2.3.3 The four major learning styles

McCarthy (1990) described that there are four learning styles depending upon how people perceive and process the information. McCarthy et al., (2000) also asserted that in the 4MAT the learners are guided by the key conceptual questions in each quadrant McCarthy et al., (2000) as cited in Jackson P. R, 2001: 59-60). The four major types of learners are; imaginative learners; analytical learners; common sense learners and dynamic learners as categorized by McCarthy (1990, 1996, 2000).

1) Quadrant 1, Type 1: Innovative/imaginative learners

(Learners want to know: Why? They seek out meaning)

Type one learners are referred to as innovative or imaginative learners who perceive the information concretely and process it reflectively. They believe in self, seek the meaning and clarity, and integrate the experience with self. They like to listen and share ideas to learn, work for harmony and need to be personally involved. They seek commitment and are interested in the people and culture. They struggle to connect the content of the school with their need to grow and understand their world.

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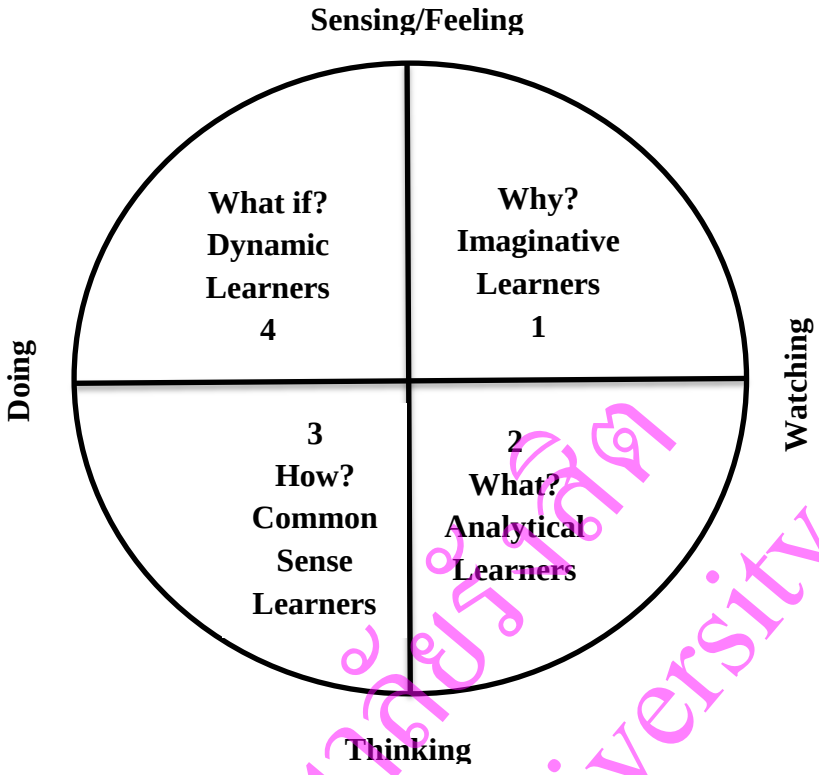

Figure 2.1 Learning styles

Source: (McCarthy 1990: 32)

2) Quadrant 2, Type 2: Analytical learners

(Learners want to know: What? They focus on the concept**)**

Type two learners are analytical learners who perceive information abstractly and process it reflectively. They are interested in formulating the theories by integrating their observation into what they know. They are sequential thinkers and learn by thinking through ideas of the experts. They need details, and are industrious. They prefer the traditional classroom setting, and seek intellectual competence and personal effectiveness, skilled verbally and are passionate readers. They find school well matched for their need.

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3) Quadrant 3, Type 3: Common sense/pragmatic learners

(Learners want to know: How does it work. They learn by applying**)**

Type three learners are common sense learners who perceive information abstractly and process it actively. They integrate theory and practice and learn by testing theories and applying the common sense. They are pragmatic learners and they believe in if something work, and then use it. They are good problem-solvers, think that they need to work on real problems and try to seek the answer by themselves. They are experiment and skill oriented and likes to know how things work. They find school a place of frustration, as they want to see how what they are learning is of immediate use to them.

4) Quadrant 4, Type 4: Dynamic/manipulative learners

(Learners want to know: What can it become. They enjoy creating**)**

Type four learners are dynamic learners who perceive information concretely and process it actively. They integrate experience and application and learn by trial and error. They are interested in new things and can adapt with people who like changes. Since they reach the conclusion with trial and error, they may not have the logical justification of how they reach the conclusion. They are manipulative and pushy and take risks. School for them is often tedious and overtly sequential and is frustrated with the orderly structure of the school.

2.3.4 Eight steps of the 4MAT System in teaching-learning

McCarthy's 4MAT System provides teachers with a structure for planning meaningful learning experiences for all styles of learners. In addition, McCarthy's 4MAT gives the hand-in-experience of learning by engaging the learners in diverse learning sets where learners need to form and test the understanding of the

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materials. Eight steps of teaching and learning process is described below (McCarthy, Germain, and Lippitt L, 2002):

1) Step 1- connect or create an experience (Right Mode)

The learners are made to engage in a concrete experience, which leads to a search for the prior knowledge, and experience. The interactive dialogue commence of what learners already know and believe with what teacher intends to teach. The learners experience the overall learning experience sets to proceed. Teacher encourages diversification of ideas, dialogues, and participation. This step is designed to encourage rational and symbolic thinking which a right hemispheric function is.

Therefore, the teacher has to connect the students directly to the concept in a personal way. He can initiate the problem-solving activity to capture the attention and begin with a situation that is familiar to students and can build on what they already know. Teacher can also facilitate the learning through team work and prepare the learning experience such that students response in diverse and personal ways.

2) Step 2 - Examine or reflective on the experience (Left Mode)

The learners make judgment on the perceptions and dialogue generated in step one. The teacher engages student reflection upon their existing level of their knowledge and experience to determine if their opinions and beliefs are supportable. Overall, in quadrant one (right and left) the goal is engagement and motivation. However, in quadrant one left the teacher's role is to assist student as they clarify and pattern their thinking. In quadrant one left, beliefs and opinions begin to evolve into organizers and structures for future thinking and theory building. This phase of the 4MAT Cycle emphasizes left hemispheric thinking and therefore has as its goal the imposition of structure.

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In this stage the teacher can guide the student reflection and help them analyze the experience, encourage the students to share their perceptions and beliefs, let them review and summarize the attributes. He/she can establish a positive attitude towards the diversity of different people's experience and clarify the reason for the learning.

3) Step 3- Image or integrate the observation into concepts (Right Mode)

Learners integrate their personal experiences into conceptual understanding for the validation and analysis of ideas. The learners are encouraged to symbolize, in as many modalities as feasible, their present state of understanding of the subject matter. Image making, is a right mode activity. The emphasis here is the expansion of representations of meaning.

This step requires the learner to begin to shift from reflective experience to reflective thinking. The teacher's role here is to draw attention to aspects of structure and objectivity implicit in the students' representations of what they know. Teacher should now provide a meta-view, lifting students into a wider view of the concepts. Teacher should use different medium other than reading and writing to connect student's personal knowing to the concept, involve students in reflective production that blends the affective and cognitive domain. Transform the concept yet to be taught into image and experience and deepen the connection between the concept and its relationship to the students' lives. Also let the students compare what they already know with what experts have found.

4) Step 4- Inform or develop theories and concepts (Left Mode)

Students are engaged in objective thinking. The emphasis here is analysis of verifiable concepts, facts, generalizations, and theories. The role of the teacher is to present information and experience in complete and systematic ways. The good "two left" application lecture builds upon the personal connections

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established in quadrant one to foster conceptual thinking. This is a left mode teaching set. Therefore, in quadrant 2 the teacher introduces the concepts, facts and principles to be taught and impart the students with the information and knowledge.

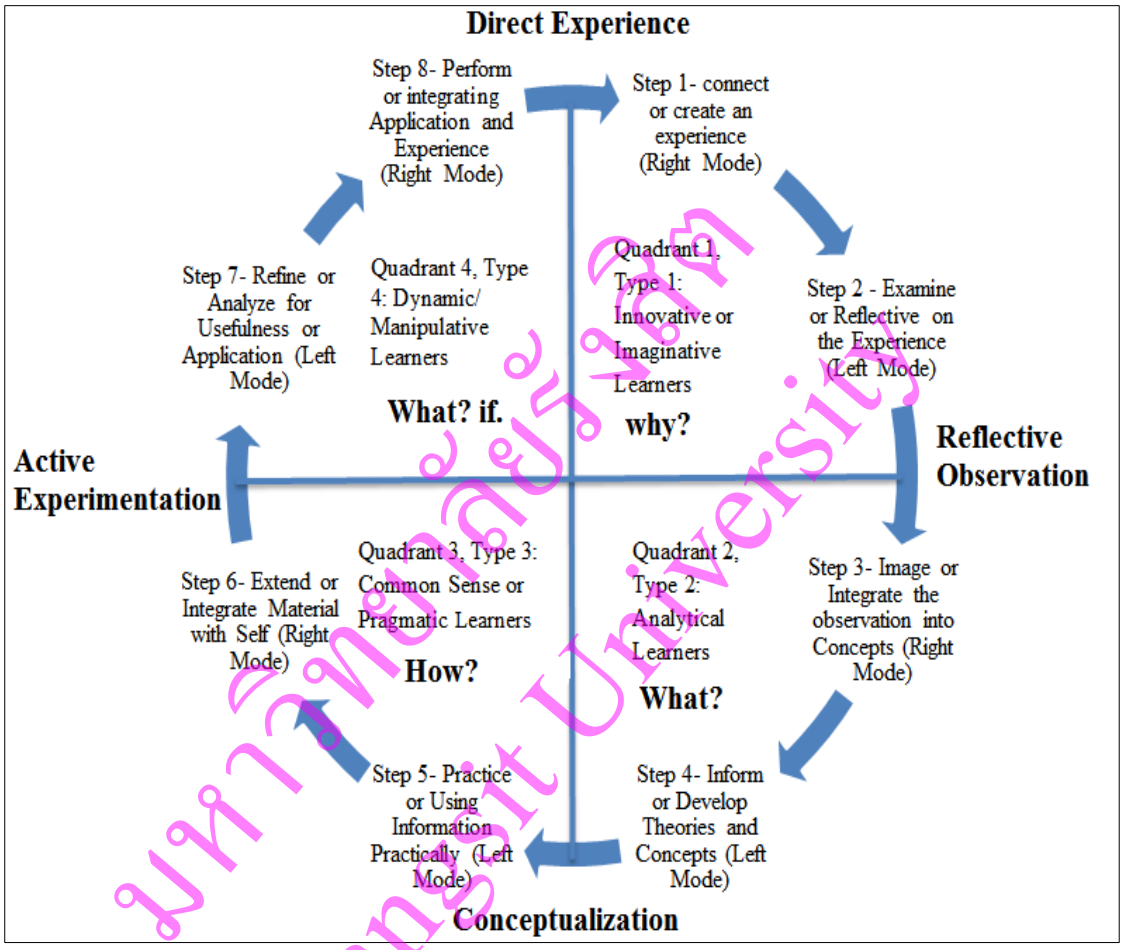

Figure 2.2 Eight steps of the 4MAT System

Source: (Silva 2009: 7)

The teacher provides the body of knowledge related to the concept and emphasize the most significant aspects of the concepts in an organized and organic manner. Teacher should present the information sequentially so that students see continuity. Students should be drawn to important and discrete details and not provide many facts which may bring confusion. Teacher should use varieties of

delivery systems: interactive lecture, text, guest speakers, films, visuals, demonstrations, etc. when available.

5) Step 5- Practice or using information practically (Left Mode)

Step 5 emphasize on shifts from acquisition and assimilation to testing and adaptation. Students will apply what has been taught. In quadrant three left, the goal is reinforcement and diagnostic evidence of the student's ability to apply the concepts taught. The teacher's role here is coaching and assisting as students refine their ability to find applications of their ideas. Because the emphasis of this teaching/learning set is left mode, correct answers and student products, which demonstrate their ability to apply the concepts, are important here.

Teacher provides hands-on activities for practice and mastery. Teacher must check for understanding of the concepts and skills by using relevant standard materials, i.e. worksheets, text problems, workbooks, teacher prepared exercises, etc. Students must be provided with opportunity to practice new learning in multi-modal ways (learning centers, games fostering skills development, etc.). Teacher set high expectations for skill mastery, implements the concept of mastery learning to determine if re-teaching is necessary and how it can be carried out. Finally, give opportunity to students to create additional multi-modal practice for each other.

6) Step 6- Extend or integrate material with self (Right Mode)

In this learning set, the student tests the limits and contradictions of his/her understanding. Students are encouraged to develop their own applications, which demonstrate that they understand and can apply what has been learned. Project work is the essence of this phase of the 4MAT System. The right mode emphasis in this learning set is designed to encourage students to create personal applications their experiences with the ideas learned. Therefore, in quadrant three right and left mode focuses on practice and demonstrating to their ability to apply the concepts.

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The teacher's role is to encourage students to take the application of learned ideas to more sophisticated, personal levels. Teacher encourages tinkering with ideas/relationships/connections. Place the students in such situations where they need to find information not readily available in school texts. Provide opportunity for students to design their own open-ended explorations of the concept. Teacher must also provide multiple options so students can plan a unique "proof" of learning. Encourage students to organize and synthesize their learning in some personal, meaningful way.

7) Step 7- Refine or analyze for usefulness or application (Left Mode)

Learners critically examine the place of the newly acquired knowledge and experience in his/her existing worldview. The central issue here is what new questions do I have and what must be done to integrate this learning into a meaningful conceptual subset. Working alone or preferably in pairs and triads, learners in this learning set edit and refine their work. They also face and resolve contradictions implicit in the tension between new and earlier schema.

The teacher's role here is to guide the refinement of the old schema and encourage the formation of a more complete perspective. Teacher should provide necessary guidance and feedback to students' plans, encouraging, refining, and helping them to be responsible for their own learning. Teacher must help students analyze their use of the learning for meaning, relevance, and originality. Point out students' mistakes if any and encourage them to learn from the mistake. Finally, let the students review and summarize the whole experience with which the learning began.

8) Step 8- Perform or integrating application and experience (Right Mode)

In this learning set, the learner returns to the place where he/she began, and integrates the learning experience into a slightly different, personally held

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worldview. This is the step where presentations are given, share ideas, learning is accepted into daily lives. The teacher's role is to join in the celebration and facilitate entry into the next unit of study.

Eventually, in quadrant four the students summarize their learning, and share and apply in new situation. For this teacher should support students in learning, teaching and sharing with others. Create and establish atmosphere that celebrates the sharing of learning. Set the situation for practicing and sharing of the learning to the larger community. Nevertheless, leave students wondering (creatively) about further possible applications of the concept, extending the "what if" into the future.

2.3.5 Related theories supporting the 4MAT System

2.3.5.1 Constructivism

Bernice McCarthy's 4MAT has the firm inheritance from the constructivism. The constructivism is a theory, which states that, learning is an active process, and it maintains that individual create or construct their own understanding and/or knowledge through the interaction of what they already know, and through the ideas, events, and activities or experiences they encounter (Dunn, 2005). He further explains that constructivist classroom emphasize active involvement on the creation of the knowledge and learners are able to construct new ideas or concepts based on the prior experience. Waterhouse (2005) also stated that constructivist approach helps students to learn how to seek knowledge and find answer, which are invaluable skills they will exercise in the task of lifelong learning. Papert (1993) has summed up the constructivist approach, as "the kind of knowledge that children most need is the knowledge that will help them find more knowledge" quoted by Waterhouse (2005: 42). Dunn (2005: 239) stated that constructivists agree with following:

"Learning is an active process in which the learners use sensory input and constructs meaning out of it. Learning consists of both constructing

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meaning and constructing systems of meaning. That is, each meaning we construct makes us better able to give meaning to other sensations that fit a similar patterns or schema. The crucial act of constructing meaning is mental: it happens in the mind. This is what Dewey refers to as reflective activity. Learning involves language: the language we use influences learning. Learning is a social activity. Learning is contextual: we learn in relationship to what we already know and believe. Learning is not possible to assimilate new knowledge without having some structure developed from previous knowledge to build on."

The 4MAT is based on the theories of John Dewey, Piaget, Vygotsky and learning style theory of Carl Jung, Brig Myers, and Kolb, which combines researches from pedagogy, learning theory, and brain hemisphericity.

The following reviews of the related theories of pedagogy, learning, and hemisphericity places the foundation to Bernice McCarthy's 4MAT Model.

2.3.5.2 John Dewey's pedagogy of instrumentalism

Nodding (2007: 31) "to be educative, an experience has to be built on or connected to prior experience….teacher must start where the students are…also ask where a given experience may lead. There must be continuity in experience." John Dewey was progressive thinker who compared the old education with the new. Although he did not recommend abandoning the traditional one but he wanted them to be taught in a ways that makes them genuine subject matter. According to Dewey, the aim of education was more education. Therefore, education functioned as both end and means. He believed that to be educative, an experience had to be built on or connected to prior experience. Today we can realize in, as teacher must start from where the students are and where the given experience may lead. Teachers must design lesson that connect the student's prior experience with the present and lead to future experience to move toward sophisticated grasp of object. Dewey is associated with the child-centered education because he emphasize on the

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necessity of student engagement and activity. Dewey described students as active pursuers of their own purposes (as cited in Noddings N, 2007). McCarthy, Germain, and Lippitt (2002) asserted that learning required the transactional interaction between the individual and the environment that is grounded on Dewey's biology-based theory made a case for learning by doing instead of learning by abstraction or rote. Thus, he preferred the word "instrumentalism" which is related to pragmatism as a description of his philosophy of education, which emphasized the testing of the practical consequences of the ideas. They said, Dewey's 'Experience' is the interaction of the individual with environment as a testing ground for ideas, is paramount.

McCarty et al., (2002: 1.2) also claimed that Dewey's, How We Think, described the five steps methods for thinking. They are: "(1) reflecting upon a problem; (2) establishing the limits or characteristics of the problem in precise terms; (3) testing possible solutions and postulating a wide range of hypotheses; (4) considering possible outcomes and acting on these considerations, and (5) acceptance or rejection of the solutions." They said that stages of thinking were designed to systematize a "method" for working through each human experience as it arose.

They pointed out that Dewey's philosophy of education accentuates the importance of human experience as an entry to human understanding. He believed in the harmony between the individual and the environment. His pedagogy unites the mind and the body of the learners through a method of thinking and doing, "an experience he called the supreme art form… the art of education" McCarty et al. (2002: 1.2).

In the 4MAT, we can visualize Dewey's contribution, as there is the emphasis on the student's experience and the necessity for the teacher to understand students' experience in order to design effectively a sequence to fulfill their potentials.

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2.3.5.3 Jean Piaget

The 4MAT System firmly believes in Piaget's theory of cognitive developmental. In this, Piaget describes how human makes sense of the world by gathering and organizing the information from the environment. Dunn (2005: 235) "Piaget believed that all healthy human being are born with cognitive structures for organizing and processing information……prior information is used to make logical connections with new information. Each time new information is received it is added to mental schema, the mental models we use for organizing and classifying information."

He explains that the highly organized reflexes or the potential to perform something exist called as schema. The number of the schemata available to an individual at any given time constitutes that individual's cognitive structure. Piaget, (1952) in Santrock, (2006) said that how children uses and adapt their schemata is dependent on two cognitive structures: assimilation and accommodation. When an individual perceives new information from the surrounding and match with the already existing knowledge it is referred to as assimilation. If the intellectual growth takes place as result of assimilation of new information (modifies the cognitive structure) accommodation is said have occurred. Assimilation and accommodations are referred to as the functional variants as they occur at all levels of intellectual development, Hergenhahn and Olson, (2005).

According to Santrock (2011), children make sense of the outer environment by organizing their experiences. For Piaget organization is grouping of the isolated behaviors and thoughts into higher-order system. While children move from stages of thoughts, cognitive conflict occurs, which Piaget called dis-equilibrium. Children have to resolve and reach the equilibrium of thought to become comfortable. Piaget's theory as represents constructivism views that children actively build system of meaning and understanding of reality through experience and interaction. In this view, children actively construct knowledge by assimilating and

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accommodating new information (Slavin, 2003). This belief is dominant in 4MAT System of instruction, as students must interact with their environment to learn

2.3.5.4 Vygotsky theory of social constructivism

Lev Vygotsky was a supporter of the social constructivism and contended that traditional schools of transmission and instruction model where teacher transmits information to students made them receptive and passive. Dunn (2005: 236) "For Vygotsky the social context of environment is of great importance in the learning process. Within the environment, mediation takes place. Mediation refers to the interaction with significant people, materials, tools, and symbols that convert social interaction into psychological functions and future learning." McCarthy' 4MAT System links Vygotsky's theory as it promotes learning context in which students play active role in learning with the help of teachers, experts, and peers. Teachers' role shift from instructor to facilitator where students construct their own knowledge or meaning collaboratively with teachers and peers. The four key principle ideas have been derived from Vygotsky' theory:

1) Social natures of learning where children learn through joint interaction with teacher and peers that are more capable. This not only make student to think and present the learning outcomes to other students but also make thinking processes available to other students.

2) Zone of proximal development is a concept that when a child is engaged in a task that could not be done alone but can perform a task with the assistance of peers or teachers.

3) Therefore, when learners are paired with more advanced peers, they gradually attain their expertise through the interaction with them, which Vygotsky termed as cognitive apprenticeship.

4) Finally, Vygotsky believed that children must be given complex, difficult and realistic task and given enough support to achieve these task rather than giving them simple knowledge and expect some day to build up to complex task which he referred to as scaffolding (Slavin, 2003).

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Therefore, we can clearly see that in 4MAT System, learning starts with joint interaction between teacher and learners and moves toward independence of learners in acquiring knowledge.

2.3.5.5 Carl Gustav Jung's theory of personality type

Carl Jung's theory of personality type describes holistic concept of human development, which assumes the measurable and consistent individual preference for making sense of the world. The difference in the human behavior is due to certain basic differences in the ways people prefer to use modes of perception and judgment. Variations in behaviors rely on four basic functions: sensing, thinking, feeling, and intuition. According to Jung, sensing refers to taking in the observation by way of the senses, which tells you something exists. Thinking, a term used to define logical decision-making processes, tells you what something is. Feeling, a term for the process of appreciation in terms of subjective/personal value, tells you whether something is of value or not. Intuition, a term used for apprehension of meanings, relationships and possibilities by way of insight, tells you when something connects, where it came from and where it is going, McCarthy, Lippitt and Germain, (2002).

Jung's contribution to 4MAT (and subsequently to teaching/learning environments) was his precise description and research on Psychological Types and their preferences in personal development.

Jung also described two types of the attitudes individual have towards the environment: extrovert and introvert. According to Luttrell (2009), extroverts are characterized by their involvement of energy toward the outer environment. They place their importance on the objectivity and gain more from the surrounding environment than from the cognitive information while introverts focus on the consolidation of energy within themselves and their attitudes are more concerned and subjective appraisal.

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Jung combined two types of attitudes and four functions to form the eight different personality types shown in the diagram below;

Jung's Psychological Type

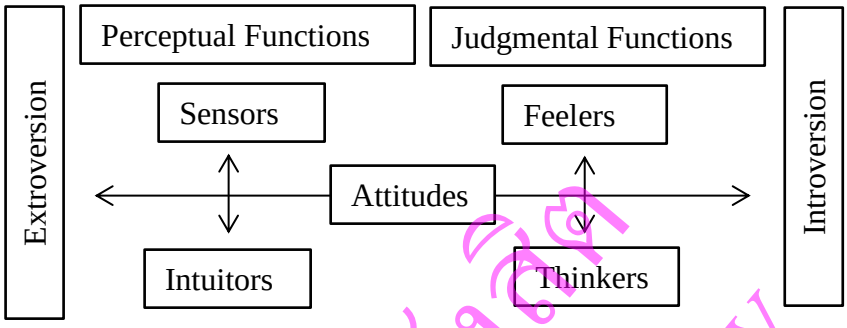

Figure 2.3 Jung's Psychological Type

2.3.5.6 David Kolb's theory of experiential learning

Kolb believed that learning is a continuous process where individual refine and integrate basic adaptive modes for perceiving, thinking, acting and feeling. The major assumptions of the Kolb's Model includes the followings: (1) Learning is a continual process, not an outcome; (2) Learning is grounded in personal experience; (3) Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world, and (4) Learning involves transactions between the individual and the environment whereby experiences are transformed into knowledge and actions. Kolb's theory is, therefore grounded in the idea that individuals attain higher levels of cognitive complexity through the integration of preferred and less preferred modes of adapting their personal circumstances, McCarthy, Germain, and Lippitt, (2002: 1.4).

Learning style is formed by the combination of how people perceive (grasp) and process (transform) the information, which forms the most comfortable way to learn. By combining two dimensions of concrete experience and abstract conceptualization ("how we perceive") with two dimensions of active

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experimentation and reflective observation ("how we process"), Kolb established four categories of learning styles based on four learning modes.

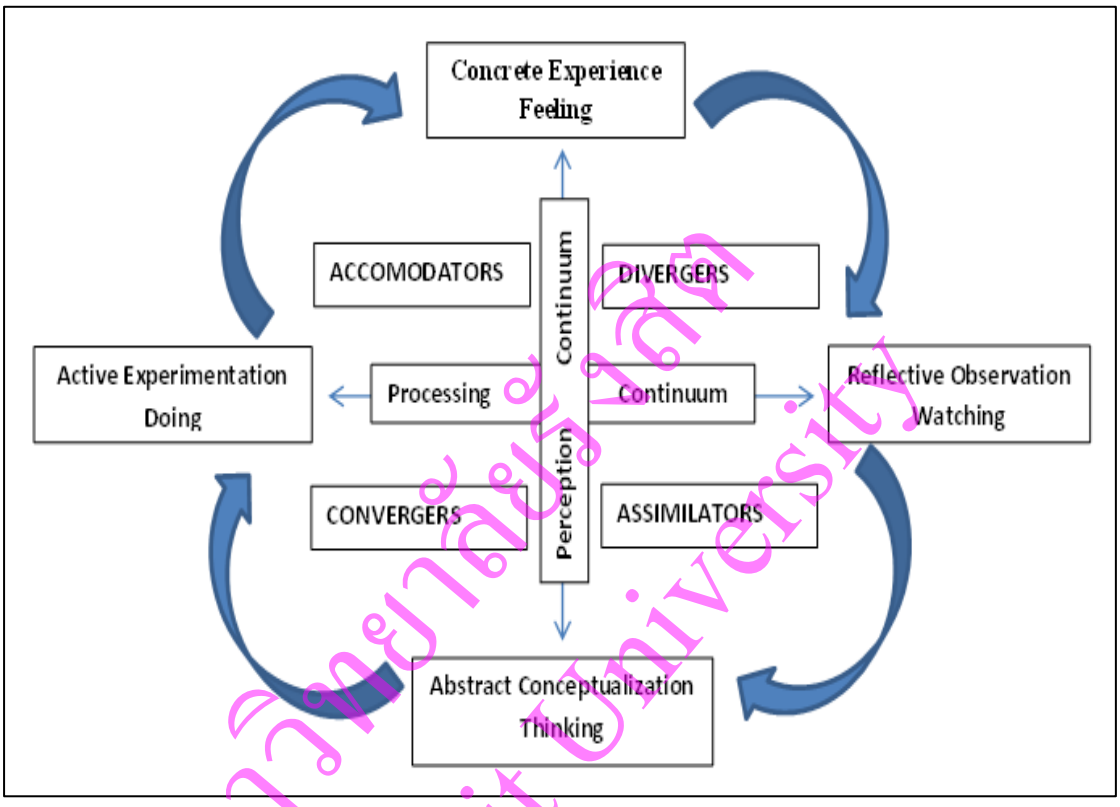

Figure 2.4 Kolb's Learning Styles

Source: "Experiential learning and Kolb's learning cycle." (Zein, A., 2009: 2)

Kolb has set out two major learning dimensions (sensing/feeling thinking and acting/watching learners) and four different kinds of abilities or styles: concrete experience abilities (CE), reflective observation abilities (RO), abstract conceptualization abilities (AC) and active experimentation (AE), (Kolb in Musa, 2003). Kolb's learning model is based on two continuums that form a quadrant:

1) Processing Continuum: approach to a task, such as preferring to learn by doing or watching

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2) Perception Continuum: emotional responses, such as preferring to learn by thinking or feeling.

Kolb found that the learning cycle involves four processes that must be present for learning to take place which he called as experiential learning. He asserted that experience is the source of learning and development (1984) where by each ends of the continuums (modes) provide a step in the learning process which Abidn Zein, (2009) described as;

1) Concrete experience (Feeling): learn from specific experience and relate to people. They are very sensitive other's feelings.

2) Reflective observation (Watching): they make the observation by judging the environment from different perspectives. They look for meaning of things.

3) Abstract conceptualization (Thinking): they use logical analysis of ideas and use the intelligence in a situation.

4) Active experimentation (Doing): they have the abilities to get the things done by influencing the people and events through action. They are risk takers

2.3.5.7 Gardner's Theory of Multiple Intelligence

Howard Gardner (1993) proposed, "a pluralistic view of mind acknowledging that people have different cognitive strength and contrasting cognitive styles". He has identified nine intelligences-defining intelligence as the "ability to solve problems or to fashion products, that are valued in one or more cultural or community setting– linguistic, logical-mathematical, spatial, musical, bodily kinesthetic, interpersonal, intrapersonal, naturalist and existential or spiritual intelligences" Smilksterin, (2011: 91).

Sparked (n.d) has identified two implications of multiple intelligences in classroom teaching: (1) educators should recognize and teach to a

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broader range of talents and skills and (2) teacher should structure the presentation of material in a style that engages most or all of the intelligences. To assess the students' intelligences Lazear (1992) suggested that educator create the "intelligence profile" for each student so that educator know each child's progress which includes authentic assessment namely portfolios, independent projects, student journals, and assigning creative tasks. The positive side of Gardner's Multiple Intelligences philosophy is that it "supports the belief that we should acknowledge and encourage the development of diverse strengths and talents in all our students" Westwood, (2004: 50).

Davis et al., (2012); Veenema et al., (n.d), and Trevino, (n.d) describe the Multiple Intelligence as follows:

1) Linguistic intelligence

This is an ability to analyze information, communicate, make sense of the world, and create new products involving oral and written language. Students like to write, tell stories, and enjoy reading. The techniques to boost this intelligence are; note taking, verbal response to questions, writing term papers, storytelling, tape recording, brainstorming, and journal writing.

2) Logical-mathematical intelligence

This includes an ability to develop equations and proofs, make calculations, and solve abstract problems. Students prefer number and reasoning, enjoy computing, play and win strategy games. Appropriate techniques to improve the logical-mathematical intelligence include using calculations, logic puzzles, and categorizations.

3) Visual-spatial intelligence

This is an ability to perceive, and recognize the visual and spatial information, to transform information, and create visual image from memory.

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Students love to do art activities, daydream a lot, can easily read maps and charts. They can distinguish colors, shapes, and translate into meaningful symbols. They learn best by making video drawings, color-coding, class notes, drawing, or doodling, visualizing and flash cards.

4) Musical intelligence

This includes producing, remembering, and making sense from different patterns of sounds. Students can play musical instruments, study with music playing at the background, sing songs to themselves. They can learn by using mnemonic devices, and singing, tapping feet or hands, listening, and making a poem or rap.

5) Naturalist intelligence

This type of intelligence includes the ability to identify and distinguish among plants, animals, and weather formations that are found in natural world. Students try to comprehend, appreciate, and seek for orderly patterns in the natural environment. The learning is affected by weather pattern, changing season, warmth of sun and sound of the natural phenomenon.

6) Bodily-Kinesthetic intelligence

The person can use his/her body to create products and solve the problems. This can be relating to “learning by doing.” They excel in the physical activities, fidget in the classroom, good at acting out skits, role-playing, body gesture, and building model, touching and operating equipment, typing, dancing, and driving. They learn better by mimicking action of someone after the task is complete.

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7) Interpersonal intelligence

It includes the ability to recognize and understand other person's feelings, moods, desire, motivations, and intentions. Students can exhibit this intelligence when they thrive in small group, when they notice and react to the mood of their friends and classmate and when they convenience their teacher. They are likely to have plenty of friends, involves in school activities, enjoy group games. They learn by debating, and having study group project.

8) Intrapersonal intelligence

This requires having ability to recognize and understand one's own moods, feelings, desires, motivations, and intensions. They are independent, self-confident, and self-motivated. They learn best by writing in journals, silent reading meditating on materials and pondering upon self.

Despites, counting how many different types of intelligence are there, 4MAT system of instruction prepares to educate the intelligences. 4MAT has been found to be very powerful in its implication for education of multiple intelligences. Each of the four quadrants in 4MAT system incorporates the multiple intelligence dimensions. According to Armstrong, "broadly construed, a person's learning styles is the intelligence put to work. In other words, learning styles is pragmatic manifestation of the intelligences operating in natural learning context" (as cited in Morley, 2000: 12).

Lindsey (1997) pointed out that when teachers design instruction around the 4MAT cycle, they need to: Establish personal meaning (Intrapersonal Intelligence); Explore diverse opinions and viewpoints (Interpersonal Intelligence); Conceptualize and structure knowledge (Logical/Linguistic Intelligence); Promote usefulness and transferability (Spatial Intelligence), and Encourage Creative Expressions of Knowledge. Musical and Bodily/Kinesthetic Intelligences are incorporated throughout mostly through the 4MAT design emphasis

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on Right Mode strategies. Mathematical Intelligence is used when math is specifically taught as well as when it is appropriate to enhance meanings, ideas, skills, or individual projects. (McCarthy, et al., 2002: 8.25).

2.3.6 Hemisphericity and dominance

Exploration on the brain organization began four century ago by Rene Descartes, which was made more evident by Roger Sperry in the recent years with the help of the technologies.

However, Joseph Bogen, neurologist was the person who originated the term hemisphericity. Beaumont, Young and McManus (1984) defined hemisphericity as the idea that people may rely on a preferred mode of cognitive processing, which is linked to activity on the part of the left or right cerebral hemispheres. McCarthy, Germain, and Lippitt (2002: 5.3), summarize the research on hemispheric specialization and brain functions:

1) The hemispheres of the human brain process information and experience in identifiably different ways.

2) The neural organization in each hemisphere is complementary, yet different.

3) The Corpus Callosum, the bundle of nerve fibers connecting the two hemispheres, serves to integrate the functions of the hemispheres.

4) Hemispheric dispositions (preference) are identifiable.

5) Individual preference for hemispheric integration has a supportable relationship to cognitive processing style, especially with regard to new learning.

6) Brain research supports the belief that traditional education favors an all too narrow approach to teaching. Our “at-risk” students may be at risk due to our teaching methodologies rather than from any innate deficiencies of their own.

7) Research on the effects of right and left mode instruction indicates that students differ with regard to hemispheric dominance, and that these differences influence student retention and performance.

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McCarthy et al., (2002: 5.3) emphasized, “meaningful teaching is teaching which systematically engages both hemispheres of the brain in problem-solving and understanding”. Solso (1995) identified the lateralization of the brain by asserting that left hemisphere is associated with special functions such as language, conceptualization, analysis, and classification. On the other hand, right hemisphere is associated with integration of information over time, as in art and music; spatial processing; recognition of faces and shapes. Sperry and Gazzaniga (1996) in the “split-brain” patients, they found out that each half of the brain acted with its own memory and will, competing for control. From these experiments, they drew up the conclusion that each hemisphere has its own separate and private sensations, its own perceptions, and its own impulses to act. The research also shows that the two hemispheres have distinctly different functions that are not readily interchangeable and corpus callosum is responsible for unifying awareness and allows the hemispheres to share memory and teach.

Dorfsman (1997) argued that studies have mentioned about the left and right brain but have never quoted the scientific study about the effect of hemisphericity on education. He supported that only 4MAT system has taken hemisphericity toward education. McCarthy favored findings from the split brain research as it suggested that the hemispheres of the brain served different functions, responded to different stimuli, and, though always working together, appeared to have distinct domains of expertise (Ojure, 1997). Johnson (1999) argues that if the learning activities are constructed to stimulate both side of the brain the student achievement increases. The researchers have confirmed that traditional instructional strategies activate the left-brain only. Therefore, curriculum throughout the educational process should encourage developing the activities which will involve development of processing using both side of the brain.

Sousa (2011) stated, the brain researchers have found out that the brain has the capabilities to integrate different and seemingly disconnected activities going on in specialize areas of the brain into a unified whole. In the experiments conducted by Santrock (2011: 35) stated “brain has considerable plasticity and its development

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depends on experience, that what children do can change the development of their brain.” The 4MAT System of instruction considers the teaching and learning techniques that activate the left and right hemispheres of the brain and address the preferred ways of processing, and organizing information through reflection or experimentation. McCarthy (1997) stated that left side of the brain is analytical and seeks for cause and effect by segmenting the things into pieces and classifying. It is efficient is learning of language and symbols, and can understand abstract experience, create theories and models. This part works in time and requires the information in sequence.

Whereas the right half of the brain is more intuitive, senses feelings, capable of making the images, and seeks patterns, relationships, and connections. Therefore, she argues that to enable the higher order thinking learner requires using both sides of the brain, teaching to both sides, connecting to real-life situation and encouraging the problem solving. Learners must be reinforced to master symbols, movements, music and language.

2.3.7 Learning styles

How people learn, depend upon their preference of how they perceive and process the information. Kaplan & Kies (1993) defines learning as an internal process that occurs when an observable, permanent change takes place. Further De Bello (1990) said that learning style could be described as the way people retain or absorb information. Dunn, Beaudry & Klavas (1989) & Dunn (1984) also defined learning style as a biological and developmental set of personal characteristics defined by the way individual process information. Barbe & Milone (1981); Claxton & Murrell (1987); Felder (1993); Felder & Silverman (1988); Kolb (1984); Schmeck (1988) argued that depending on the learning style, students focus on different types of information, perceive information differently, and understand at different paces, Fox J. and Bartholomae, (1999). Ojure, (1997: 16) stated;

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Researchers of learning style believe that different learning styles have equal worth and no different styles are inferior to other. The style and ability are two separate entities. Students who are of equal ability may not prefer to learn in the same ways, as opposed to students of unequal ability may have the preference to the same style, which eventually is assumed that diversity should be honored as it is linked to multiculturalism and other diversity based educational movements.

"People learn in different ways. These differences depend on many things: who we are, where we are, how we see ourselves, and what people ask us…We hover near different places on a continuum. And our hovering place is our most comfortable place." (McCarthy, 1980 as cited in Musa and J. R. G, 2003: 2)

Therefore, learning and learning style is specific and individualistic and can be enhanced through the collaborative interaction between teacher and students. The learning style defines that how individual can make the learning simpler and easier. Individual can have their own ways and ability to learn in easier and convenient ways.

If the teacher knows the student's learning style, choosing possible teaching strategies, teaching procedures and techniques and learning instruments can be facilitated and also appropriate learning opportunities to student's learning styles can be improved (Akkoyunlu,1995 and Claxton and Murrell, 1987 as cited in Elci, Kilic and Alkan, 2012).

Researchers have appraised from the results of different studies that providing appropriate learning opportunities to the student's learning styles improves: positive development in their attitudes towards the fields; indulgent behaves to those having cognitive difference; academic success; behavior in well-disciplined and being more responsible (Elci, Kilic and Alkan, 2012). Acharya (2002) stated that identifying the student's style and then providing instruction consistent with their style contribute to learning that is more effective.

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Melton & Sowders (n.d: 5) said, “integrating what we know about learning styles and how the brain works with how we teach affords us the best opportunity to begin addressing the needs of all learners in our schools, including “at risk” students.” In addition, McCarthy (1979, 1983, 1985, and 1987) stated, “most instruction in today’s high school is addressed to the analytic learner. Schools validate the way analytic learners learn, but about 70% of our students are not analytic learners, according to recent research" (Melton & Sowders, n.d: 5). They argued that only the analytic learners get the kind of teaching they need. The other three types are expected to learn in the analytic mode.

James and Gardner (1995: 20) defined learning style as the “complex manner in which, and conditions under which, learners most efficiently and most effectively perceive, process, store and recall what they are attempting to learn.” (cited in Bielefeldt, 2006). Bielefeldt, (2006) asserted that the learners in the classroom are organized around the experiences that stimulate the thinking to construction of new knowledge. He describes the three modes through which the information can be taken in as:

2.3.7.1 Auditory

Auditory learners learn through listening. They grasp up new ideas and concepts better when they hear the information. Lectures and discussions is suitable for auditory learners, besides role-playing exercises, structured sessions, and reading aloud are deemed to favor this type of learners. They can follow instructions very precisely after being told only once or twice what to do. Since they make meaning by hearing and speaking they use the voice and ears to collate the information. They have the ability to repeat and rephrase the information during the discussion. Music in the background can be one of the strategies that can enhance and facilitate the learning of auditory learners.

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2.3.7.2 Visual

Visual learners learn through sight. These learners prefer to see how things work rather than lecture and discussion. They prefer watching demonstrations and learn best through watching video clips. The incorporation of the visual displays such as video clips, diagrams, graphic, power point presentations, overhead transparencies, flipcharts, handouts, and field trips in the instruction can facilitate the learning rather than lecture and discussion but they also require seeing the instructors' body language and facial expressions.

2.3.7.3 Kinesthetic

Kinesthetic learners use the motor skill to learn. They have the tendency to engage their body while learning to take place. They can be categorized as "hand-on" learners who prefer doing things against talking. Instructor requires preparing the active learning environment. Some instructors may for sure misunderstand these behaviors as in-disciplinary however, kinesthetic learners learn best by through action and movement.

2.4 Related research on the 4MAT System

Many studies had been carried out to investigate the effectiveness of 4MAT System since its first implementation in 1987. Many studies have found that 4MAT System have been very successful in improving the academic achievement of the students in various disciplines and in wide range of grades including the university students. Following researches prove the effectiveness of 4MAT System;

Silva, D. L. (2009) explored the 4MAT teaching cycle mathematics to the engineering students of Mapua Institute of technology, Philippines. The study was carried out to find out the influence of the approach on the behavior, attitude, and academic performance of the students. A descriptive qualitative method of research was utilized. The study utilized the survey questionnaires, rating scale, observations,

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and interviews. The result showed that with the help of 4MAT cycle of learning, the students developed certain habits of mind and attitude. The results showed that there was a significant difference between the pretest and posttest mean scores of experimental group and the control group as revealed by F = 181.325, DF 1,77, P ≤ 0.001 for lesson one and F = 168.987, DF = 1,77, P ≤ 0.001 for lesson two. The students also agreed that they were given ample of opportunities to master and apply a new learning in various situations. The interview survey questionnaires also revealed the students developed certain habits of mind and attitude like openness and respect for the opinion of group members, creativity and perseverance in finding the solutions to the problems, patience in finding additional information to solve the problems, commitment to learning, and responsibility for one's learning.

In the study conducted by Tatar, E. and Dikici, R. (2009) on the effect of the 4MAT method of instruction on achievement in Mathematic found that 4MAT method of instruction was more efficient than the traditional method in teaching of the binary operation subject in mathematics. The sample of the study consisted of 58 ninth grade students in two separate classes. The data collected were primarily from three scales; 'mathematical knowledge test', 'mathematics attitude scale' and 'knowledge test on binary operation and its properties'. The significant difference in the results of the pretest and posttest between the control and experimental group in the students' mathematical knowledge levels, their attitudes towards mathematics and their knowledge levels on the binary operation and its properties showed that 4MAT method of instruction contributed positively on learning mathematics.

Similarly, in the recent study by Ovez, F. T. D, (2012) on the effect of the 4MAT Model on student's algebra achievements and levels of reaching attainments, the result showed the that implementation was successful. The study was an experimental design with the pretest and posttest control group. The study consisted of 105, 8^{th} grade students enrolled in the primary school in the district of Balikesir during the 2011-2012 academic years. The teaching was provided to the experimental group based on the 4MAT teaching model and to the control group in compliance with applications and activities in the textbook within the framework of attainments in

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algebra learning domain. The results showed that difference in the algebra learning domain achievement scores [t = 3.039; (p = .003 < .01)] of the experimental and control groups was significantly in favor of the experimental group suggesting that algebra teaching based on the 4MAT teaching model was more successful in increasing the students' success and thus achievements.

In recent study by Mert (2012) on the effectiveness of the 4MAT teaching model upon student achievement and attitude levels towards mathematics in the unit of Hoop and Circle had confirmed that 4MAT method of instruction was more efficient than the traditional method. An experimental pattern model with pretest, posttest control group had been used in the research with sample consisting of 81 students of 7th grade at public school in Balikesir durng 2009-2010 academic periods. The results of a paired t-test conducted yielded the significance [t = 2.74; (p = .00 < .05)] between the average grades of the experimental group in the pre and posttests.

Elci, A. N, Kilic, D. S and Alkan, H. (2012) studied the 4MAT Model's impact on the learning style, success and attitudes towards mathematics with 30 pre-service teachers as experimental group and 35 same grade students as control class. They utilized the quasi-experimental study depending on the pretest-posttest. Learning Style Measure (LSM) was used to determine the learning style of the students. Results showed that academic success was statistically significantly higher in the experiment group (mean = 62.20, SD = 4.95) than the control group (mean = 43.89, SD = 8.93) with p–value of < 0.0001. The intervention increased the success of experiment group.

Therefore, the researchers are interested to use 4MAT System to design the lessons because it focus the learners, let learner experience, practice and apply the learning. It is found that many studies using 4MAT System have similar findings; that it has improved the academic achievement and attitudes towards the learning.

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2.5 Reasoning ability

Reasoning is a cognitive activity. It is about thinking activity that is of crucial importance throughout our lives. Consequentially, the ability to reason is of central importance in all major theories of intelligence structure. Whenever we think about the causes of events and actions, when we pursue discourse, when we evaluate assumptions and expectations based on our prior knowledge, and when we develop ideas and plans, the ability to reason is pivotal. Justifying and supporting concepts and ideas is as important as convincing others through good reasons and discovery of conclusions through the analysis of discourse.

Why do student need the reasoning skills? In a world with too much of information distributed, it becomes the responsibility of the individual to organize, discriminate and make good decision (Joetee, 2012). If the foundation is built in the school the students can develop and apply when they grow up.

According to Piagetian Theory, he describes the four stages of cognitive development. These stages of cognitive development are the continuous pattern although children may not be able to jump from one stage to another suddenly. These stages of cognitive development follow the stages as (1) sensory motor (0-2 years), preoperational (2-7 years), concrete operational (7-11 years), and formal operational (11-adult). Understanding occurs in concrete and formal operational level (Johnson, 1993). Students at the concrete operational stage are able to tackle problems in logical fashion, understand laws of conservation and reversibility, and are able to classify and differentiate. However, they cannot make non-observable or imaginary operations. Soylu, H (2006) cited report of Bigs and Collins (1982) that students who are identified at the concrete operational might have an inefficient working memory and have difficulty of multiple concepts simultaneously and they fail to recognize which concept is the best answer to the problem. Concrete operational students will often consider a problem to have a single correct solution and will have difficulty to identifying responses for open-ended questions that have multiple answers. In formal operational students have deep working memory so they are able to solve abstract

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problems in logical fashion, becomes more scientific in thinking such as testing the hypothesis and analyzing data and they can keep concepts and their interrelationships in their mind while considering answers. According to developmental theory, descriptive and theoretical concepts constructions are linked to intellectual development because the process depends on reasoning patterns and also reasoning ability relies on not only maturation but also individual self-regulatory mechanisms. Furthermore, students normally progress from concrete to abstract stage with increasing age, grade level, and practice. Students who have reached the formal stage can use logical operations (Bybee & Sund, 1990), which are important for science learning and achievement (Lawson, 1995; Piaget, 1964).

In psychology there are two categories of reasoning: inductive reasoning and deductive reasoning. In deductive reasoning, we derive a conclusion that is necessarily true if the premises are true. In inductive reasoning, we try to infer information by increasing the semantic content when proceeding from the premises to the conclusion. Popular psychological doctrine would have it that deduction, being analytical, is carried out by the left hemisphere, while induction, being synthetic, is a right hemispheric process, (Goel, V. and Waechter, R. L., 2012).

2.5.1 Inductive reasoning

It is reasoning from bottom-up. It starts from the specific premises and moves toward the general conclusion. In teaching inductive reasoning, it moves from examples to concept development. Inductive reasoning involves making predictions about situation based on the existing knowledge which is necessarily probabilistic. People use inductive reasoning in their daily life. For instance student supposes that, soap is slippery and bitter in taste; soap is a base/alkali; therefore, all bases/alkalis are slippery and bitter. Generally induction is involved in a range of cognitive activities such as categorization, probability judgment, analogical reasoning, scientific inference, and decision making. Inductive reasoning generalizes the knowledge from known to unknown. Therefore, it is creative in nature (Brett K. Hayes, Evan Heit, and Swendsen, H. 2010: 278). Since in inductive reasoning the conclusion is drawn from

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the observation of few specific instances, premises provide only a limited ground for accepting the general conclusion. Inductive reasoning, while commonly used in science, is not logically valid, because it is not strictly accurate to assume that a general principle is correct, (William Molnar, 2009: 1).

2.5.2 Deductive teaching

Deductive reasoning involves the claim that one or more propositions (the premises) provide some grounds for accepting another proposition (the conclusion). A key feature of deduction is that conclusions are contained within the premises and are logically independent of the content of the propositions. Deductive arguments can be evaluated for validity, a relationship between premises and conclusion involving the claim that the premises provide absolute grounds for accepting the conclusion (i.e. if the premises are true, then the conclusion must be true). (Goel, V, 2003). Deductive reasoning flow from general concept to specific rule and then applies this rule in variety of specific instances. Scientists use this type of reasoning when they test general laws and principles. For instance, all acids taste sour and turn blue litmus red; an orange is sour and turns blue litmus red; therefore, orange is an acid. As name implies, deductive reasoning is used by scientists to deduce the cause of the natural phenomenon.

One form of deductive reasoning is the law of detachment. This type of deductive reasoning follows this structure: A conditional (if) statement, followed by a hypothesis (then) and a conclusion (therefore). For an instance: All acids turn blue litmus red. Vinegar is an acid. Therefore, vinegar turns blue litmus red.

The researcher in this study incorporates the inductive and deductive reasoning process in the lesson plan in teaching chemistry unit “Acids, Bases and Salts”.

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2.6 Conclusion

For centuries, the pedagogical theories and principles have driven the success of the student learning. Researchers have found that science (chemistry) learning relies on personal growth, prior knowledge and experience, reasoning ability, and instruction. When it comes to instruction, the teacher's role can be the facilitator and guide the learning of the students. Therefore, teacher and students will be together until the students master the concepts and materials. Barletts (1932) quoted by Brenda Mergel (1998: 7) the pioneer of the constructivist claimed that "learners construct their own reality or at least interpret it based upon their perceptions of experiences, so an individual's knowledge is a function of one's prior experiences, mental structures, and beliefs that are used to interpret objects and events." 4MAT System interprets constructivist theories by incorporating the enacting principles. The 4MAT cycle begins from connecting the students' prior experiences, to analyzing the experiences, to imaging, to informing, to practicing, tinkering the material learned, to analyzing the usefulness and finally integrating the learned materials into the personal life. Besides, the 4MAT System incorporates the hemisphericity, which enables the students to utilize both sides of the brain, whole brain development. The 4MAT System approach brings the holistic development of the individual. Therefore, it provides the greater range to thinking and depth to understanding and encourages creative expression and problem solving which is the constructivist view of learning and purpose of 21st Century education.

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CHAPTER 3

RESEARCH METHODOLOGY

In this chapter, the researcher describes the research design, the subjects used for the study, experimental procedure, data collecting procedures, research instruments used for collecting the data, validity and reliability of the instruments and statistics used for analyzing data.

3.1 Research design

The purpose of this research was to study the effects of instruction using the 4MAT System on academic achievement and reasoning ability in Chemistry unit "Acids, Bases, and Salts" of the tenth grade students. The researcher used one group pretest posttest experimental design and incorporates both qualitative and quantitative method.

Pretest	Instruction using 4MAT System	Posttest
Y_b[4]	X[5]	Y_a[6]

Qualitative research analysis consisted of students' reflection and researcher's observation; while descriptive statistics; frequency, mean, standard deviation and inferential statistics, paired sample t-test were used to analyze the data. There were two dependent variables to be measured in this study; academic achievement and reasoning ability using instruction using the 4MAT System as independent variable. The difference if any, between the two measurements computed is ascribed to the manipulation of the independent variable.

[4] Dependent variables before manipulation
[5] Independent variable
[6] Dependent variables after manipulation

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3.2 Population, sample and subject

3.2.1 Population

The population of the research consisted of the students of the two higher secondary schools of Tsirang district in Bhutan. There were 141 students in Mendrelgang Middle Secondary School and 251 students in Damphu Higher Secondary School which together totaled up to 392 students.

3.2.2 Sample

The sample of the study consisted of the students of Mendrelgang Middle Secondary School where the study was carried out which comprised 141 students. The students were divided into four divisions (sections).

3.2.3 Subject

The researcher used the purposive sampling technique to select the subjects to participate in the study from the samples. Out of the four sections which were organized with a mixed ability by the school, the researcher selected section B as experimental group representing a normal classroom. There were 31 students in the section.

3.3 Data collection

3.3.1 Approval from concerned authority

Before carrying out the study in the presumed school the researcher obtained the approval from the Ministry of Education. The researcher also got the permission and approval from the school principal. Finally, the approval was obtained from the class teacher and the teacher teaching Chemistry in that particular class (Section B) of Mendrelgang Middle Secondary school.

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3.3.2 Anonymity of the participants and confidentiality of their views

Researcher ensured that anonymity and confidentiality of the participants were observed. The views and opinion shared by the participants were kept secret and confidential and were highly undisclosed to teachers and school authority.

3.4 Research instrument

The research instruments used in this research are of two types; experimental instrument and data collection instrument.

3.4.1 Experimental instrument

Experimental instrument consisted of the lesson plan prepared based on the format of the 4MAT System. The lesson objectives were formulated without diluting the curriculum objectives. It incorporated all domains of thinking levels (cognitive, psychomotor and affective). Five lesson plans were implement to teach Chemistry unit "Acids, Bases and Salts". The lesson encompassed the variety of instructional materials appropriate for the constructivist learning principles. The activities, exercises and assessment techniques and tools were used to monitor and assess the students' progress.

3.4.2 Data collection instrument

The pretest and posttest questions were used to collect the data during the study. The pretest and posttest constituted academic achievement questions and reasoning ability questions. The questions were prepared following Bloom's level of thinking. There were 30 achievement questions and 10 reasoning skill questions.

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3.5 Validity and reliability

"Two essential characteristics of the measurement instruments that must be considered in establishing the appropriateness and usefulness of measurement instruments are reliability and validity." Jurs and Wiersma, (2005: 324).

3.5.1 Validity

In this research, the test questions were validated by content experts from Rangsit University and Royal University of Bhutan (RUB).

Table 3.1 Experts who validated the instruments

Experts	Profession
Dr. Saput Moolsin	Chemistry Department, Faculty of Science. Rangsit University, Thailand
Kezang Choden,	Lecturer in Chemistry Education. Samtse College of Education, RUB
Punam Mongar	Lecturer in Chemistry. Sherubtse College, Kanglung, Trashigang, RUB.

3.5.2 Reliability

Reliability means "consistency of the instrument in measuring whatever it measures" Jurs and Wiersma, (2005: 324). To check the reliability of the data collecting instrument, test was conducted in another school and Kuder-Richardson (KR-20) coefficient computed. The result obtained; 0.971 for academic achievement and 0.708 for reasoning ability questions. The coefficient obtained revealed that the questions were reliable.

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3.6 Experimental procedures

To complete the experiment the following steps were carried out:

1) Orientating the subjects on the purpose of the experiment and briefing them about the 4MAT System.

2) A pretest was administered before beginning the experiment.

3) Then the researcher taught selected content in Chemistry using the 4MAT System.

4) At the end of the experiment, the posttest was administered.

5) The means of the pretest and posttest were compared to find the difference and significance value.

6) The students' reflections were collected at the end of every lesson. Researcher observed the learning behaviors of students at the end of each lesson.

3.7 Data analysis

3.7.1 Demographic data analysis

Demographic information of the subjects was analyzed using the frequency, and percentage.

3.7.2 Analysis of academic achievement and reasoning ability test scores

Academic achievement and reasoning ability test scores were analyzed to examine the effects of the instruction using the 4MAT System on students' academic scores in Chemistry unit "Acids, Bases, and Salts." The mean and standard deviation of pretest and posttest within an experimental group were computed. The value of the 2-tailed significance (p-value) < 0.05 was referred to determine the significant difference between the means of both the academic achievement test and reasoning ability test score.

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CHAPTER 4

RESULTS OF DATA ANALYSIS

This chapter presents the findings of the research study. The purpose of the research was to find the effect of the instruction using the 4MAT System on students' academic achievement and reasoning ability in chemistry unit "Acids, Bases and Salts" in one of the middle secondary schools in Bhutan. The researcher took 31 students that comprised one experimental group and taught chemistry lesson (Appendix VI) implementing the 4MAT System to find its effect in the academic achievement and reasoning ability. The data collected from the pretest and posttest of the achievement and reasoning ability were analyzed using mean, standard deviation and paired sample t-test. The 2-tailed significant value was compared to 0.05 for the significance of the results. The results of data analysis are presented as follows:

4.1 Demographic information of the subjects in the study

4.2 Analysis of scores of academic achievement test

4.3 Analysis of scores of reasoning ability test

4.1 Demographic information of the subjects in the study

This part of the questionnaire (Appendix IV, Part A) consisted of the personal information about the respondents which included gender and age.

There were 31 students as shown in the table 4.1 which consisted of 17 males (54%) and 14 females (46%) within the range of 16-20 years of age. There were 7 students of age 16 (3 males and 4 females), 8 students of age 17 (3 males and 5 females), 9 students of age 18 (6 males and 3 females), 6 students of age 19 (4 males and 2 females) and 1 student of age 20 (1 male).

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Table 4.1 Frequency and percentage of the students by age and gender

Group	Gender	Frequency (n)	Percentage (%)	Age				
				16	17	18	19	20
Experimental group	Male	17	54	3	3	6	4	1
	Female	14	46	4	5	3	2	0
	Total	31	100	7	8	9	6	1

4.2 Analysis of scores of academic achievement test

The primary objective of the study was to determine the effect of the instruction using the 4MAT System on students' academic achievement. By comparing the means of the pretest and posttest, the mean difference was found to be 6.00 as shown in the figure 4.1.

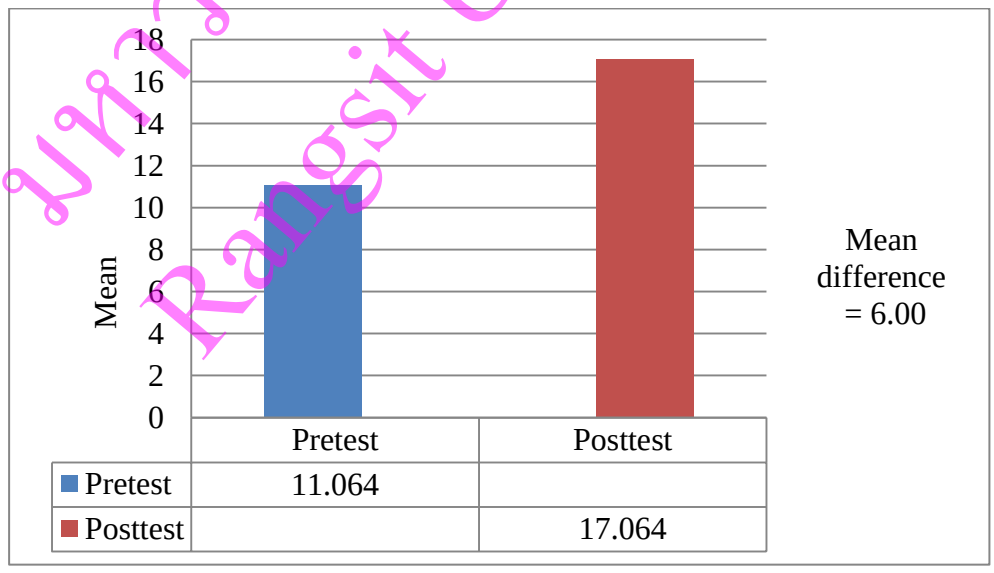

Figure 4.1 Comparison of pretest and posttest of achievement scores

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To determine the significance difference of the mean gain, dependent paired sample t-test was applied and the result showed that the difference was significant at 0.05 level as shown in the Table 4.2.

Table 4.2 Pre-posttest results of academic achievement

	Mean ($\bar{x}$)	Std. Deviation	Mean Difference	N	t-value	Df	Sig. (2-tailed)
Pretest	11.06	2.619	6.00	31	12.749	30	0.000*
Posttest	17.06	3.405					

* Significant Level < 0.05, Not Significant > 0.05

4.3 Analysis of score of reasoning ability test

The second objective of the study was to determine the effect of the instruction using the 4MAT System on students' reasoning ability. It was learned that the mean difference between means of the pretest and posttest of the reasoning ability test was 2.677 as shown in the figure 4.2.

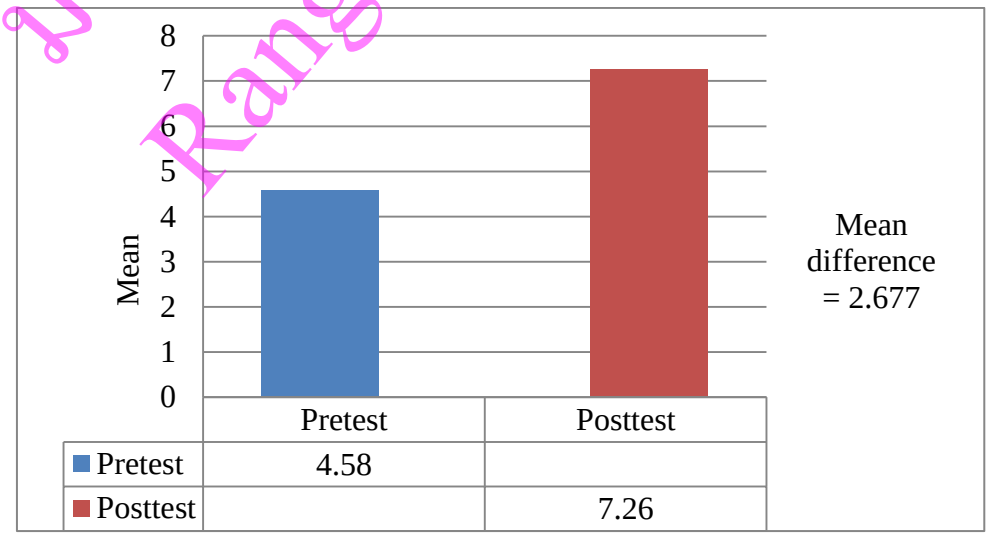

Figure 4.2 Comparison of pretest and posttest of reasoning scores

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Dependent paired sample t-test was applied to determine the significance difference of the mean gain, and the result showed that the difference was significant at 0.05 level as shown in the Table 4.3.

Table 4.3 Pre-posttest results of reasoning scores

	Mean ($\bar{x}$)	Std. Deviation	Mean Difference	N	t-value	Df	Sig.(2-tailed)
Pretest	4.58	1.522	2.677	31	9.706	30	0.000*
Posttest	7.26	0.964					

*Significant level < 0.05, not significant > 0.05

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CHAPTER 5

CONCLUSION AND DISCUSSION

This chapter presents the conclusion from the analysis of data and the discussion on the findings and recommendations for practice and future research.

5.1 Conclusion and discussion

The purpose of this research was to study the effects of instruction using the 4MAT System of Bernice McCarthy (1972) in teaching chemistry unit "Acids, Bases, and Salts" lesson (Appendix VI) to the tenth grade students in Bhutan. The research had two objectives;

1) To find out the effect of the instruction using the 4MAT System on students' academic achievement, and
2) To find out the improvement in reasoning ability of the subjects.

One group experimental design was carried out to determine the objectives with pretest and posttest before and after the treatment process. There were 31 students who participated in the study as subjects of the study. The research instruments used were lesson plan, achievement test and reasoning test. Descriptive statistics and paired sample t-test were computed to analyze and determine the significant levels of both the variables. Following conclusions were drawn from the findings from the analysis of the data.

5.1.1 Conclusion from academic achievement test

The result of the analysis of the test scores of academic achievement revealed that the mean of the posttest was comparatively higher than that of the mean

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of the pretest (Table 4.2). Paired sample t-test yielded $t_{(30)}$ value of 12.749 with 2-tailed significant level [p = 0.000 at 0.05)]. The result supported the hypothesis 1 which stated that there would be significant improvement in the academic achievement after the treatment procedure using the instruction using the 4MAT System. Therefore, it can be concluded that the 4MAT System was effective in teaching the academic achievement of the tenth grade students in Chemistry unit "Acids, Base, and Salts".

The result is consistent with the study by McCarthy and her Associate (Historical Perspective, 2002). It also supported the findings of Melton, (2009: 5) that 'all students can be successful' when taught around their learning styles. The result also corresponds to the study by Silva, (2009) that yielded the significant difference between the pretest and posttest mean scores of experimental group and control group. The finding is congruent to the result of the study carried out by Mert, (2012) that yielded the significance between the average grades of the experiment group in the pre and posttests in mathematics of seventh grade. The result of this study also sustained the study by Elci, Kilic and Alkan, (2012) with pre-service teachers who found that academic success was statistically significantly in the experimental group.

Several learning theories are in favor of the results from the findings. Firstly, the findings are grounded in constructivist theory which views learners as taking an active role in their own development, as goal-oriented agents who actively seek knowledge (Bliss, 1994), and who actively construct and reconstruct knowledge and understanding (Hodson, 1998). Dewey's (1933) belief of child-centered education in which emphasis was given on student engagement and activity is prevalent and led to the improvement in learning achievement. Vygotsky's theory of proximal development as supports the findings which states that children learn through joint interaction with teacher and peers that are more capable and move towards independence of learners in acquiring knowledge as in the 4MAT System.

The success in learning achievement is supported by 'research on the effects of right and left mode instruction which indicates that students differ with

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regard to hemispheric dominance, and that these differences influence student retention and performance' (Historical Perspective, 2002).

5.1.2 Conclusion from the analysis of reasoning ability test

The result of the analysis of the reasoning ability showed (Table 4.3) that there was increase in the mean scores of the posttest when compared to the mean scores of the pretest. The paired sample t-test values indicated significant with significant level of [$t_{(30)} = 9.706$] and [$p = 0.000$ at < 0.05)]. The result is favoring the hypothesis 2 which stated that there will be improvement in the reasoning ability at the end of the treatment procedure using instruction using the 4MAT System. It is obvious from the t-test value that 4MAT System was effective in improving the reasoning ability in "Acids, Bases, and Salts" unit of Chemistry of the tenth grade students.

Reasoning ability of the learners is supported by Carl Jung's theory of Personality Type which is described by the second function of the variation of behaviors that thinking which refers to logical decision making process, tell what something is. It is in line with Piaget's cognitive development theory. All the subjects in the study show (Table 4.1) that they have already crossed the concrete operational (7-11) and formal operational (11-above) stages (Johnson, 1993). The result is also supported by Kolb's Theory of Experiential Learning that states individuals attain higher levels of cognitive complexity through the integration of preferred and less preferred modes of adapting their personal circumstances (McCarthy, Germain, and Lippitt, 2002: 1.4).

Research on the effects of right and left mode instruction indicates that students differ with regard to hemispheric dominance, and these differences influence student retention and performance. The 4MAT System seems to have presented the right kind of environment by allowing the use of both side of the brain although student hardly felt of it which favoured the reasoning ability.

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5.1.3 Students' reflection

It is clear from the students' reflection in general that the lessons were very active and productive. They enjoyed learning by doing as the lesson recommended because the 4MAT gives the hand-in-experience of learning by engaging the learners in diverse learning sets where learners need to form and test the understanding of the new knowledge**.** The students also pointed out that the lesson incorporated both theory and practical in appropriate proportion. The instruction supplemented with varieties of activities and assessment. However, the students were bit reluctant initially to proceed with practical experiment as they were not used to with it. The reason they pointed out was that Chemistry deals with the chemicals both harmful and benign. They feared of the handling of the possible chemicals and experimental accidents. Some of the students even go to the extent to mention that learning by doing improved their retention power.

The students also had the complaints of the lesson taught. In the beginning they suggested that the lesson was very slow. However, the pace of the lesson had to be in accordance to the ability of the students in general pointed out by McCarthy (1990: 31) that "4MAT capitalizes on individual learning styles." The instructor began the instruction in slow pace to understand the learning ability of the learner and meet the learning pace. One of the advantages of 4MAT System as emerged from the students' reflection is that they learn to cooperate with each other. This is what Lindsey, B., (1997) found that the 4MAT System provided the teachers and designers of the instruction with balanced vehicle for addressing cooperative learning strategies throughout a complete lesson plan. Students also complained of instructor being lenient and students taking advantage. But it is in line with 4MAT principles that learners must be comfortable during learning. This is indicative that instructor should manage the classroom decorum and discipline such that learners are just comfortable during learning and not violate the discipline.

In summary students seems to have preferred the teaching through 4MAT System. They seem to be satisfied with learning and motivated with such type

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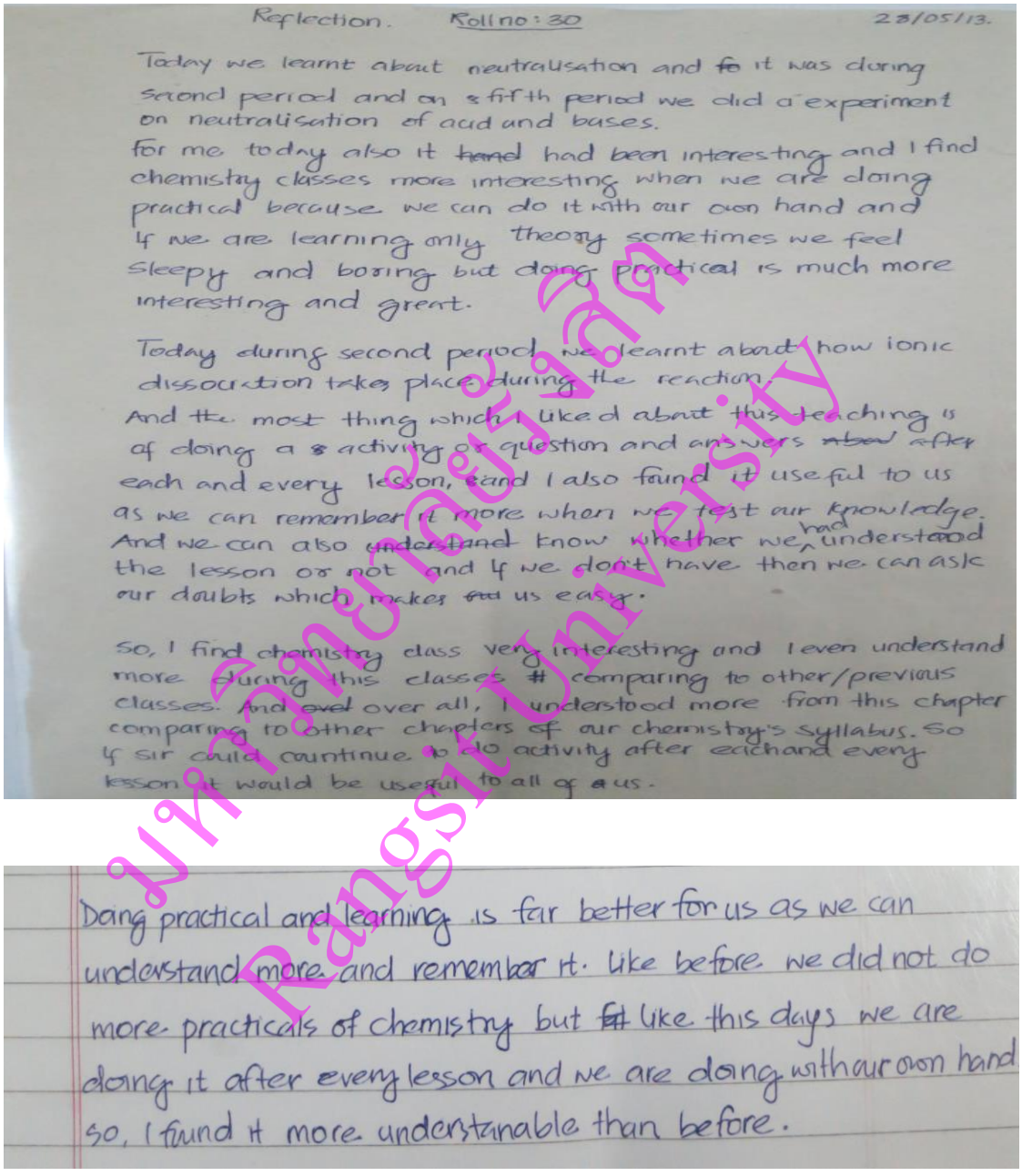
of learning strategy. This indicates that a change in teaching-learning strategy can enhance learning process. This is indicative from the students' reflection below:



Reflection. Roll no: 30 23/05/13.

Today we learnt about neutralisation and ~~fo~~ it was during second period and on fifth period we did a experiment on neutralisation of acid and bases.
for me today also it ~~hamd~~ had been interesting and I find chemistry classes more interesting when we are doing practical because we can do it with our own hand and if we are learning only theory sometimes we feel sleepy and boring but doing practical is much more interesting and great.

Today during second period we learnt about how ionic dissociation takes place during the reaction.
And the most thing which I liked about this teaching is of doing a activity or question and answers ~~nbew~~ after each and every lesson, and I also found it useful to us as we can remember it more when we test our knowledge. And we can also understand know whether we had understood the lesson or not and if we don't have then we can ask our doubts which makes ~~fod~~ us easy.

So, I find chemistry class very interesting and I even understand more during this classes # comparing to other/previous classes. And ~~evel~~ over all, I understood more from this chapter comparing to other chapters of our chemistry's syllabus. So if sir could countinue to do activity after eachand every lesson it would be useful to all of ~~a~~ us.

Doing practical and learning is far better for us as we can understand more and remember it. like before we did not do more practicals of chemistry but ~~fit~~ like this days we are doing it after every lesson and we are doing with our own hand so, I found it more understanable than before.

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Figure 5.1 Statement of students' reflection

5.1.4 Reflective observation by researcher

On the very first day, researcher met the students in their class and exchanged the warm greeting. Students were briefed on the purpose of the experiment the researcher was going to carry out. Researcher also introduced them the 4MAT System and how this System helps in learning process. After the lengthy presentation a pretest was administered to the class. Since the time for test was lengthy, the lesson began the next day.

On the second day the experimenting began. The students were busy with themselves. The teaching-learning became a hurdle as students were reluctant to participate and stared at each other when asked to form groups. It seemed the 4MAT System demanded them more than what they used to do before. Moreover, 4MAT required the students to be active, constructive and reflective than traditional method where students received the knowledge with seldom activity. Throughout the experiment the students were asked to work in group and they formed into groups of 5 in order to build the cooperation among themselves to carry out the task assigned. In the beginning the students used to do the task assigned individually although they were grouped. However, they slowly learned to work in group which is reflected as "We all gave cooperation to fulfill our experiment." Lesson learned from the study were as following;

1) Time

The students came across the difficulty in completing the tasks which were assigned both in the class and home task. This could be because the 4MAT System necessitated the students to be creative, constructive and think on their own. The period assigned was insufficient to complete a lesson. Therefore, the students had to be kept overtime to complete the lesson. Most of the times, the lesson had to be carried over to next day or next period to complete.

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2) Lesson plan

Every lesson started with connecting the student's prior knowledge. Students were allowed to recollect and discuss their experiences in group and present the experience to start with the new lesson. Teacher also distributed the worksheet that demanded the recollection of the knowledge in their lower classes. Instructor incorporated the purpose of learning in every lesson so that students were hooked on what they were going to accomplish at the end of the lesson and how each lesson was related to life. Instructor considered the learning style of each student as a result small group were formed which is evident in the lesson plan. Discussion and presentation of the task were the main features whereby the students build confidence and presentation skills. The information was well researched to be imparted to the students. The lesson used varieties of materials, demonstrations, videos, images and exercise and assessment tools like worksheets and rubrics. However, the instructor could not use the expertise from outside during the research study as teachers were engaged with their daily schedule and another reason being the school located in the rural area.

3) Feedback

Timely correction of students' task and feedback became the part of the formative assessment which helped the students to make the instant correction. However, the progress of the reasoning ability of the students was not able to be recorded. The project work assigned challenged the students to search and research from various source to authenticate originality and validate their learning. Resource constraint in the school library stumble their progress. Internet facilities were available but their inability of searching skills hindered their progress. The learning could only be shared among the same class through presentation by different groups by the their nominated presenter and regret of not being able to share elaborately outside the class due to time constraint as completing the lesson itself was a hurdle to the students as well as to instructor.

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4) Classroom management

The classroom management was an issue. McCarthy's 4MAT considers how comfortably individual learn thing by his/her learning style. Considering this view, the researcher tried to omit the actions and behaviors of the learners, some of whom tried to disobey the learning management decorum of the class. It was obvious from the observation and feedback from some of the students as mentioned "…was lenient and student trying to take advantage". However, with time the learner learned to cooperate and appreciate each other and their views which are apparent from their statement "we all gave cooperation to fulfill our experiment and you also help in between." It is obvious that teacher must prepare lesson plan that keeps students engaged and prevent the outward behavior in the classroom.

Nevertheless, students seem to be satisfied with what they could accomplish and achieved from learning through the 4MAT System which is evident from their reflection. Implementation proved to be challenging but not impossible which motivated students where real learning could take place. If students are challenged with and guided properly there is potential in students to learn things in new ways. New strategy can be the tools to dig their potential and ability. Learning lie- in how instruction is prepared. 4MAT System seems to be appropriate to instill the habit of learning.

5.2 Recommendations

Although teacher centered is the preferred teaching-learning methods in Bhutan, it is time that teaching-learning process needs a change in order to democratize the learning. The 4MAT System of instruction supports the child centered learning type and also many features of the 4MAT System support the principles of educating for Gross National Happiness. The results of the study showed that the 4MAT System of instruction was effective in teaching-learning of "Acids, bases and Salts" in Chemistry. Therefore, instruction using the 4MAT System can be practiced and be tried in the various subjects by the teachers in Bhutanese context.

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5.2.1 Recommendation for practice

1) The 4MAT System takes into accounts the learning styles of the students. Students have different learning styles. If the learning activities and exercises are prepared using the 4MAT System there can be same learning outcomes.

2) The instructor could use the time series record to monitor the progress of the reasoning ability of the learners. This can help the teacher to see the steady improvement or stifle of students' reasoning ability.

5.2.2 Recommendation for future research

The principles of the 4MAT System support the science learning process, further research could be pursued in followings;

1) Since the instruction using the 4MAT System is based on the principles of constructivism and brain hemisphericity, the curriculum and instructional designer can use the 4MAT System in designing the instructional materials and learning activities.

2) Since the instruction using the 4MAT System provides the teachers and designers of the instruction with balanced vehicle for addressing cooperative learning strategies throughout a lesson plan, further researcher can investigate the effect of instruction using the 4MAT System in the cooperative learning strategies.

มหาวิทยาลัยรังสิต Rangsit University

REFERENCES

"4MAT Model's Impact on the Learning Styles, Success and Attitudes Towards Mathematics". *Journal of education and instructional studies in the world.* 2011 Volume: 2 Article: 15 ISSN: 2146-7463. [Online] Available at: http://www.wjeis.org, 4 January 2013.

Arnol, N, Baker, L, Bratt, T, Fagan, B, and Hainer, E. V. "Integrating Learning Styles and Skills In the ESL Classroom: An Approach to Lesson Planning." *NCBE Program Information Guide Series, Number* 2, 1999. [Online] available at: http://goo.gl/UEq1vM, 2 January 2013.

Bliss, J. "Children learning science." In B. Jennison and J. Ogborn (Eds.). *Wonder and Delight: Essays in science education in honor of the life and works of Eric Rogers 1902-1990.* London: Inst. Of Physics Publishing. 1994.

Bybee, R. W. *Learning Science and the Science of Learning*. National Science Teachers Association. David Beacom publisher. Arlington, Virginia. 2002.

Chalfen, K., Hetland, L., and Veenema, S. (eds.) "Multiple Intelligences: The Research Perspective." The Project Zero Classroom: Approaches to Thinking and Understanding. Harvard Graduate School of Education and Project Zero.1997 [Online] Available at: http://goo.gl/Ifjeem, 8 February 2013.

Colon, M., and Morris, W. R. "Is it Worth the Time and Effort? Teacher's Perceptions of 4MAT in the Southern Union." School of Education and Psychology, Southern Adventist University. 2009. [Online] Available at: http://goo.gl/hgOrVH, 01 December 2012.

Coll, R. K., and Neil Taylor, T. G. "Using Constructivism to Inform Tertiary Chemistry Pedagogy" *Chemistry education: research and practice* 2001, Vol. 2, No. 3, pp. 215-226. [Online] Available at: http://goo.gl/kFv5Yf, 27 January 2013.

Craven, S. E. "4MAT: Applying a Learning Style System to create Interesting and Innovative Presentations." Master's Thesis, Faculty of Education. University of Lethbridge. 2000. [Online] Available at: http://goo.gl/UFrfHo, 3 November 2012.

มหาวิทยาลัยรังสิต Rangsit University

REFERENCES

"4MAT Model's Impact on the Learning Styles, Success and Attitudes Towards Mathematics". *Journal of education and instructional studies in the world.* 2011 Volume: 2 Article: 15 ISSN: 2146-7463. [Online] Available at: http://www.wjeis.org, 4 January 2013.

Arnol, N, Baker, L, Bratt, T, Fagan, B, and Hainer, E. V. "Integrating Learning Styles and Skills In the ESL Classroom: An Approach to Lesson Planning." *NCBE Program Information Guide Series, Number* 2, 1999. [Online] available at: http://goo.gl/UEq1vM, 2 January 2013.

Bliss, J. "Children learning science." In B. Jennison and J. Ogborn (Eds.). *Wonder and Delight: Essays in science education in honor of the life and works of Eric Rogers 1902-1990.* London: Inst. Of Physics Publishing. 1994.

Bybee, R. W. *Learning Science and the Science of Learning*. National Science Teachers Association. David Beacom publisher. Arlington, Virginia. 2002.

Chalfen, K., Hetland, L., and Veenema, S. (eds.) "Multiple Intelligences: The Research Perspective." The Project Zero Classroom: Approaches to Thinking and Understanding. Harvard Graduate School of Education and Project Zero.1997 [Online] Available at: http://goo.gl/Ifjeem, 8 February 2013.

Colon, M., and Morris, W. R. "Is it Worth the Time and Effort? Teacher's Perceptions of 4MAT in the Southern Union." School of Education and Psychology, Southern Adventist University. 2009. [Online] Available at: http://goo.gl/hgOrVH, 01 December 2012.

Coll, R. K., and Neil Taylor, T. G. "Using Constructivism to Inform Tertiary Chemistry Pedagogy" *Chemistry education: research and practice* 2001, Vol. 2, No. 3, pp. 215-226. [Online] Available at: http://goo.gl/kFv5Yf, 27 January 2013.

Craven, S. E. "4MAT: Applying a Learning Style System to create Interesting and Innovative Presentations." Master's Thesis, Faculty of Education. University of Lethbridge. 2000. [Online] Available at: http://goo.gl/UFrfHo, 3 November 2012.

มหาวิทยาลัยรังสิต Rangsit University

REFERENCES (CONT.)

Davis, K., Christodoulou, J., Seider, S., and Gardner, H. "The Theory of Multiple Intelligences." 2012 [Online] Available at: http://goo.gl/T4vvFx, 8 February 2013.

Demircloglu, H, and Norman, N. "Effects of Some Variables on Chemistry Achievement and Chemistry, related Attitudes of High School Students." 1999. [Online] Available at: http://goo.gl/awDgBM, 17 January 2013.

Dikkartin Ovez, F. T. "The Effect of the 4MAT Model on Student's Algebra Achievements and Level of Reaching Attainment." Education Faculty of Necatibey Elementary Mathematics Education Department, Balıkesir University. Int. J. Contemp. *Math. Sciences*, Vol. 7, 2012, no.45, 2197-2205. 2012. [Online] Available at: http://goo.gl/SdfmEr, 19 December 2012.

Dorn, R.I. "Washington State K-12 Science Learning Standards." 2010. [Online] Available at: http://goo.gl/qzldMJ, 13 December 2012.

Driskill, W. C. "Effectiveness of the 4MAT Instructional Design on Personal and Cognitive Attitude of Student." Dissertation. Faculty of Graduate School of The University of Texas, Austin. 1998.

Duman, B. *The Effects of Brain-Based Learning on the Academic Achievement of Students with Different Learning Styles.* 2010. [Online] Available at: http://goo.gl/hSdy6w, 25 November 2012.

Dunn, S. G. *Philosophical Foundation of Education: Connecting Philosophy to Theory and Practice*. New Jersey: Thistle Hill Publishing Services, LLC. 2005.

Elci, A. N, Kilic, D. S and Alkan, H. "4MAT Model's Impact on the Learning Styles, Success and Attitudes towards Mathematics." *Journal of Education and Instructional Studies in the World.* 2012. Volume: 2 Issue: 3 Article: 15 [Online] Available at: http://goo.gl/OgVD4T, 07 December 2012.

"Experiential learning and Kolb's learning cycle." Publisher; Zein, A. August 7, 2009. [Online] Available at: http://goo.gl/QAEwt6, 21 January 2013.

Gardner, H. "Howard Gardner's Theory of Multiple Intelligence." 1983. [Online] Available at: http://goo.gl/iMiWln, 9 February 2013.

มหาวิทยาลัยรังสิต Rangsit University

REFERENCES (CONT.)

Germain, C. S., Lippitt, L., & McCarthy, B. "The 4MAT ® Research Guide. Reviews of Literature on Individual Differences and Hemispheric Specialization and their Influence on Learning." 2002. [Online] Available at: http://goo.gl/ijZILX, 19 December, 2012.

Hodson, D. *Teaching and learning science: A personalized approach.* Buckingham, Philadelphia: Open University Press. 1998.

Hofstein, A., & Mamlok-Naaman, R. "High-School Students' Attitudes toward and Interest in Learning Chemistry: *International year of Chemistry* (*attitude toward chemistry)*." 2011 [Online] Available at: http://goo.gl/oFA96k, 16 January 2013.

"Human Resource Development – Master Plan (2002-2012) of the Education Department." Ministry of Education, Bhutan. 2002. [Online] Online available at: http://goo.gl/3Oz3NE, 20 August 2013.

Jackson, P. R. "The Effect of Teaching Methods and 4MAT Learning Styles on Community College Students' Achievement, Attitudes, and Retention in Introductory Microbiology." Dissertation. College of Education, Health, and Human Services. Lynn University. 2001.

Joan, M., Nicoll-Senft, and Susan, N. S. Assessing the Impact of the 4MAT Teaching Model across Multiple Disciplines in Higher Education. Routledge, Taylor & Francis Group, LLC. Central Connecticut State University. 2010.

Joetee, K. "Reasoning skills, problem solving ability and academic ability: implications for study programme and career choice in the context of higher education in Thailand." Doctoral Theses, School of Education, Durham University. 2012.

Johnson, D., Childs, A., Ramachandran, K., and Tenzin, W. A., "Needs Assessment of Science Education in Bhutan." UNESCO. 2008. [Online] Available at: http://goo.gl/bNWQx2, 20 January 2013.

Johnson, M. A., and Lawson, A.E. What are the relative effects of reasoning ability and prior knowledge on biology achievement in expository and inquiry classes. *Journal of Research in Science Education, Volume: 35, Issue 1, 89-*

มหาวิทยาลัยรังสิต Rangsit University

REFERENCES (CONT.)

103. 1999.

Jurs, S. G., and Wiersma, W. *Research Methods in Education: An Introduction*. 8th Edition. Pearson Education, Inc. United State. 2005.

Kolb, D., Boyatzis, R. E., and Mainemelis, C. "Experiential Learning Theory: Previous Research and New Directions." Case Western Reserve University. 1999. [Online] Available at: http://goo.gl/TdI8t, 15 January 2013.

Lindsey, B. "Cooperative Learning: Better with 4MAT." A Position Paper of About Learning, Incorporated. 1997.

McCarthy, B. "4MAT" 2007. [Online] Available at: http://goo.gl/Lpf0Qk, 10 February 2013.

McCarthy, B., & McCarthy, D. *Teaching around the 4MAT cycle: Designing instruction for diverse learners with diverse learning styles*. Thousand Oaks, CA: Corwin Press. 2006.

McCarthy, B. *About Teaching 4MAT in the Classroom.* First Edition. Publisher About Learning, Inc. 2000.

McCarthy, B. "A Tale of Four Learners: 4MAT's Learning Styles." *How Children Learn.* Volume 54 Number 6 *Pages* 46-51. 1997. [Online] Available at: http://goo.gl/fZPoA0, 19 February 2013.

McCarthy, B. "Using the 4MAT System to Bring Learning Styles to Schools." 1990. [Online] Available at: http://goo.gl/9XALyR, 23 November 2012.

McLeod, S. "Simply Psychology." Published (2008) updated (2012). [Online] Available at: http://www.simplypsychology.org/bruner.html, 3 March 2013.

Melton, R. "Teaching to All Learners." 2008. [Online] Available at: http://goo.gl/7LDxpJ, 26 February 2013.

Melton, R., and Sowders, J. "The Effectiveness of 4MAT lesson Design in addressing the needs of at-risk Elementary School Students." 2009. [Online] Available at: http://goo.gl/c9m58o, 1 December 2012.

Mergel, B. "Instructional Design & Learning Theory." 1998. [Online] Available at: http://goo.gl/RL05s8, 24 March 2013.

Mert, U. S. "The Effectiveness of the 4MAT Teaching Model upon Student

มหาวิทยาลัยรังสิต Rangsit University

REFERENCES (CONT.)

Achievement and Attitude levels." *International Journal of Research Studies in Education Volume* 1 *Number* 2, 43-53. Balikesir University. 2012. [Online] Available at: http://goo.gl/HVWFe8, 10 February 2013.

"Sherig Matters, 30th Education Policy Guidelines and Instructions EPGI 2012." Published by; Policy and Planning Division. 2012. [Online] Available at: http://goo.gl/azbz7O, 10 December, 2012.

"Inductive and Deductive Reasoning." Published by; Molnar, W. Updated on: May 16, 2009. [Online] Available at: http://goo.gl/3gAfUA, 12 April 2013.

Monk, M. and Osborne J. *Good Practice in Science Teaching*. USA. Philadelphia. 2000.

Musa, A. and Wood, B. "Online Learning and Learning Styles." Education in a Changing Environment: Conference Proceedings. 2003. [Online] Available at: http://www.ece.salford.ac.uk/proceedings/2003, 12 February 2013.

Neill, J. "500 Word Summary of Dewey's "Experience and Education." Updated; 1st Oct, 2005. [Online] Available at: http://goo.gl/lA7R0u, 12 January 2013.

Nicoll-Senft, J. M., and Seider, S. N. "Assessing the Impact of the 4MAT Teaching Model across Multiple Disciplines in Higher Education." *College Teaching*, 58: 19–27. Routledge, Taylor & Francis Group, LLC. 2010. [Online] Available at: http://goo.gl/YtU1Ug, 21 December, 2012.

Nowacki, A. S. "Using the 4MAT Framework to Design a Problem-based Learning." *Journal of Statistics Education Volume 19, Number* 3, 2011. [Online] Available at: http://goo.gl/i5Hw0W, 25 December 2012.

Powell, K. C., and Kalina, C. J. "Cognitive and Social Constructivism: Developing Tools for an Effective Classroom." *Education Vol. 130 No.2.* 2009 [Online] Available at: http://goo.gl/tgrkwm, 3 March 2013.

Pratoomtong, W. "A Development of Science Learning Activities Based on 4MAT System and Learning Styles to Promote Multiple intelligences of Sixth Grade Students." Dissertation, Ed.D. (Science Education). Srinakharinwirot University. 2011. [Online] Available at: http://goo.gl/7KU5fq, 19 December 2012.

มหาวิทยาลัยรังสิต Rangsit University

REFERENCES (CONT.)

Ornstein, A. C. *Strategies for Effective Teaching*. Second Edition. USA: Brown & Benchmark Publishers. 1995.

Rabgay, T. "The Effective of Cooperative Learning Method on Learning Achievement and Opinion of the Seventh Grade Students Towards Science Subject, Bhutan." Master's Thesis in Curriculum and Instruction. Faculty of Education. Graduate School, Rangsit University, 2012.

Rhine, R. J. A Concept from Approach to Attitude Acquisition. *Psychological review*, 65, (1958): 362-370.

Saleh, I. M and Khine, M. S. Attitude Research in Science Education: *Classical and Contemporary Measurement*. Publisher, IAP. 2011.

Santrock, J. W. *Educational Psychology*. Fifth Edition. New York, America: McGraw Hill Company. 2011.

Santrock, J. W. *Educational Psychology: Classroom Update: Preparing for PRAXIS^{MT} and Practice*. Second Edition. New York: McGraw Hill Company. 2006.

Schummer, J. "The Philosophy of Chemistry." *Philosophies of the Sciences, Blackwell-Wiley*, pp. 163-183. 2010. [Online] Available at: http://goo.gl/o6R7Yz, 14 February 2013.

"Science Curriculum Framework: Class PP-XII." Published by: Department of Curriculum and Development. Ministry of Education. Royal Government of Bhutan. 2011 [Online] Available at: http://www.curriculum.bt, 12 December 2012.

"Science Framework for California Public Schools Kindergarten through Grade Twelve with New Criteria for Instructional Materials." Published by: California Department of Education. 2004. [Online] Available at: http://goo.gl/dXA0e, 13 December 2012.

Silva, D. L. "4MAT Teaching Cycle: Brain-Based Approach to Teaching." *Philippine Association for Technological Education. Philippine Journal of Engineering Education. Vol. III No.1* August 2009. [Online] Available at: http://goo.gl/Ekxb9u, 21 December 2012.

มหาวิทยาลัยรังสิต Rangsit University

REFERENCES (CONT.)

Slavin, R. E. *Educational Psychology: Theory and Practice*. Seventh Edition. United State of America: Pearson Education. 2003.

Sousa, D. A. *How the Brain Learns*. Fourth edition. U. S. A. Publisher: Corwin.. 2011.

Soylu, H. "The Effectiveness of gender and Reasoning Ability on the Students' Understanding of ecological Concepts and Attitude towards Science." Master's Thesis in Secondary School Science and Mathematics Education. Graduate School of Natural and Applied Science. Middle East Technical University, 2006.

Staver, J. R. "Teaching science." *Educational Practices Series –17*. 2007. [Online] Available at: http://goo.gl/9cyW5E, 25 February 2013.

Trevino, P. "Multiple Intelligence Theory as a Tool for Improving Student Achievement." [Online] Available at: http://goo.gl/nPSLHu, 8 February 2013

"UN Newsletter Bhutan." Vol: I, Issue 1 October, 2008. [Online] Available at: http://goo.gl/lrfACq, 20 January 2013.

Wangchuk, K. "Factor Affecting the Learning of Science in Lower Secondary Schools in Eastern and Western Bhutan." Master's Thesis of Education in curriculum and Instruction. Faculty of Education. Graduate School, Rangsit University, 2011.

Waterhouse, S. *The Power of eLearning: The Essential Guide for Teaching in the Digital Age*. United State of America. Pearson Education, Inc. 2005.

Westwood, P. *Learning and Learning Difficulties: A Handbook for teachers.* University of Hong Kong. 2004.

Wikipedia. "System thinking." [Online] Available at: http://en.wikipedia.org/wiki/Systems_thinking, 13 February 2013.

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APPENDICES

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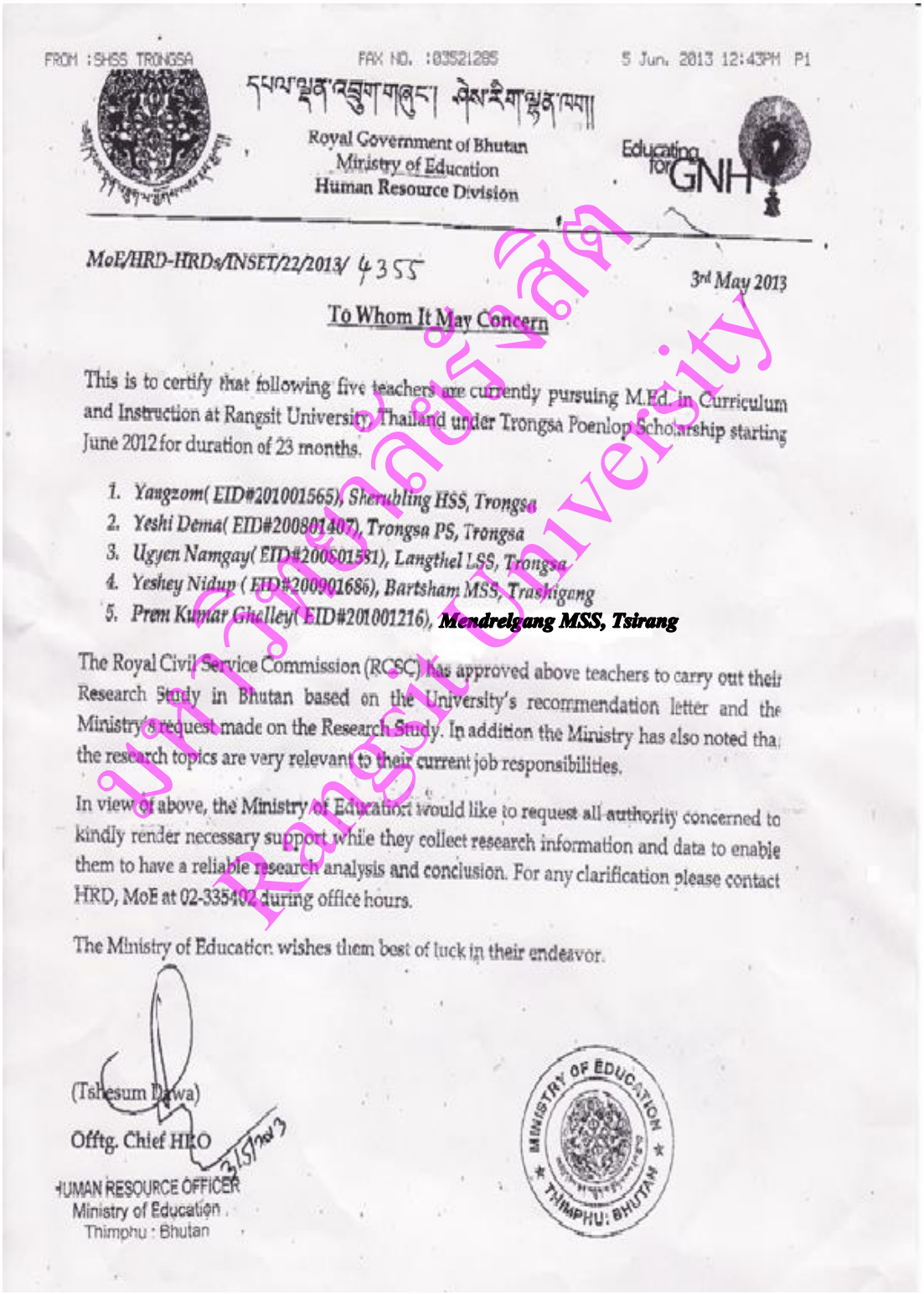
Appendix I:

Approval letter from Ministry of Education



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

རྒྱལ་ཡོངས་འབྲུག་གཞུང་། ཚེས་རིག་ལྷན་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),* ***Mendrelgang MSS, Tsirang***

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
3/5/2013
HUMAN RESOURCE OFFICER
Ministry of Education
Thimphu : Bhutan

MINISTRY OF EDUCATION * THIMPHU: BHUTAN *

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Appendix II:

IOC of achievement test items

Question No:	Expert 1	Expert 2	Expert 3	IOC
1	1	1	1	1
2	1	0	1	0.66
3	0	0.5	1	0.5
4	1	0.5	0	0.5
5	1	1	0	0.66
6	1	1	1	1
7	1	0.5	1	0.83
8	0	1	1	0.66
9	1	1	1	1
10	1	1	0	0.66
11	1	1	0	0.66
12	1	1	1	1
13	0	1	1	0.66
14	1	1	1	1
15	0	0.5	1	0.5
16	0	1	1	0.66
17	1	1	1	1
18	0	0.5	1	0.5
19	0	1	1	0.66
20	1	1	0	0.66
21	1	1	1	1
22	1	0.5	0	0.5
23	1	1	0	0.66
24	1	0.5	0	0.5
25	0	1	1	0.66
26	1	0.5	1	0.83

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27	0	1	1	0.66
28	1	1	1	1
29	1	1	1	1
30	1	1	0	0.66
IOC =				0.5 – 1.0

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Appendix III:

IOC of reasoning test items

Question No:	Expert 1	Expert 2	Expert 3	IOC
1	1	1	1	1
2	1	1	1	1
3	1	0.5	1	0.83
4	1	0.5	1	0.83
5	1	0	0.5	0.5
6	1	1	1	1.0
7	1	0	1	0.66
8	1	1	1	1.0
9	1	0	1	0.66
10	1	1	1	1
IOC =				0.5 – 1.0

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Appendix IV:

Pretest-posttest questions

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

Instructions: This questionnaire consists of 2 sections:

Part A: Personal information of respondent

Part B: Students' conceptual test in the unit, Acids, Bases and Salts

Part C: Reasoning ability questions in the unit, Acids, Bases and Salts.

Part A: Personal Information

Select/cross ☒for the appropriate answer of your choice in the given box

Gender:

☐ Male ☐ Female

Age: _____Years Grade (in figure) _____

Question	Levels thinking
1. Red litmus paper does not change color in an unknown substance. The unknown substance is ☐ acid ☐ neutral ☐ base ☐ impossible to tell	Remember
2. Ordinary precipitation tends to be slightly acidic; it ranges from a pH of about 5.6 to a pH of about 5.0. An environmentalist collected sample of rain water for analysis. He tested the water and found that pH of the water is 4.9. The pH indicates ☐ the atmosphere is normal. ☐ the atmosphere is polluted with gases. ☐ that atmosphere have more dust particles in air.	Understand

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	☐ that atmosphere contains more clouds	
3.	A solution has a pH 7. The pH of the solution can be decreased by ☐ adding water ☐ adding acid ☐ adding base ☐ adding both acid and base	Apply
4.	In an accident at factory, some nitric acid was spilt. Which substance, when added in excess, neutralizes the acid without leaving an alkaline solution? ☐ Aqueous ammonia ☐ Aqueous sodium hydroxide ☐ Calcium carbonate ☐ Water	Analyze
5.	A patient suffering from gastritis is given antacid tablets. The types of the reaction that takes place in the stomach is ☐ decomposition ☐ neutralization ☐ displacement ☐ precipitation	Evaluate

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Appendix V:

Pretest and posttest scores of achievement and reasoning ability

	Learning Achievement		Reasoning Ability	
Student Identity Number	Pretest	Posttest	Pretest	Posttest
01	8	15	3	6
02	9	19	3	7
03	9	12	4	6
04	10	14	2	7
05	10	14	5	9
06	11	15	4	6
07	14	20	3	7
08	12	18	6	6
09	12	13	3	7
10	14	24	6	8
11	15	23	6	8
12	11	14	6	8
13	8	14	4	7
14	8	14	3	7
15	10	15	4	8
16	11	23	8	7
17	16	19	5	9
18	14	15	3	7
19	11	17	4	6
20	8	14	6	7
21	8	17	7	9
22	13	20	3	9
23	14	22	5	6
24	9	14	5	7

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25	6	14	6	8
26	13	20	2	7
27	11	20	5	8
28	11	14	5	7
29	8	16	6	8
30	14	20	5	6
31	15	20	4	7

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Appendix VI:

Lesson plan

A. General Information

1. Learning unit: Acids, Bases and Salts Subject: Chemistry Grade Level:10
2. Topic: Acids and Bases Time: 120 Minutes
3. Teaching and learning materials:

B. Content

Acids are substances that can change blue litmus red.

Bases are substances that turn red litmus blue.

C. Learning Objectives

1. Define acids and bases.
2. Identify the physical properties of acids and bases.
3. Check the urine and identify whether it is acid or base.
4. Survey, test and identify the acidity and alkalinity of soil samples of their school campus (different location).

D. Prior knowledge:

Acids are sour in taste and Bases are bitter.

E. Assessment Techniques

F. Learning Activities

Activity 1: To categorize substances into acids, and bases using litmus paper test.

Activity 2: Investigate the acidity or alkalinity of the soil from different places in the school using the litmus paper.

Essential question: How do students know the substances are acids, bases or neutral?

Quadrant 1	Teacher/student activity	Instructional materials	Assessment Techniques
Step 1: Connect or create an	Provide substances which consist of acids and bases and litmus paper. Students in	Substances consisting acids and bases and litmus	Observation

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experience (Right Mode)	group will use the litmus paper to test the substances.	paper	
Step 2: Examine/Attend or Reflective on the Experience (Left Mode)	Teacher asks the students to categorize the substances after the test. Students will categorize the substances as acids and bases. Activity 1.	Notebooks, pen	Check the student's activity sheet
Quadrant 2			
Step 3: Image or integrate the observation into Concepts (Right Mode)	Present a video, title: properties of acids and bases. Students will listen, watch and write the properties of acids and bases.	Video with title: properties of acids and bases Source: http://youtu.be/xeGXJplg_TE Projector,	Lists the properties and explain the properties of acids and bases.
Step 4: Inform or Develop Theories and Concepts (Left Mode)	Teach provides handout on acids and bases and properties of acids and bases. Students will read in group and answer the questions that follow.	Handout	Checking answers to the question followed in the handout.
Quadrant 3			
Step 5: Practice or Using Information Practically (Left Mode)	Students test their own urine, and sputum using litmus paper.	Urine, sputum, test tube and litmus paper	Students report the results of the test.
Step 6: Extend or	Teacher provides group work on the investigation of the	Soil samples from different places,	Monitor the students on

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Integrate Material with Self (Right Mode)	acidity and alkalinity of the farm soil from different places in their locality. Activity 2.	litmus paper, plastic container, Filter paper.	their group work.
Quadrant 4			
Step 7: Refine or Analyze for Usefulness or Application (Left Mode)	Students check other group's work using the litmus paper.	Litmus paper, soil samples	Group evaluation about the group work
Step 8: Perform or integrating Application and Experience (Right Mode)	Teacher establish atmosphere for sharing their learning with fellow students.	Arranged classroom for presentation of the group work.	Question by teacher and students

Activity 1:

Instruction: To categorize substances into acids, and bases using litmus paper test.

Name: …… Date: …. / …… / …….

Group No: ……

Materials: Given in the table

Instructions: Test the following substances using litmus paper and complete the question that follows.

Procedure:

a. Dip or rub the litmus paper in/with items provided to you.
b. Observe the colour change.

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Substances	Litmus paper	
	Blue to…	Red to….
Coffee (A)		
Vinegar (B)		
Caustic solution (C)		
Antacid tablet solution (E)		
H_2SO_4 (F)		
Lime water (G)		
Blue vitriol (H)		
HCL (I)		
Vitamin B Complex solution (J)		
HNO_3 (K)		

1. Name the substances that turn red litmus blue.

……

2. Name the substances that turn blue litmus red.

……

3. Conclude the meaning of acids and bases.

……..

4. Explain the properties of acids and bases based on the observation.

……

Activity 2: Group Work

Instruction: Investigate the acidity or alkalinity of the soil from different places in the school using the litmus paper.

Name: …… Date: …. / …. /…….

Group No: ……

Materials: Soil samples from different places, litmus paper, plastic container, Filter paper.

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Instructions:

1. Put 1-3 teaspoonful of soil into plastic container
2. Fill to same volume with distilled water
3. Stir vigorously for one minute
4. Let stand for at least 30 minutes.
5. Filter the soil using a filter paper into a separate plastic container.
6. Insert test strip into resultant solution.
7. Compare color to the color chart provided with the strips

Sample soils (Name of the place)	Colour change with litmus paper	Acidic/Alkaline
Sample A (from:		
Sample B (from:		
Sample C (from:		
Sample D(from:		

1) Which soil samples are acidic and which samples are alkaline?
2) How did you know that the soil samples are acidic or alkaline?
3) What is the use of litmus paper?

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Handout

After reading the passage, answer the questions that follow:

Many chemicals are used at home and school laboratory. The chemicals are classified as acids, bases or alkalis. What are acids? The word `acid' is Latin for `sour'. The three commonly used acids in the laboratory are hydrochloric acid, sulphuric acid and nitric acid. Nature also has an abundant supply of acids. For example, citric acid can be found in fruits and vegetables such as lemons and oranges. Malic acid is found in apples, tartaric acid in grapes and oxalic acid in rhubarbs. Acids are also formed in the

bodies of human beings and animals. Lactic acid accumulates in our muscles when we exercise. All acids have certain common properties. Acids have sour taste. They turn blue litmus paper red. Acids are important chemicals and are used in countless industrial processes such as the manufacture of fertilizers, drugs, plastics, dyes and explosives.

The name base has long been associated with a class of compounds whose aqueous solutions are characterized by a bitter taste; a soapy feeling when applied to the skin; ability to restore the original blue color of litmus that has been turned red by acids.

The word “alkali" is synonymous with base. It is of Arabic origin, but the root word comes from the same Latin kalium (potash) that is the origin of the symbol for potassium; wood ashes have been the traditional source of the strong base KOH since ancient times.

There are some metallic oxides or hydroxides which are insoluble in water. These substances are called the bases. The others are soluble in water. These substances are called alkalis. Therefore, all alkalis are bases but all bases are not alkalis.

Some acids and bases are strong, others are weak. Acids and bases are corrosive in nature and are injurious and fatal if tasted or touched accidentally. Therefore, everybody must read the label and handle acids and bases cautiously and safely.

Knowledge about acids and bases and how they can be utilized has benefited mankind tremendously and made life much easier for us.

Questions

1) How are chemicals classified?
2) What is the meaning of acids?
3) Give another word (s) that has the same meaning as ‘classified’.
4) What are the common properties of acids and bases?
5) What are the common properties of bases?
6) What is the difference between base and alkali?
7) How have the knowledge of acids and bases benefited the mankind?
8) Which words in the passage means the same as deadly?

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Appendix VII:

Chemistry laboratory reporting form

Steps	Description	Scores
Title	Write name (or group name), the date of the experiment, and the title of the experiment.	3
Introduction (Objectives)	State the hypothesis of the experiment clearly. (Why are you doing this experiment? What are you trying to learn from it?) This does not have to be longer than one or two sentences.	2
Procedure	The laboratory notebook should contain sufficient information that another person could fully comprehend and, if necessary, reproduce the experiment. This should not be copied from the laboratory manual, but may be paraphrased. This should also include any observations you make during the experiment, such as gases evolving, color changes, etc.	5
Data	All raw data should be listed in a logical, concise manner. Tabulate the final results.	5
Questions	Answer any questions asked, including work, reasons, and explanations, if needed. Your data and observations should be the foundation to any and all questions; however, the concepts that should have been gained through the experiment (if different from your data and observations) should be included as well.	5
Conclusion	Make a final conclusion, describing what concept you learned and how it was learned through this experiment. Write your name (name of the group members).	5
Total		25

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Appendix VIII:

Rubric to assess the reasoning skill

	Outstanding	Very Good	Good	Poor
Induction	The student constructs a valid generalization and clearly articulates the logic of this generalization based on the specifics that have been identified.	The student constructs a valid generalization but does not clearly articulate the logic underlying that generalization.	The student constructs a generalization that has some relationship to the specifics that have been identified; however, the specifics do not totally support the generalization.	The student does not construct a generalization or constructs one that is not at all supported by the specifics.
Deduction	The student generates a valid prediction or conclusion and accurately articulates the relationship between the prediction or conclusion and the principle or premise that was used.	The student generates a valid prediction or conclusion but does not completely articulate the relationship between the prediction or conclusion and the principle or premise that was used.	The student generates a prediction or conclusion that is only partially supported by the premise or rule that was used.	The student does not generate a prediction or conclusion or generates one that is not at all supported by the premise or rule that was used.

Source: http://www.uen.org/Rubric/rubric.cgi?rubric_id=1219, 4 April 2013

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VITAE

NAME	Prem Kumar Ghalley
DATE OF BIRTH	13 March, 1983
PLACE OF BIRTH	Bhutan
EDUCATION	DAV College, Punjab University, India Bachelor's Degree in Science, 2008. Samtse College of Education, Bhutan Post Graduate Diploma in Education, 2009. Rangsit University, Thailand Master's Degree of Education in Curriculum and Instruction, 2013.
SCHOLARSHIP	Trongsa Penlop Scholarship, 2012.
POSITION AND OFFICE	Middle Secondary School Teacher Martshala Middle Secondary School Samdrup Jongkhar, Bhutan. premghalley@gmail.com

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