AN ASSESSMENT OF THE CONCEPT ATTAINMENT MODEL IN MIDDLE SCHOOL MATHEMATICS TEACHING*

Aye Su Myat[1]

Abstract

The main purpose of this study is to assess a concept attainment model in middle school mathematics teaching. Both quantitative and qualitative research methods were used in this study. Quantitative research method was used to analyze students' mathematics achievement and mathematics process skills. Qualitative research method was used to investigate attitudes of teachers towards the attainment of mathematics concepts and the proposed concept attainment model, and those of students towards mathematics learning through learning activities based on the proposed concept attainment model. For quantitative research, an experimental study was conducted. One of the quasi-experimental designs, viz., the nonequivalent control group design, was used in this study. The subjects were randomly selected from Grade Seven in BEHS Phado, BEHS (Branch) Quarter (2) Phado, BEHS (Branch) Myoe Chaung, BEHS Myoe Ma, BEHS (Branch) Hnget Thike, and BEHS (Branch) La-Ka-Ya 3. There were (581) Grade Seven students in the experiment. For qualitative research, the students who participated in the experimental groups and the teachers who taught the experimental groups were randomly selected. The instruments used in this study were pretest, posttest, questionnaire, and interview. Learning materials for this study were selected from Grade Seven mathematics textbook, Volume 2. According to the pilot testing, the internal consistency of pretest question was 0.782. The data were analyzed by using independent samples *t* test and one-way analysis of covariance (One-Way ANCOVA). According to results, differences in mathematics achievement and mathematics process skills were significantly found between the two selected groups. The qualitative data also supported the findings from the quantitative study. Finally, research findings proved that the proposed concept attainment model has positive contribution to middle school mathematics teaching.

Keywords: Models, Model of Teaching, Concept, Concept Attainment, Concept Attainment Model

Introduction

Mathematics is an intricate subject where various parts of the content are so interrelated to each other. In the field of mathematics, it can be found some different words: concept, skill, theory, model, etc. Medin (2000, cited in Santrock, 2006) proposed that concepts are elements of cognition that help to simplify and summarize information. If a student has a wrong concept about one part, he will find the difficulty to make progress in others. Otherwise, the erroneous procedure may develop into a habit. Therefore, it is sure that concept attainment is essential for improving students' mathematics learning and skills.

Objectives of the Research

The main objective of the research is to assess the concept attainment model in middle school mathematics teaching.

Specific objectives are as follows.

1. To construct a new concept attainment model for middle school mathematics teaching
2. To create learning activities based on the proposed concept attainment model for middle school mathematics teaching

[1] Dr, Assistant Lecturer, Methodology Department, Yangon University of Education

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3. To assess the impact of concept attainment model and learning activities on students' mathematics achievement and mathematics process skills
4. To make suggestions and recommendations for the improvement of mathematics teaching

Research Hypotheses

The hypotheses of this study are as follows.

H_1: There is a significant difference between the mathematics achievement of students who are taught with the proposed concept attainment model of teaching mathematics and the mathematics achievement of those who are taught with formal instruction.

H_2: There is a significant difference between the mathematics process skills of students who are taught with the proposed concept attainment model of teaching mathematics and the mathematics process skills of those who are taught with formal instruction.

H_3: Students who are taught with learning activities based on the proposed concept attainment model may have positive attitudes towards mathematics learning.

H_4: Teachers who taught the experimental groups may have positive attitudes towards the attainment of mathematics concepts and the proposed concept attainment model.

Scope of the Research

The following points indicate the scope of the study.

1. This study is geographically restricted to two regions: Bago and Mandalay.
2. Participants in this study are Grade Seven students from the selected schools in the (2017-2018) Academic Year.
3. This study is confined to methodology of middle school mathematics teaching in Myanmar.
4. The content area covers five chapters from the prescribed mathematics textbooks Volume 2, Geometry, for Grade Seven.

Definition of Key Terms

Definitions of key terms are presented as follows.

Models. Models are prescriptive teaching strategies designed to accomplish particular instructional goals (Zubair, 2012).

Model of teaching. A model of teaching is a plan that can also be utilized to shape courses of studies, to design instructional material, and to guide instruction (Zubair, 2012).

Concept. Concept represents a category of objects which share common properties (Archer, 1969, cited in Zubair, 2012).

Concept attainment. Concept attainment is the process of finding and defining attributes of a given class, that is, identifying examples and non-examples of a category (Bruner, 1956, cited in Prabhakaram, 1998).

Concept attainment model. Concept attainment model is a model of teaching, designed to help students learn concepts for organizing information and to help students become more effective at learning concepts (Bruner, 1956, cited in Zubair, 2012).

Statement of the Problem

One of the problems encounter in current mathematics classroom is that some teachers still use teaching methods which stress mainly upon memorization with the primary focus placed on test scores. They teach mathematics concepts just for examinations but not for understanding. Another problem is that some teachers have fewer opportunities to create learning activities to develop their students' mathematics process skills such as problem-solving, reasoning and proof,

communication, connection, and representation. Hence, mathematics teachers need to analyze how to teach concepts.

Significance of the Research

Chauhan (1996) states that a concept is the basic unit of all types of learning. Concepts in mathematics are the basic building blocks for thinking, particularly higher-level thinking. If students attain concepts, they can classify objects and ideas, and then they can derive rules and principles. It allows students to think and process abstractly. So, mathematics teachers need to emphasize how to teach mathematics concept. Therefore, it is necessary to develop a new concept attainment model and to assess its effectiveness in middle school mathematics teaching. This study will fulfil the needs of mathematics education in Myanmar and will meet the objectives of teaching mathematics.

Review of Related Literature

Educational Philosophy

Educational philosophies related to this study are progressivism, cognitivism, and constructivism.

Dewey, first an advocate of progressive education, placed great emphasis on actions and experience (Hook, 1986, cited in Hessong & Weeks, 1991). Since, progressivism places more emphasis on experience and experiment, they stress on learning by problem-solving or by scientific inquiry instead of memorization.

Cognitivism considers learning as a change in cognitive thinking and focuses on internal mental processes that change the way people conceptualize, realize, and understanding their environment (Ertmer & Newby, 2013). In concept attainment, students observe, and identify attributes of each until they develop a tentative hypothesis (definition) about the concept.

Constructivism equates learning with creating meaning from experience (Bednar, 1991, cited in Ertmer & Newby, 2013). In constructivism, social communities have a strong impact on constructed meaning. According to Vygotsky (n.d., cited in Sang, 2003), the idea of zone of proximal development (ZPD) is the pupils' performance, under the help of adults or cooperation from their peers. Vygotsky's zone of proximal development is presented in Figure 1.

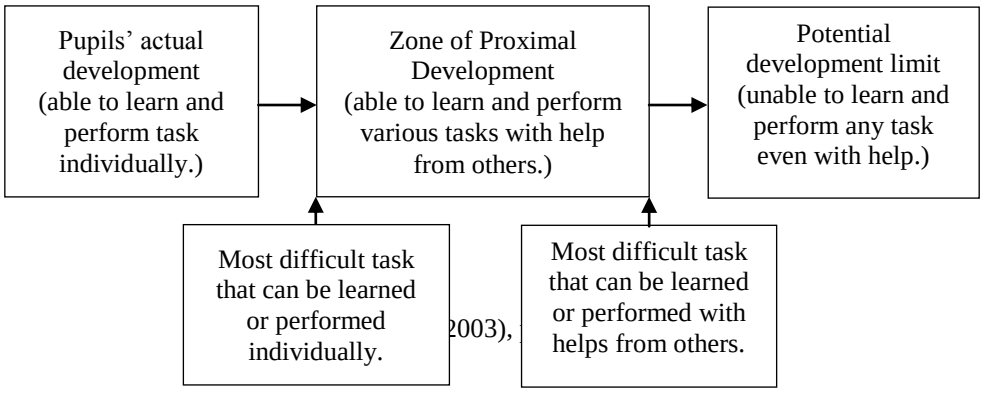


Figure 1 Zone of Proximal Development (ZPD)

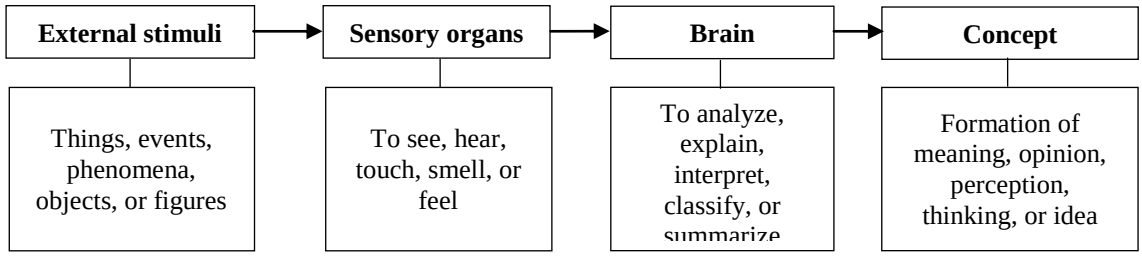
Cognitive Teaching and Learning Theories

Cognitive theories mainly stress on the acquisition of knowledge and growth of the mental structure and emphasize on the conceptualization of the students learning process.

According to Piaget's cognitive development theory (Sang, 2003), concept learning is closely related with the children's age level: sensory-motor stage (0-2 years), pre-operational stage (2-7 years), concrete operation (7-12 years), and formal operation (after 12 years). The children's cognitive development in each stage is an important factor that influences the formation of concrete or abstract concepts.

Gagne (1977, cited in Sang, 2003) put forward eight types of learning based on the learning process and arranged from simple to complex: signal learning, stimulus-response learning, learning through chaining, learning through verbal association, learning through multiple discrimination, concept learning, principle learning, and problem-solving. In order to be mastered in concept learning, understanding of definitions or observations of objects related to the concepts is crucial.

According to Bruner (1973, cited in Sang 2003), the most important function of concept formation is to categorize information into general characteristics. It is closely related to perception. The perception process begins from the external stimuli which have been perceived by human sensory organ, and transmitted to the brain via the sensory nerves to interpret the information received, followed by the classification into categories based on their special characteristics. Figure 2 briefly illustrates the process of concept formation via the perception process.



Source: From Sang (2003), p. 89.

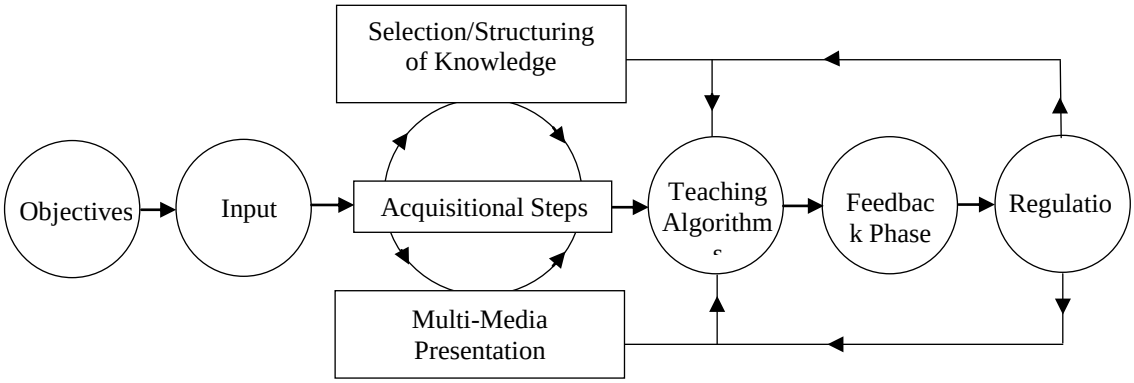
Figure 2 Process of Perception and Concept Formation

Landa's theory specifies that students ought to be taught not only knowledge but the algorithms and heuristics of experts as well. They also have to be taught how to discover algorithms and heuristics on their own. The teacher or the pedagogue must first set up the algorithm or algorithms of the activity he wishes to form and should introduce pupils to algorithms and other intellectual activity applicable to a variety of scientific subjects and fields (Khin Zaw, 2001).

Models of Teaching

In this research, Talyzina's cognitive-cybernetic or neocybernetic model, Glaser's basic teaching model, and Bruner's concept attainment model are taken into considered.

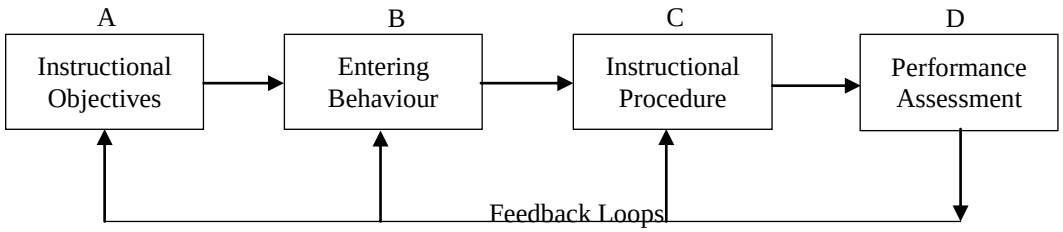
Talyzina's cognitive-cybernetic or neocybernetic model bases on step-by-step approach or stage-by-stage formation of intellectual activities. Talyzina's cognitive-cybernetic or neocybernetic model is composed of eight steps and it is illustrated in Figure 3.



Source: From Khin Zaw (2001), p. 42.

Figure 3 Professor Dr. Talyzina's Cognitive-Cybernetic or Neocybernetic Model

Glaser's basic teaching model was given by Robert Glaser (1962, cited in Singh, Sharma, & Upadhya, 2009). It consists of four major components namely instructional objectives, entering behaviour, instructional procedures, and performance assessment with feedback links. Figure 4 illustrates Glaser's basic teaching model of teaching.



Source: From Joyce and Weil (1972), p. 216.

Figure 4 Glaser's Basic Teaching Model

Bruner, Goodnow, and Austine (1956, cited in Zubair, 2012) developed a concept attainment model. Concept attainment model has three variations, namely: reception model, selection model, and unorganized material model. The reception model is more direct in teaching students the elements of a concept and their use in concept attainment. The selection model permits students to apply this awareness of conceptual activity more actively by using their own initiation and control. The third variation of this model transfers concept theory and attainment activity to a real life setting using unorganized data (Joyce & Weil, 1980).

Mathematics process skills. Mathematics process skills are the skills that can be acquired through the processes of problem-solving, reasoning and proof, communication, connection, and representation (National Council of Teachers of Mathematics [NCTM], 2000). In 2000, this council proposed five process skills that should be incorporated into the mathematics curriculum at every grade level. These skills are (a) problem-solving, (b) reasoning and proof, (c) communication, (d) connection, and (e) representation. Mathematics teachers should try to give learning opportunities for their students to acquire these mathematics process skills.

Strategies of Concept Attainment

The concept attainment strategies are divided into selection and reception strategies based upon learning conditions.

In selection strategies, the teacher presents unlabelled examples of the concept and the students inquire as to which of the presentations are examples and non-examples and attempt to construct positive examples on their own. With reception strategies, the learner's major area of freedom is in the hypotheses he chooses to adopt. The teacher presents examples of the concept that are labelled 'yes' or 'no'.

Previous Related Research

Five related studies are presented to determine whether concept attainment model is more effective than any other teaching method.

The first one, "Effectiveness of Concept Attainment Model on Achievement in Arabic Grammar of Standard IX Students", was a thesis conducted by Shamnad (2005). Its findings revealed that concept attainment model was definitely better than the conventional method for student achievement.

The second one was conducted by Anjum (2014), namely, "A Study of Effect of Concept Attainment Model on Achievement of Geometric Concepts of VIII Standard Students of English Medium Students of Aurangabard City". This study revealed that there was a significant difference between concept attainment model and traditional method on the achievement of students in understanding of geometric concepts.

The next one, "Effect of Concept Attainment Model of Teaching on Achievement in Physics at Secondary Stage", was a research conducted by Kaur (2014). This study pointed out that concept attainment model of teaching is superior and effective in terms of physics concept understanding of students in comparison to conventional method.

Jones and Hilaire (2014) conducted "Concept Learning in the Undergraduate Classroom: A Case Study in Religious Studies". In this case study, Bruner's concept attainment model was explored in the undergraduate religion classroom. It suggested that by asking questions that force learners to engage in higher-order thinking and place judgments on the concepts they are learning, greater conceptual understanding will occur.

The last one, "To Study the Effectiveness of Concept Attainment Model of Teaching on Achievement of Secondary School Students in Chemistry", was a study conducted by Kaur (2017). The results showed that students exposed to concept attainment model possessed higher score than the students taught through traditional method.

Proposed Concept Attainment Model for Middle School Mathematics Teaching

In proposed concept attainment model, there are five main components (see Figure 5). Detailed description is presented as follows.

Planning for concept attainment activities. Firstly, the teacher selects a concept. Then, the teacher identifies specific objectives to develop the selected concept. And then, the teacher selects exemplars and non-exemplars of the concept. After that, the teacher sequences them and selects appropriate medium to present the selected concept.

Assessing prerequisite skills. The second step of this model is assessing prerequisite skills of the students. If students' prerequisite skill is not enough to go on to the next step, the teacher has to fulfil and make their background knowledge strengthen. If their prerequisite skill is enough, it is ready to implement concept attainment activities.

Implementing concept attainment activities. When the teacher orients reception activity, he presents exemplars and non-exemplars of the concept one-by-one. At each encounter, the learners analyze and compare their attributes in positive and negative instances. Then, students list them. And then, students generate hypothesis with regard to the concept. Finally, students state definition of the concept according to its attributes.

In selection oriented activity, the teacher presents an array of unlabelled exemplars. Students may ask about their own exemplars in order to attain the concept. The students also control the sequence of the exemplars by choosing the ones they want to inquire about. And then students generate hypothesis.

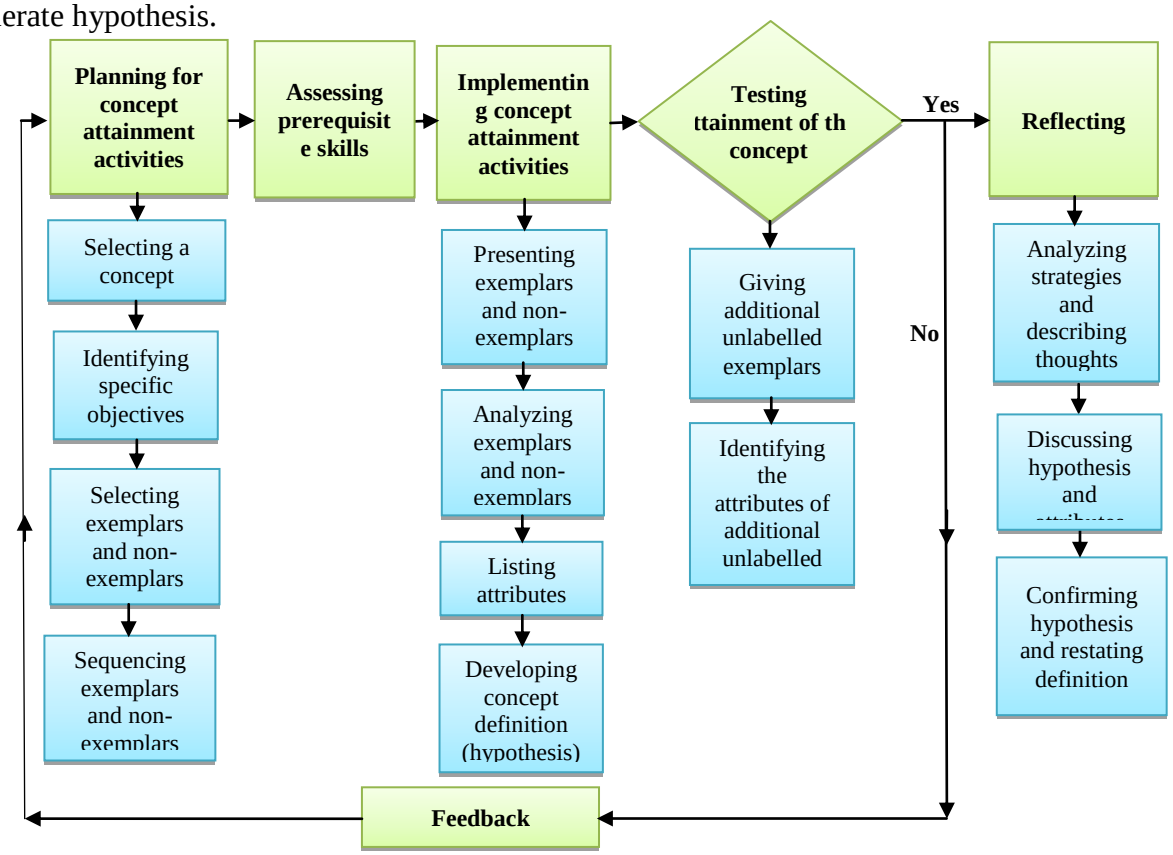


Figure 5 Proposed Concept Attainment Model

Testing attainment of the concept. The teacher gives additional unlabelled exemplars to test attainment of the concept. After testing attainment of the concept, the teacher has to check students' answers. If the students' answers are right, they can proceed to the next step, reflecting. If not, the teacher will provide feedback.

Providing feedback or reflecting. Providing feedback is necessary for the students who do not get the concept. If they attain the concept surely, they can move to reflecting. In reflecting, the teacher asks the students to analyze the strategies. Students describe their thoughts and discuss the hypothesis and attributes. Finally, the teacher confirms hypothesis, names concept, and restates definition according to essential attributes.

Research Method

Both quantitative and qualitative research methods were used in this study.

Quantitative Research Method

Quantitative research method was used to analyze students' mathematics achievement and mathematics process skills. One of the quasi-experimental designs, viz., the nonequivalent control group design was used.

Population and sample. Grade Seven students from the selected schools were selected as the subjects. Table 1 shows population and sample of the quantitative study.

Table 1 Population and Sample

Selected Region and Township	Name of School	No. of population	No. of Subject
Bago Region (Kyauktaga Township)	BEHS Phado	101	101
	BEHS (Branch) Quarter 2 Phado	81	81
	BEHS (Branch) Myoe Chaung	112	112
Mandalay Region (Yemethin Township)	BEHS Myoe Ma	279	135
	BEHS (Branch) Hnget Thike	65	65
	BEHS (Branch) La-Ka-Ya 3	87	87
Total		**725**	**581**

Instruments. Pretest and posttest were used as quantitative research instruments.

Pretest. The pretest question consists of (30) multiple choice items. Test items were constructed based on Grade Six mathematics textbook (Volume 2). The total score for pretest is (30) marks. Time duration is (45) minutes, (1) period.

Posttest. There are two main parts in the posttest question. The first part contains (30) multiple choice items and the second contains (10) short questions. They were constructed from prescribed mathematics textbooks (Volume 2) for Grade Seven. The total score for posttest is (60) marks and time duration is one and a half hours.

Learning activities. To construct learning activities for concept attainment, (20) concepts were selected from Grade Seven mathematics textbooks (Volume 2).

Procedure. Firstly, a pilot study was conducted and the internal consistency of pretest question was 0.782. And then, full-scale study was conducted from July 2017 to January 2018. In full scale study, only (16) periods were taken to give treatment in accordance with the monthly course. A pretest was conducted before the experimental groups were given treatment. In full scale study, (16) concepts were selected to give treatment. After that, posttest was administered in the last week of January 2018.

Qualitative Research Method

Qualitative research method was used to investigate attitudes of teachers and students.

Population and sample. Students who participated in the experimental groups and teachers who taught the experimental groups were selected as the subjects.

Instruments. Questionnaire and interview were used.

Questionnaire. Five-point Likert scale with '5' stands for strongly agree and '1' stands for strongly disagree, was used to indicate the attitudes towards each item.

***Interview*.** The first part of interview question is about the demographic information and the second one is about the attitude of teachers towards the proposed concept model.

Procedure. The questionnaires were distributed to the participants in the last week of the experiment. It took the students about (20) minutes and the teachers about (30) minutes. For interview, a semi-structured interview form was created. The interview took about (15) minutes. It is firstly audiotape recorded, and then transcribed.

Analysis of Data

The Statistical Package for the Social Science (SPSS) Version 23 was used to analyze the quantitative data. The data were analyzed by using the independent samples *t* test and one-way analysis of covariance (One-Way ANCOVA).

Research Findings

Quantitative Research Findings for Pretest

Table 2 shows *t* values for pretest scores of Grade Seven students.

Table 2 *t* Values for Pretest Scores

School	Group	*N*	*M*	*SD*	*MD*	*t*	*df*	Sig. (2-tailed)
S1	Experimental	50	10.54	4.55	2.27	3.44	99	.001**
	Control	51	8.27	5.56				
S2	Experimental	40	10.05	3.27	-0.24	-0.36	79	.722 (ns)
	Control	41	10.29	2.84				
S3	Experimental	56	12.71	2.61	2.82	7.17	110	.000***
	Control	56	9.89	1.37				
S4	Experimental	66	16.70	3.79	6.64	12.40	133	.000***
	Control	69	10.06	2.18				
S5	Experimental	32	12.06	2.88	2.88	3.76	63	.000***
	Control	33	9.18	3.27				
S6	Experimental	43	12.88	3.31	2.11	3.59	85	.001**
	Control	44	10.77	2.00				

Note. S1 = BEHS Phado; S2 = BEHS (Branch) Quarter 2 Phado; S3 = BEHS (Branch) Myoe Chaung; S4 = BEHS Myoe Ma; S5 = BEHS (Branch) Hnget Thike; S6 = BEHS (Branch) La-Ka-Ya 3; ns = not significant.

***p* < .01. ****p* < .001.

The results showed that there were significant differences between entry behaviour of the two selected groups in S1, S3, S4, S5, and S6. Therefore, their posttest scores will be analyzed by using one-way analysis of covariance (One-Way ANCOVA). But in S2, there was no significant difference between the pretest scores of the two groups. Therefore, its posttest score will be analyzed by using the independent samples *t* test.

Quantitative Research Findings for Posttest

Table 3 presents *t* value for posttest scores of Grade Seven students in S2.

Table 3 *t* Value for Posttest Scores of Grade Seven Students in S2

	Group	*N*	*M*	*SD*	*MD*	*t*	*df*	Sig. (2-tailed)
PS	EG	40	4.63	3.56	1.12	1.48	79	.144 (ns)
	CG	41	3.51	3.22				
RP	EG	40	4.08	4.40	1.91	2.43	79	.018*
	CG	41	2.17	2.32				
CM	EG	40	7.60	1.93	0.82	1.89	79	.063 (ns)
	CG	41	6.78	1.98				
CN	EG	40	5.08	1.61	2.32	6.87	79	.000***
	CG	41	2.76	1.43				
RE	EG	40	7.20	2.51	2.00	3.39	79	.001**
	CG	41	5.20	2.80				
MA	EG	40	28.58	10.88	8.17	3.72	79	.000***
	CG	41	20.41	8.76				

Note: PS = Problem-Solving; RP = Reasoning and Proof; CM = Communication; CN = Connection; RE = Representation; MA = Mathematics Achievement; ns = not significant.

*$p < .05$. **$p < .01$. ***$p < .001$.

According to the results presented in Table 3, the mean scores of reasoning and proof, connection skill, representation skill, and mathematics achievement of the experimental group were significantly higher than those of the control group. It showed that the use of the proposed concept attainment model had a significant influence on those skills. But there were no significant differences between the problem-solving skill and the communication skill of the two groups.

Table 4 shows summary of ANCOVA results for the problem-solving skill on posttest of Grade Seven students in S1, S3, S4, S5, and S6.

Table 4 Summary of ANCOVA Results for Problem-Solving Skill on Posttest of Grade Seven Students in S1, S3, S4, S5, and S6

School	Tests of Between-Subjects Effects					Unadjusted Mean		Adjusted Mean	
	Source	*df*	*F*	Sig. (2-tailed)	Partial Eta Squared	EG	CG	EG	CG
S1	Pretest	1	0.23	.634	.002	8.66	7.35	8.63	7.39
	Group	1	10.01	.002**	.093				
	Error	98							
S3	Pretest	1	0.02	.900	.00	8.84	7.36	8.85	7.45
	Group	1	19.58	.000***	.15				
	Error	109							
S4	Pretest	1	1.23	.270	.009	8.09	6.42	8.30	6.22
	Group	1	15.76	.000***	.107				
	Error	132							
S5	Pretest	1	0.28	.600	.004	7.94	5.09	7.98	5.05
	Group	1	70.29	.000***	.531				
	Error	62							
S6	Pretest	1	14.41	.000	.15	5.84	4.64	5.39	5.07
	Group	1	0.25	.620	.00				
	Error	84							

Note. **$p < .01$. ***$p < .001$.

According to the results presented in Table 4, there were significant differences between the problem-solving skill of the two groups in S1, S3, S4, and S5 according to F (1, 98) = 10.01, p = .002, partial eta squared = .09; F (1, 109) = 19.58, p = .000, partial eta squared = .15; F(1, 132) = 15.76, p = .000, partial eta squared = .11; and F (1, 62) = 70.29, p = .000, partial eta squared = .53. But in S6, there was no significant difference according to F (1, 84) = 0.25, p = .620, partial eta squared = .00.

Table 5 describes ANCOVA results for skill of reasoning and proof on posttest of Grade Seven students in S1, S3, S4, S5, and S6.

Table 5 Summary of ANCOVA Results for Skill of Reasoning and Proof on Posttest of Grade Seven Students in S1, S3, S4, S5, and S6

School	Tests of Between-Subjects Effects					Unadjusted Mean		Adjusted Mean	
	Source	*df*	*F*	Sig. (2-tailed)	Partial Eta Squared	EG	CG	EG	CG
S1	Pretest	1	0.02	.887	.000	5.24	3.06	5.23	3.01
	Group	1	30.57	.000***	.238				
	Error	98							
S3	Pretest	1	0.04	.846	.00	10.70	9.18	10.72	9.15
	Group	1	11.05	.001**	.09				
	Error	109							
S4	Pretest	1	0.91	.341	.007	7.73	3.78	7.88	3.63
	Group	1	88.04	.000***	.400				
	Error	132							
S5	Pretest	1	0.04	.842	.001	7.75	4.48	7.77	4.47
	Group	1	63.05	.000***	.504				
	Error	62							
S6	Pretest	1	10.52	.002	.11	5.21	3.48	4.78	3.90
	Group	1	1.52	.221	.02				
	Error	84							

Note. **p < .01. ***p < .001.

Table 6 presents ANCOVA results for communication skill on posttest of Grade Seven students in S1, S3, S4, S5, and S6.

According to the results presented in Table 5, there were significant differences between the skill of reasoning and proof on posttest of the two groups in S1, S3, S4, and S5 according to F (1, 98) = 30.57, p = .000, partial eta squared = .24; F (1, 109) = 11.05, p = .001, partial eta squared = .09; F (1, 132) = 88.04, p = .000, partial eta squared = .40; and F (1, 62) = 63.05, p = .000, partial eta squared = .50. But in S6, there was no significant difference according to F (1, 84) = 1.52, p = .221, partial eta squared = .02.

Table 6 Summary of ANCOVA Results for Communication Skill on Posttest of Grade Seven Students in S1, S3, S4, S5, and S6

School	Tests of Between-Subjects Effects					Unadjusted Mean		Adjusted Mean	
	Source	*df*	*F*	Sig. (2-tailed)	Partial Eta Squared	EG	CG	EG	CG
S1	Pretest	1	0.35	.852	.000	6.88	5.06	6.87	5.07
	Group	1	30.88	.000***	.240				
	Error	98							
S3	Pretest	1	0.30	.587	.00	9.13	8.66	9.09	8.70
	Group	1	2.92	.090	.03				
	Error	109							
S4	Pretest	1	3.30	.072	.024	7.85	5.87	8.14	5.59
	Group	1	32.88	.000***	.199				
	Error	132							
S5	Pretest	1	0.22	.643	.003	6.63	4.61	6.58	4.65
	Group	1	22.22	.000***	.264				
	Error	62							
S6	Pretest	1	1.17	.283	.01	8.70	7.93	8.63	8.00
	Group	1	2.94	.090	.03				
	Error	84							

Note: ***$p < .001$.

According to the results presented in Table 6, there were significant differences between the communication skill of the two groups in S1, S4, and S5 according to F (1, 98) = 30.88, p = .000, partial eta squared = .24; F (1, 132) = 32.88, p = .000, partial eta squared = .20; and F (1, 62) = 22.22, p = .000, partial eta squared =.26. But in S3 and S6, there were no significant differences according to F (1, 109) = 2.92, p = .090, partial eta squared = .03 and F (1, 84) = 2.94, p = .090, partial eta squared =.03.

Table 7 shows ANCOVA results for connection skill on posttest of Grade Seven students in S1, S3, S4, S5, and S6.

According to the results presented in Table 7, there were significant differences between the connection skill of the two groups in S1, S3, and S5 according to F (1, 98) = 80.70, p = .000, partial eta squared =.45; F (1, 109) = 12.16, p = .001, partial eta squared = .10; and F (1, 62) = 52.44, p = .000, partial eta squared = .46. But in S4 and S6, there were no significant differences according to F (1, 132) = 0.77, p = .381, partial eta squared = .01; and F (1, 84) = .09, p = .765, partial eta squared = .00.

Table 7 Summary of ANCOVA Results for Connection Skill on Posttest of Grade Seven Students in S1, S3, S4, S5, and S6

School	Tests of Between-Subjects Effects					Unadjusted Mean		Adjusted Mean	
	Source	*df*	*F*	Sig. (2-tailed)	Partial Eta Squared	EG	CG	EG	CG
S1	Pretest	1	0.77	.381	.008	7.36	4.43	7.31	4.48
	Group	1	80.70	.000***	.452				
	Error	98							
S3	Pretest	1	1.81	.181	.02	9.21	8.64	9.16	8.69
	Group	1	12.16	.001**	.10				
	Error	109							
S4	Pretest	1	0.46	.501	.003	6.09	5.58	6.00	5.67
	Group	1	0.77	.381	.006				
	Error	132							
S5	Pretest	1	0.14	.705	.002	5.84	3.27	5.87	3.24
	Group	1	52.44	.000***	.458				
	Error	62							
S6	Pretest	1	4.18	.044	.05	7.79	7.64	7.66	7.64
	Group	1	0.09	.765	.00				
	Error	84							

Note: **$p < .01$. ***$p < .001$.

Table 8 shows ANCOVA results for representation skill on posttest of Grade Seven students in S1, S3, S4, S5, and S6.

Table 8 Summary of ANCOVA Results for Representation Skill on Posttest of Grade Seven Students in S1, S3, S4, S5, and S6

School	Tests of Between-Subjects Effects					Unadjusted Mean		Adjusted Mean	
	Source	*df*	*F*	Sig. (2-tailed)	Partial Eta Squared	EG	CG	EG	CG
S1	Pretest	1	0.00	.999	.000	9.00	6.08	9.00	6.08
	Group	1	38.81	.000***	.284				
	Error	98							
S3	Pretest	1	0.06	.812	.00	8.96	7.73	8.97	7.71
	Group	1	16.34	.000***	.13				
	Error	109							
S4	Pretest	1	0.13	.718	.001	8.97	6.49	8.92	6.54
	Group	1	36.13	.000***	.215				
	Error	132							
S5	Pretest	1	0.00	.966	.000	9.59	6.97	9.56	6.97
	Group	1	25.40	.000***	.291				
	Error	62							
S6	Pretest	1	6.96	.010	.08	10.09	6.08	10.06	9.82
	Group	1	0.19	.668	.00				
	Error	84							

Note ***$p < .001$.

According to the results presented in Table 8, there were significant differences between the representation skill of the two groups of S1, S3, S4, and S5 according to F (1, 98) = 38.81, p = .000, partial eta squared = .28; F (1, 109) = 16.34, p = .000, partial eta squared = .13; F (1, 132) = 36.13, p = .000, partial eta squared = .22; and F (1, 62) = 25.40, p = .000, partial eta

squared = .29. But in S6, there was no significant difference according to F (1, 84) = 0.19, p = .668, partial eta squared = .00.

Table 9 shows ANCOVA results for the mathematics achievement on posttest of Grade Seven students in S1, S3, S4, S5, and S6.

Table 9 Summary of ANCOVA Results for Mathematics Achievement on Posttest of Grade Seven Students in S1, S3, S4, S5, and S6

School	Tests of Between-Subjects Effects					Unadjusted Mean		Adjusted Mean	
	Source	*df*	*F*	Sig. (2-tailed)	Partial Eta Squared	EG	CG	EG	CG
S1	Pretest	1	0.29	.590	.00	37.14	25.98	37.04	26.08
	Group	1	104.12	.000***	.52				
	Error	98							
S3	Pretest	1	0.02	.892	.00	46.84	41.68	46.81	41.71
	Group	1	48.32	.000***	.31				
	Error	109							
S4	Pretest	1	1.68	.197	.01	38.73	28.14	39.24	27.65
	Group	1	111.22	.000***	.46				
	Error	132							
S5	Pretest	1	0.06	.815	.00	37.75	24.42	37.80	24.83
	Group	1	179.69	.000***	.74				
	Error	62							
S6	Pretest	1	14.88	.000	.15	37.63	33.48	36.28	34.80
	Group	1	0.61	.438	.01				
	Error	84							

Note: ***p < .001.

According to the results presented in Table 9, there were significant differences between the posttest scores of the two groups in S1, S3, S4, and S5 according to F (1, 98) = 104.12, p = .000, partial eta squared = .52; F (1, 109) = 48.32, p = .000, partial eta squared = .31; F (1,132) = 111.22, p = .000, partial eta squared = .46; and F (1, 62) = 179.69, p = .000, partial eta squared = .74. But in S6, there was no significant difference according to F (1, 84) = 0.61, p = .438, partial eta squared = .01.

Figure 6 shows comparison of mean scores of mathematics process skills and mathematics achievement on posttest.

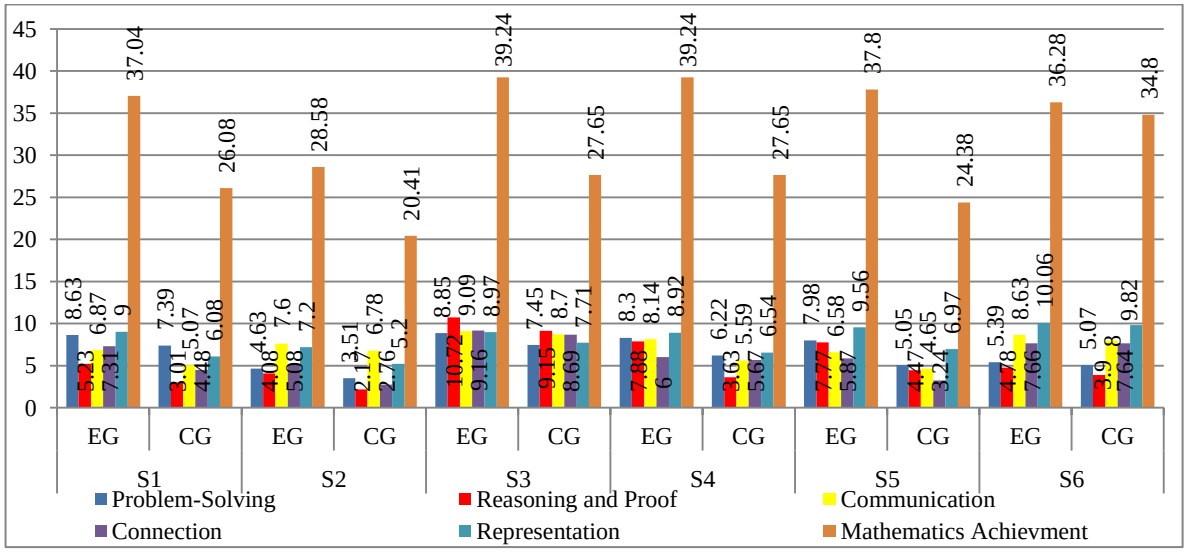


Figure 6 Comparison of Mean Scores of Mathematic Process Skills and Mathematics Achievement on Posttest

Percentage of responses from questionnaire. According to the responses of the teachers and the students, percentage of agreement and disagreement were calculated for all items in the questionnaires.

Students' attitudes towards learning activities based on the proposed concept attainment model. In the questionnaire, items 1 to 4 dealt with developing students' collaborative skills, items 5 to 8 are about developing inquiry skills, items 9 to 12 dealt with developing self-confidence, and the last items 13 to 16 dealt with developing mathematics process skills. Responses of students and teachers on these items are expressed in the following Table 10.

Table 10 Attitudes of Students and Teachers towards Learning Activities based on the Proposed Concept Attainment Model

No.	Statement	Students						Teachers					
		N1	Percentage (%)					*N2*	Percentage (%)				
			Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree		Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1.	Sharing thoughts, ideas, and opinions to friends	287	12.5	73	11.5	2.7	0.3	6	16.7	66.6	16.7	0	0
2.	Listening carefully to others' thoughts, ideas, and opinions	287	24.5	61.3	12.5	0.7	1	6	33.3	50	16.7	0	0
3.	Collaborating with others	287	27.9	60.6	8.4	2.4	0.7	6	33.3	66.7	0	0	0
4.	Helping others who do not have the first idea of the lesson	287	28.6	60	6.6	4.5	0.3	6	33.3	66.7	0	0	0
5.	Discovering various concerns about a problem	287	18.1	57.8	13.6	8.7	1.8	6	16.7	66.6	16.7	0	0
6.	Discovering the possible ways to solve a problem	287	26.1	57.8	9.4	5.7	1	6	16.7	83.3	0	0	0
7.	Inquiring to acquire new knowledge	287	30.3	56.4	10.8	1.8	0.7	6	16.7	66.6	16.7	0	0
8.	Inquiring not only mathematics field but also other fields	287	33.7	51.6	10.5	3.5	0.7	6	16.7	66.6	16.7	0	0
9.	Contrasting the right and the wrong of an idea	287	13.6	61.7	23.3	1.4	0	6	16.7	83.3	0	0	0
10.	Solving difficult problems	287	13.9	65.9	17.4	2.8	0	6	16.7	66.6	16.7	0	0
11.	Explaining clearly thoughts, ideas, and opinions to friends	287	18.5	62.7	15.3	3.5	0	6	33.3	66.7	0	0	0
12.	Developing confidence in discussing the lesson with my teacher in the class	287	19.9	48	25.8	5.6	0.7	6	33.3	66.7	0	0	0
13.	Developing connection skill and the skill of reasoning and proof	287	15	59.2	21.6	3.5	0.7	6	16.7	83.3	0	0	0
14.	Developing problem-solving skill	287	25.8	58.9	12.9	2.1	0.3	6	16.7	83.3	0	0	0
15.	Developing communication skill	287	25.8	60.6	10.1	3.5	0	6	33.3	50	16.7	0	0
16.	Developing representation skill	287	26.1	54.1	15.3	4.2	0.3	6	16.7	83.3	0	0	0

Note: *N1* = number of students who participated in the experimental groups; *N2* = number of teachers who taught the experimental groups.

Grade Seven teachers' attitudes towards the attainment of mathematics concepts. The attitudes of the teachers who taught the experimental groups towards the attainment of mathematics concepts are firstly presented in terms of ten items. Teachers' responses on these items are expressed in Table 11.

Table 11 Grade Seven Teachers' Attitudes towards the Attainment of Mathematics Concepts

No.	Statement	*N*	Percentage (%)				
			Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1.	Mathematics concepts are the most important things for developing mathematics process skills.	6	50	50	0	0	0
2.	Only when mathematics concepts are attained, one will be able to keep on studying mathematics theorems, corollaries, and properties.	6	50	50	0	0	0
3.	Only when mathematics concepts are attained, one will be able to keep on studying difficult lessons.	6	33.3	66.7	0	0	0
4.	Only when mathematics concepts are attained, one will be able to solve mathematics problems successfully.	6	66.7	33.3	0	0	0
5.	Only when mathematics concepts are attained, one will be able to prove mathematics problems.	6	33.3	66.7	0	0	0
6.	Only when mathematics concepts are attained, one will be able to communicate clearly his thoughts and opinions to others.	6	33.3	66.7	0	0	0
7.	Only when mathematics concepts are attained, one will be able to connect the relationships among axioms, postulates, theorems, corollaries, and properties.	6	33.3	66.7	0	0	0
8.	Only when mathematics concepts are attained, one will be able to read and understand the meanings of pictures, graphs, and symbols.	6	16.7	66.6	16.7	0	0
9.	Only when mathematics concepts are attained, one will be able to study mathematics happily.	6	50	50	0	0	0
10.	Only when mathematics concepts are attained, one will be able to value and appreciate mathematics.	6	66.7	33.3	0	0	0

Note: *N* = number of teachers who taught the experimental groups.

Findings from open-ended responses. At the end of attitude questionnaires for teachers, three open-ended questions were added. The first one is about the contributions of the proposed model towards the development of mathematics teaching. The second one is about the difficulties they met while implementing learning activities through this model. The last one is to write down their opinions and attitudes towards this model. According to their responses, all teachers propounded that this model made provision for teaching of mathematics. Some students could not participate along with the activities at the beginning and the common difficulty was time limitation. In addition, prepared learning activities based on this model and teaching aids were very excellent. And students were very interested in teaching through this model.

Findings from interview. Three teachers who taught the experimental groups in the selected schools were interviewed. The first one is from School 1. BA (History) is her first degree and total service is (14) years. Among (14) years, the service for mathematics teaching is (10) years. The second one is from School 2. Her first degree is BA (History). Her total service is (25) years and the service for mathematics teaching is above (10) years. She finished both primary teachers training course and junior teachers training course. The last one is from School 4. Her first degree is BSc (Chemistry). Her total service is (10) years and the service for mathematics teaching is four years. They all finished primary teachers training course and junior teachers training course, but the last teacher also finished first year of BEd corresponding course.

They said that some students could not analyze and compare the attributes of concepts at the beginning. After three periods, they developed how to analyze, how to compare, and how to develop a concept. They changed their learning styles and actively participated in teaching-learning process. During this study, the students developed their collaborative skills, self-confidence, inquiry skills and mathematics process skills. Based on their experiences of teaching with the prepared learning activities, they made a precious suggestion that each teaching-learning activity should take about (50) minutes. In conclusion, they propounded that it is very suitable and valuable approach for teaching of mathematics.

Summary of Research Findings

Quantitative research findings and qualitative research findings from six selected schools are summarized as follows.

Summary of quantitative research findings. Except from S6, differences in mathematics achievement and mathematics process skills were significantly found between the experimental groups and the control groups.

Summary of quantitative research findings from students' questionnaires. Students' responses towards the learning activities expressed that the students in the experimental groups developed positive attitudes towards their learning.

Summary of quantitative research findings from teachers' questionnaires. Teachers' responses expressed that they had positive attitudes towards the attainment of mathematics concept and towards the proposed concept attainment model.

Summary of qualitative research findings. According to interview responses, the teachers were not in line with their major specializations. But they had many experiences in teaching and they devoted their time and effort in implementing those activities. They said that all the prepared learning activities and materials were very useful for teaching of mathematics. And they propounded that the proposed model was very suitable and valuable approach for teaching of mathematics.

Discussion

In terms of the statistical results, the students' performance had significant difference on the achievement of mathematics process skills and on overall mathematics achievement. According to quantitative research findings, it can be concluded that students' true attainment of mathematics concept make them acquire mathematics process skills. According to the responses of teachers and students, they had positive attitude towards the proposed model. These results of qualitative study also supported the findings of the quantitative study which were consistent with the findings of the five related studies.

Suggestions

To make students' progress in developing mathematics achievement and mathematics process skills, teachers should create effective classroom environment with many opportunities. Skills and concepts once developed must be maintained through reapplication and not allowed to deteriorate through disuse. Since students do not learn with equal facility or at equal rates, there must be provision for individual differences. If the instruction is to attain a maximum of usefulness, it must be carried on with the deliberate purpose of securing maximum of transfer.

This research study is not perfect and suitable for all situations. In this study sample schools were randomly selected from Bago and Mandalay Regions. Further research should be carried out for the rest states and regions for replication. It partially provides to improve middle school mathematics teaching methodology to some extent, however the results of this study do not represent to crowded classrooms. So, new mathematics teaching approach for large classrooms should be developed. According to time limitations, this research was conducted for only five units from mathematics Volume 2. Further research should be carried out for mathematics Volume 1. In this study, the effectiveness of the proposed model was evaluated through five mathematics process skills. It can also be evaluated according to Bloom's taxonomy of instructional objectives.

Conclusion

The results of quantitative study and qualitative study supported its major hypotheses. According to the findings of the research, it is hoped that this proposed model can be useful to some extent for mathematics teaching. Through the proposed model, the students will attain mathematics concepts easily and happily. If they are taught through the process of concept attainment, they can learn faster, maintain for a long time, and transfer it to new situations. It will also be beneficial to teachers. This study will hopefully serve as a future reference for researchers in other subject areas. Based on these findings, future researchers can conduct further researches on the effectiveness of concept attainment model.

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References

Anjum, S. K. (2014). A study of effect of concept attainment model on achievement of geometric concepts of VIII standard students of English medium students of Aurangabad city [PDF file]. *Scholarly Research Journal for Interdisciplinary Studies, 2*(15), 2451-245. Retrieved December 22, 2015 from www. Srjis.com/srjis-new/.../Nov.../27. Shaikh%20 Kashefa%20 Anjum.pdf

Chauhan, S. S. (1996). *Advanced educational psychology* (6th ed.). New Delhi: Sanjay.

Ertmer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective [PDF file]. *Performance Improvement Quarterly, 26*(2) pp.43-71. Retrieved November 22, 2015 from http://ocw.metu.edu.tr/pluginfile.php/ 3298/course/ section/ 1174/peggy_2013 comparing_critical_features.pdf

Hessong, R. F., & Weeks, T. H. (1991). *Introduction to the foundation of education* (2nd ed.). New York: Macmillan Publishing Company.

Jones, J. L., & Hilaire, R. St. (2014). Concept learning in the undergraduate classroom: A case study in religious studies [PDF file]. *International Journal of Instruction, 7* (2), 65-74. Retrieved December 22, 2015 from www.e-iji.net/dosyalar/iji-2014-2-5.pdf

Joyce, B., & Weil, M. (1972). *Models of teaching*. New Jersey: Prentice-Hall.

Joyce, B., & Weil, M. (1980). *Models of teaching* (2nd ed.). New Jersey: Prentice-Hall.

Kaur, N. (2014). Effect of concept attainment model of teaching on achievement in physics at secondary stage [PDF file]. *International Journal of Advance Research in Education Technology and Management, 1*(1),6-11. Retrieved December 22, 2015 from http://www.ijaretm.com/Papers/ download-395331616292.pdf

Kaur, R. (2017). To study the effectiveness of concept attainment model of teaching on achievement of secondary school students in chemistry [PDF file]. *Scholarly Research Journal for Interdisciplinary Studies, 5*(25),6858-6863. Retrieved November 5, 2018 from http://oaji.net/articles/2017/1201-1529054318.pdf

Khin Zaw. (2001). *Advanced educational psychology*. Ph.D. program course material. Yangon University of Education.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Retrieved January 22, 2016, from http:// standards. nctm. org/document/chapter2/index.htm

Prabhakaram, R. S. (1998). *Concept attainment model in mathematics teaching*. New Delhi: Discovery Publishing House.

Sang, M. S. (2003). *An education course for K.P.L.I., theme 2: Student development, teaching-learning process & evaluation.* Selangor: Regalia Business Centre.

Santrock, J. W. (2006). *Educational psychology* (2nd ed.). New York: McGraw-Hill.

Shamnad, N. (2005). *Effectiveness of concept attainment model on achievement in Arabic grammar of standard IX students* [PDF file]. Unpublished master's thesis, Mahatma Gandhi University, Kottayam. Retrieved January 10, 2016 from http://arabicuniversitycollege.yolasite.com/...%20Students.pdf

Singh, Y. K., Sharma, T. K., & Upadhya, B. (2009). *Educational technology: Teaching learning.* New Delhi: APH Publishing Corporation.

Zubair, P. P. (2012). *Teaching of mathematics.* New Delhi: APH Publishing Corporation.