THE EFFECTIVENESS OF DIFFERENTIATED INSTRUCTION ON HIGHER-ORDER AND LOWER_ORDER THINKING SKILLS OF MIDDLE SCHOOL STUDENTS IN MATHEMATICS

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Abstract

The purpose of this study is to investigate the impact of differentiated instruction on higher-order and lower-order thinking skills of middle school students in mathematics. Both quantitative and qualitative research methods were conducted to obtain the required data. The design adopted for quantitative study was one of the quasi-experimental designs, non-equivalent control group design. The subjects were (30) Grade Six students from BEHS (Tamarkone) in Wundwin Township, (67) Grade Six students from BEMS (1) in Wundwin Township, (140) Grade Six students from BEHS (1) in Thazi Township and (59) Grade Six students from BEHS (Khetmauk) in Thazi Township. The instruments used in the study were pretest, learning style inventory, posttest and interview questions. Experimental groups were taught with differentiated instruction, while the control groups were taught the same concept using formal method. Students' higher-order thinking skills and lower-order thinking skills on posttest were compared using one-way ANCOVA. The results showed that there were significant differences between middle school students who receive differentiated instruction and those who do not receive it in performing higher-order thinking level questions and lower-order thinking level questions in all selected schools. The interview findings pointed out that the teachers who taught the experimental groups had positive attitudes towards differentiated instructional design. Therefore, it can be concluded that differentiated instruction is a very suitable and valuable instructional design for teaching of mathematics.

Keywords: Differentiated Instruction, Mastery Learning Style, Understanding Learning Style, Interpersonal Learning Style, Self-expressive Learning Style, Higher-order Thinking Skills, Lower-order Thinking Skills**.**

Introduction

Gregory and Chapman (2002, cited in Dixon, Yssel, Connell & Hardin, 2014) expressed that it is important in education to change and renew. Factors that contribute to the ever-changing classroom landscape include common core state standards, standards-based classrooms, high expectations and accountability for all students, multicultural diversity, recognition of different learning styles and multiple intelligences, and rapid societal and technological changes. Therefore, teachers should consider new instructional design for the students of different learning abilities.

Statement of the Problem

The schools in Myanmar, all students have the opportunities to learn the same content in nearly the same way. The students may try to learn the content in their own ways according to their learning styles. Therefore, a major issue in the classroom mathematics teaching is whether the specific learning differences of each student are being met. Differentiated instruction can help teachers to promote academic achievement in students.

Purpose of the Study

The main purpose of this study is to investigate the impact of differentiated instruction on higher-order and lower-order thinking skills of middle school students in mathematics. The specific objectives are as follows.

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1. To develop a differentiated instructional design for middle school students.
2. To explore the effectiveness of differentiated instructional design on middle school students' higher-order thinking skills and lower-order thinking skills in mathematics.
3. To find out the teachers' attitudes for implementing differentiated instruction in the mathematics classroom.
4. To make suggestions and recommendations for the improvement of mathematics teaching.

Research Questions

This study aims to answer the following research questions.

1. Is there a significant difference in the higher-order thinking skills between middle school students who receive differentiated instruction and those who do not receive it?
2. Is there a significant difference in the lower-order thinking skills between middle school students who receive differentiated instruction and those who do not receive it?
3. What are the attitudes of teachers towards using differentiated instruction in mathematics classroom?

Scope of the Study

The present study is geographically restricted to two townships in Meiktila District: B.E.H.S (Tamarkone) and B.E.M.S (1) in Wundwin Township, and B.E.M.S (Khetmauk) and B.E.H.S(1) in Thazi Township. B.E.M.S (1) Wundwin and B.E.H.S(1) Thazi are regarded as urban areas , and B.E.H.S (Tamarkone) and B.E.M.S (Khetmauk) are regarded as rural areas according to Township Education Office's criteria. Participants in this study are Grade Six students who are learning mathematics with reformed curriculum and junior teachers from the selected schools in the (2021-2022) Academic Year in which junior teachers' teaching and learning activities are linked with differentiated instruction. In this study, chapter one to four in Grade Six Mathematics textbook Volume (I) and chapter one to two in Grade Six Mathematics textbook Volume (II) were selected to use in the experiment.

Definitions of Key Terms

The key terms used in this study are presented as follows:

Differentiated Instruction. Differentiated Instruction is described as student-centered and can be used to reach and engage students based on their diverse interests, strengths, weaknesses and how they learn best (Tomlinson, 2001, cited in Amadio, 2014).

Mastery Learning Style. The mastery learning style describes learning that focuses on remembering basic facts and details (Dodge, 2005, cited Thomas & Brunsting, 2010).

Understanding Learning Style. Understanding learning style describes learning that develops reasoning skills and an understanding of concepts, patterns, and proofs for ideas (Dodge, 2005, cited Thomas & Brunsting, 2010).

Interpersonal Learning Style. The interpersonal learning style describes learning from approaches that emphasize cooperative learning, real-life contexts, and connections to everyday life (Dodge, 2005, cited Thomas & Brunsting, 2010).

Self-expressive Learning Style. The self-expressive learning style describes learning that produces original work using creative application and synthesis of old skills and information (Dodge, 2005, cited Thomas & Brunsting, 2010).

Higher-order Thinking Skills. Higher-order thinking skills include analysis, synthesis and evaluation (Qasrawi & Anderlrahman, 2020).

Lower-order Thinking Skills. Lower-order thinking skills include knowledge, comprehension and application (Qasrawi & Anderlrahman, 2020).

Significance of the Study

Htoo Thant (2018) said that Myanmar government has continued changes and improvement from the by-heart learning with good marks and high grades to the system which is leading towards learning about twenty first century skills such as communication, collaboration, creativity and problem solving, critical thinking, and citizenship in education sector. In Myanmar, KG+12 system had been introduced.

Glasgow, McNary and Hicks (2006, cited in McLean, 2010) said that with the curriculum changes, teachers cannot recognize the multitude of differences in individual students within a given classroom, but often they have failed to integrate these differences into their teaching strategies. This research is expected to give some benefits for teachers and students in teaching-learning process. By using differentiated instruction, every student is expected to be more involved in learning mathematics and feel happier in doing of practical works.

Review of Related Literature

Background Philosophies for Developing Differentiated Instruction

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

Differentiated instruction is rooted in pragmatism. According to pragmatism, knowledge gained through doing, acting and living is useful and it emphasizes the functional knowledge and understanding (Wilson, Kenneth & Bennett, 1994). Thus, it fosters the learners to be creative and constructive by nature and to be an active participant in educational process.

In progressivism, children's interests and feelings are the center of education, instead of past knowledge and value (IDCJ, 2004). Thus, students' practice in instructional procedures through emphasizing their interests and feelings is conducted in implementing differentiated instruction process.

Both Vygotsky's and Piaget's theories are also constructivist, emphasizing that children actively construct knowledge and understanding rather than being passive receptacles (Savery & Duffy, 2001). Therefore, social interaction plays a fundamental role in the proposed design of differentiated instruction.

Background Learning Theories for Developing Differentiated Instruction

Five learning theories are taken into consideration in the proposed differentiated instructional design.

Piaget's theory (1936, cited in McLeod, 2008) of cognitive development explains how a child constructs a mental model of the world. Piaget regarded as cognitive development as a process which occurs due to biological maturation and interaction with the environment. Thus, the proposed design for differentiated instruction is concerned with the developmental aspect of human learning and the way in which content is structured for learning.

The approach of differentiated instruction is held by the socio-cultural learning theory which is based on the work of Russian psychologist Lev Vygotsky (1962, 1978, cited in Burkett, 2013). The socio-cultural learning theory holds that the previous experiences and culture of the learner are critical because these influence the learning process for each individual. Therefore, social interaction is essential to the development of cognition.

Differentiated instruction is grounded Gardner's multiple intelligence theory. The theory is based on the belief that all of the human intelligences should be recognized and nurtured as well as all combinations of the multiple intelligences (Armstrong, 1994, cited in Burkett, 2013). Therefore, teachers should be recognized and nurtured their students according to their multiple intelligences to adapt learning.

Brain-based learning has important implications for the differentiated classroom. The students must be in an environment conducive to learning. Students need to be challenged at appropriate levels in order for learning to occur. The brain needs to create its own understanding of ideas and skills by being presented with the concept to the facts so the learner can see the relationship between these and thus connect new information to prior knowledge (Burkett, 2013). Thus, the three concepts of brain-based learning can be considered in differentiated instruction depending on student levels of readiness, the needs of the teacher, and the nature of the content being taught.

Customized learning is really more focused on how students can be guided to initiate their own projects. It encourages them to willingly seek out knowledge according to their own drive and choice as opposed to how other methods give emphasis to specific cognitive and literary disciplines for the sake of the students' general progress (LLA, 2019).Therefore, the concept of customized learning theory is considered in proposed differentiated instructional design to encourages the students seek out knowledge through their own drive and choice, emotions, ambitions, and draw out their innate abilities to cope with actual life challenges.

Background Teaching Models for Developing Differentiated Instruction

Five teaching models are taken into consideration in the proposed differentiated instructional design.

According to Tomlinson's DI model, students' readiness, interests and learning profiles are important for teachers to recognize when providing instruction as they influence how students make sense of new information. Moreover, teachers must adapt the curricular elements, content, process and products according to students' readiness, interests and learning profiles (Erickson, 2010). Therefore, in developing proposed instructional design for differentiated instruction, the ideas of Tomlinson's model are mainly adopted for proposed design.

Dr. Khin Zaw's multimodal theoretical constructs consists of five main principles or components namely, channel capacity, brain resilience, redundancy, unitizing/symbolizing modes, and diffusing/re-synthesizing mode (Khin Zaw, 2001). The third component of instructional procedures in proposed design includes positive or negative redundancy. Moreover, the third component in the proposed design bases utilizing/symbolizing modes and diffusing/ resynthesizing modes. Therefore, this model is adopted for the major components involved in the proposed instructional design for differentiated instruction.

According to a multi-dimensional data model for learning material, the levels differ in various grades of intellectual and practical mastery of the subject in question. So systems to grade learners into various levels for defining target groups for the deployment of instructions of different difficulty degrees are already well known in the e-Learning community. The model quoted provides a one dimensional classification. More than one criterion is necessary in various degrees of intensity to characterize the specificity optimal to any given learner (Lucke, 2002, cited in Tavangarian, Leypold, Nolting, Roser & Voigt, 2004). Therefore, criteria for four mathematical

learning styles were based the ability to concentrate their learning interests in developing proposed instructional design.

According to To-With-By Model, stage one, or tier one, is "to" that is main lesson. In other words, "to" means the direction of instruction. Stage two, or tier two, is the "with" stage. "With" means the guided instruction. Stage three, or tier three, is the "by" stage. "By" means self-directed learning (Campbell, 2009).Therefore, in developing proposed instructional design for differentiated instruction; the ideas of to-with-by model are mainly adopted for the third component (instructional procedures) of proposed design.

The goal of Thomas and Brunsting (2010) was to make a deep connection between mathematics and learning styles. They identified four distinct styles of mathematics learners such as mastery math students, understanding math students, self-expressive math students and interpersonal math students. Therefore, in developing proposed instructional design for differentiated instruction, the ideas of grouping based on four mathematical learning styles are mainly adopted in the proposed instructional design.

Higher-order and Lower-order Thinking Skills

Higher-order thinking skills include analysis, synthesis and evaluation (Qasrawi & Anderlrahman, 2020). Higher-order thinking skills include critical, logical, reflective, metacognitive and creative thinking. Lesson plans include modeling of thinking skills, examples of applied thinking and adaptations for diverse student needs. Scaffolding that gives students support at the beginning of a lesson and gradually requiring students to operate independently helps students develop higher-order learning skills. Questioning strategies generate higher order thinking skills. Cooperative learning is effective for developing higher order thinking skills through individual accountability. Useful learning strategies include elaboration, organization and metacognition. Presentations are short and coupled with guided practice to teach sub-skills and knowledge. Small group activities such as students' discussion and cooperative learning are effective in the development of higher order thinking skills. Activities involve challenging tasks, teacher encouragement to stay on task and ongoing feedback about group progress (Kauchak & Eggen, 1998).

Lower order thinking skills include knowledge, comprehension and application (Qasrawi & Anderlrahman, 2020). Lower-order thinking skills involve memorizing, recalling the knowledge one already has and understanding what one knows. Lower-order thinking skills are the simple thinking processes that serve as a basis for more complex process. Higher-order and lower-order thinking skills are interconnected. Higher-order thinking skills cannot be developed and enhanced separately from lower-order thinking skills (Tikhonova & Kudinova, 2015).

In this study, higher-order thinking skills and lower-order thinking skills involves in learning objectives, the lesson plans, pre-assessment, formative assessment and summative assessment.

Proposed Instructional Design for Differentiated Instruction

In proposed differentiated instructional design, there are five main components. Each of them is briefly explained as follows.

Learning objectives. In this component, learning objectives are identified based on Bloom's Taxonomy of educational objectives and skills in twenty first century.

Pre-assessment. In analyzing pre-assessment component, the instructor assesses the students' background knowledge.

Whole class instruction (grouping). The instructor assesses background knowledge such as a whole class. In whole class learning, the instructor provides students with opportunities to work collaboratively as a whole class. The students are grouped homogeneous groups based on four mathematical learning styles within one lesson.

Questioning (scaffolding strategy). The instructor uses questions as a scaffolding activity to provide support, assess progress and be adjusted according to student's needs in discussion or interaction.

Collaborative learning (learning activities). The instructor uses a collaborative learning strategy to involve student groups in a whole class activity. Each group brainstorms responses related to the questions. Then, the class discusses and reflects on the whole class effort.

Learning process. Learning process is acquiring new knowledge, understanding, behaviours, skills, values and attitudes.

Small group instruction (grouping). When considering for implementing mathematics activities, the instructor uses small group activities. In small group learning, students are assigned to four groups based on commonalities with regard to their respective learning style (mastery, understanding, interpersonal and self-expressive).

Cooperative learning (scaffolding strategy). The instructor uses cooperative learning to incorporate scaffolding in homogeneous groupings that focus on providing peer and resource supports.

Task rotation (learning activities). The instructor use as task rotation based on their four learning styles. The tasks are based on four different strategies such as mastery strategies, understanding strategies, interpersonal strategies and self-expressive strategies.

Students' Reflection. Student's reflection is to be aware of their own thinking processes and to be able to make transparent to others. It is an assessment why they learned and how they learned and what needs to be done as a result.

Partners/ Individuals (grouping). When considering for implementing students' reflection, the instructor gives two choices for students such as partners or individuals.

Graphic organizers/Think-alouds (scaffolding strategy). In working with partners, the instructor uses graphic organizers to provide multiple formats to help students organize thinking and research. For individual learning experiences, the instructor uses think-alouds to provide opportunities for students to engage in metacognitive activities while being provided with support and guidance.

Discussion breaks/ Learning logs (learning activities). In working with partners, the instructor uses discussion breaks to provide an opportunity for students to discuss ideas, questions and information. In individual learning experiences, the instructor uses learning logs to track and reflect their learning.

Formative Assessment. The instructor can assess students' learning throughout the learning process of the model by formative assessment strategies such as asking questions, observing students' facial expressions and body language, and by listening students' discussion.

Summative Assessment. The students work more independently. After the evaluation process, the instructor examines whether the students achieved the desired learning outcomes or not. If they achieve these outcomes, they are moved to the next content. Unless they achieve these outcomes, feedback is made to provide next lesson preparation.

Method

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

Research Design

The aim of this study is to investigate the impact of differentiated instruction on students' achievement in mathematics at middle school level. This study was adopted by using the explanatory sequential mixed method (QUAN → qual) design.

Quantitative Research Method

Quantitative research method was used to analyze students' mathematics achievement and higher order thinking skills and lower order thinking skills. The non-equivalent control group design, one of the quasi-experimental designs, was adopted in this study.

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

Table 1 Population and Sample

Selected Township	Selected School	No. of population	No. of Subject
Wun Dwin	B.E.H.S (Tamarkone)	30	30
	B.E.M.S (1) Wundwin	67	67
Thazi	B.E.H.S(1) Thazi	140	140
	B.E.M.S (Khetmauk)	59	59

Instruments. Pretest, learning style inventory and posttest were used as quantitative research instruments.

Pretest. The pretest question consists of (14) multiple choice items and (5) short questions. Test items were constructed based on Grade Four mathematics textbook. The total score for pretest is (30) marks. Time duration is (45) minutes, (1) period.

Learning style inventory. In this study, the inventory for four learning styles was used by Thomas and Brusting (2010). Each component consisted of (10) items on five-point Likert-type scale from (1) to (5), totally (40) items were included in this inventory.

Posttest. The posttest question consists of (13) multiple choice items and (7) short questions. Test items were constructed based on Grade Six mathematics textbook. The total score for posttest is (30) marks. Time duration is (45) minutes, (1) period.

Learning materials. To construct learning activities for differentiated instruction, four chapters were selected from Grade Six mathematics textbook Volume (I) and two chapters were selected from Grade Six mathematics textbook Volume (II).

Data Analysis. The Statistical Package for Social Science (SPSS) Version 20 was used to analyze the quantitative data. The data were analyzed by using one-way analysis of covariance (One-Way ANCOVA).

Qualitative Research Method

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

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

Instruments. Teacher interview was used.

Interview. The first part of interview question is about the demographic information and the next is about the attitude of teachers towards the proposed differentiated instructional design.

Data Analysis. In this study, coding analysis was used to analyze the qualitative data. Thematic analysis in content analysis was used to establish the existence and frequency of concepts, most often represented by words of phrases in a text.

Pilot Study

Pilot study was conducted with Grade Six students and middle school teachers in B.E.H.S (Branch-Shaw Pin), Meiktila District. The internal consistency (Cronbach's Alpha) of the pretest and posttest were 0.797 and 0.820 respectively. Therefore, these items were suitable to use for experimental study.

Procedure

Before the experimental study, the training for differentiated instruction was given for three days. And then, the sample schools were selected randomly from Wundwin and Thazi Townships. A pretest was administered to both groups to measure the initial levels and then learning style inventory was administered to determine which learning style students have based on four types of mathematics learning styles. Learning styles results in all selected schools can be seen in Table 2.

Table 2 Learning Styles Results in S1, S2, S3 and S4

Learning Style	No. of Participants				Total
	S1	S2	S3	S4	
Mastery Learning Style	3	2	12	10	27
Understanding Learning Style	4	13	17	11	45
Interpersonal Learning Style	6	11	27	7	51
Self-expressive Learning Style	2	8	14	2	26
Total	**15**	**34**	**70**	**30**	**149**

Note. S1=B.E.H.S (Tamarkone); S2= B.E.M.S (1), Wundwin;
S3= B.E.H.S (1), Thazi; S4= B.E.M.S (Khetmauk)

The results showed the number of interpersonal learning style learners had at the first position, understanding learning style at the second position, mastery learning style at the third position and self-expressive learning style at the fourth position. Therefore, it can be interpreted that most of the students preferred to participate in interpersonal style learning (See Table 2).

Findings

Quantitative Research Findings of Pretest

Table 3,4,5,6 shows one-way ANCOVA results for pretest scores of Grade Six students in S1, S2, S3 and S4.

Table 3 One-way ANCOVA Results for Pretest Scores of Grade Six Students in S1

Source	Type III Sum of Squares	*df*	Mean of Squares	*F*	Sig
Corrected Model	.033[a]	1	.033	0.002	.960
Intercept	7905.633	1	7905.633	592.922	.000
ID	.033	1	.033	0.002	.960 (ns)
Error	373.333	28	13.333		
Total	8279.000	30			
Corrected Total	373.367	29			

Note. a. R Squared =.000 (Adjusted R Squared= .36),
ns= not significant

The results showed that there were no significant differences between entry behaviours of the experimental groups and the control groups in S1.

Table 4 One-way ANCOVA Results for Pretest Scores of Grade Six Students in S2

Source	Type III Sum of Squares	*df*	Mean of Squares	*F*	Sig
Corrected Model	79.718[a]	1	79.718	8.482	.005
Intercept	19152.195	1	19152.195	2037.771	.000
ID	79.718	1	79.718	8.482	.005**
Error	610.909	65	9.399		
Total	19884.000	67			
Corrected Total	690.627	66			

Note. a. R Squared =.115 (Adjusted R Squared= .102),
** $p <$ .01.

The results showed that there were significant differences between entry behaviours of the experimental groups and the control groups in S2.

Table 5 One-way ANCOVA Results for Pretest Scores of Grade Six Students in S3

Source	Type III Sum of Squares	*df*	Mean of Squares	*F*	Sig
Corrected Model	1.607[a]	1	1.607	0.129	.720
Intercept	35107.779	1	35107.779	2817.419	.000
ID	1.607	1	1.607	0.129	.720 (ns)
Error	1719.614	138	12.461		
Total	36829.000	140			
Corrected Total	1721.221	139			

Note. a. R Squared =.001 (Adjusted R Squared= .006),
ns= not significant

The results showed that there were no significant differences between entry behaviours of the experimental groups and the control groups in S3.

Table 6 One-way ANCOVA Results for Pretest Scores of Grade Six Students in S4

Source	Type III Sum of Squares	*df*	Mean of Squares	*F*	Sig
Corrected Model	195.771[a]	1	195.771	33.523	.000
Intercept	16080.516	1	16080.516	2753.566	.000
ID	195.771	1	195.771	33.523	.000***
Error		57	5.840		
Total	16674.000	59			
Corrected Total	528.644	58			

Note. a. R Squared =.370 (Adjusted R Squared= .359),
*** $p <$ .001

The results showed that there were significant differences between entry behaviours of the experimental groups and the control groups in S4.

Quantitative Research Findings of Posttest

Table 7 shows one-way ANCOVA results for mathematics achievement on posttest scores of Grade Six students in S1, S2, S3 and S4.

Table 7 One-way ANCOVA Results for Higher-order Thinking Skills on Posttest of Grade Six Students in S1, S2, S3 and S4

School	Source	*df*	*F*	*MD*	Sig. (2-tailed)	Partial Eta Squared	Unadjusted Mean		Adjusted Mean	
							EG	CG	EG	CG
BEHS (Tamarkone)	Pretest	1	0.086		.771	.003				
	Group	1	18.697	2.80	.000***	.409	11.33	8.53	11.33	8.53
	Error	27								
BEMS(1), Wundwin	Pretest	1	0.035		.853	.001				
	Group	1	26.765	2.32	.000***	.295	10.82	8.48	10.81	8.49
	Error	64								
B.E.H.S (1), Thazi	Pretest	1	0.011		.915	.000				
	Group	1	31.064	1.80	.000***	.185	11.03	9.23	11.03	9.23
	Error	137								
B.E.M.S (Khetmauk)	Pretest	1	0.187		.667	.003				
	Group	1	34.687	2.98	.000***	.382	11.57	8.72	11.63	8.65
	Error	56								

Note. EG = Experimental Group, CG = Control Group,
$^{***}p < .001$.

The results show that the use of proposed instructional design has a significant effect on higher-order thinking skills of posttest in students' mathematics achievement.

Table 8 One-way ANCOVA Results for Lower-order Thinking Skills on Posttest of Grade Six Students in S1, S2, S3 and S4

School	Source	*df*	*F*	*MD*	Sig. (2-tailed)	Partial Eta Squared	Unadjusted Mean		Adjusted Mean	
							EG	CG	EG	CG
BEHS (Tamarkone)	Pretest	1	0.013		.910	.000				
	Group	1	16.281	1.87	.000***	.376	9.40	7.53	9.40	7.53
	Error	27								
BEMS(1), Wundwin	Pretest	1	0.179		.674	.003				
	Group	1	7.133	1.08	.010*	.100	10.21	9.06	10.17	9.09
	Error	64								
B.E.H.S (1), Thazi	Pretest	1	2.037		.156	.015				
	Group	1	15.531	1.13	.000***	.102	10.44	9.30	10.44	9.31
	Error	137								
B.E.M.S (Khetmauk)	Pretest	1	0.047		.830	.001				
	Group	1	13.222	1.6	.001**	.191	22.43	8.90	10.46	8.86
	Error	56								

Note. EG = Experimental Group; CG = Control Group,
$^{***}p < .001$. $^{**}p < .01$. $^{*}p < .05$.

The results show that the use of proposed instructional design has a significant effect on lower-ordered thinking skills of posttest in students' mathematics achievement.

Findings of Teachers' Interviews

Four teachers who taught the experimental groups in the selected schools were interviewed. Coding analysis and thematic analysis were used to analyze the qualitative data. There are five themes to analyze the data.

Theme 1 (Teaching Experience): All teachers who taught in the experimental groups had many years of teaching experience and their total teaching services are above 10 years. They all had both primary teacher training and junior teacher training. Three teachers are BA degree holders and the rest of three teachers are BSc degree holders but only one teacher is in line with her mathematics major specialization and teaching.

Theme 2 (Knowledge about Differentiated Instruction): According to their responses, they understand differentiated instruction. They said that there were differences between the new curriculum prescribed by the ministry of education and the proposed instructional design. Teaching aids and learning materials are easy to collect in daily life situations for teachers and effective for students. Classroom setting was prepared for all students to be ease and then the students actively participate in all class learning activities.

Theme 3 (Challenges) : The challenge was that knowledge about differentiated instruction, time allocation, class size, differences between urban and rural students, knowledge about collaborative summarizing.

Theme 4 (Overcoming the Challenges) : They solved those problems by knowledge from training orientation to differentiated instruction, adaptation with time allocation, preparation with classroom setting and peer discussion.

Theme 5 (Advantages) : They propounded that it is a very suitable and valuable design for teaching of mathematics. In general, the proposed differentiated instructional design improved students' mathematics learning.

Summary of Research Findings

Research findings from the selected schools are summarized as follows.

1. There were significant differences between experimental groups and control groups on the achievement of higher-order thinking skills in all four selected schools.
2. There were significant differences between experimental groups and control groups on the achievement of lower-order thinking skills in all four selected schools.
3. Teachers propounded that it is a very suitable and valuable design for teaching of mathematics.

Discussion

Discussion for Research Question (1). In terms of the stastical results, students' performance had significant difference on the achievement of higher-order thinking skills. Therefore, the proposed differentiated instructional design could encourage the improvement of the students' mathematics higher-order thinking skills.

Discussion for Research Question (2). In terms of the stastical results, students' performance had significant difference on the achievement of lower-order thinking skills. Therefore, the proposed differentiated instructional design could encourage the improvement of the students' mathematics lower-order thinking skills.

Discussion for Research Question (3). In teachers' interview, the teachers who taught the experimental groups reported that all prepared learning activities and materials were very useful

and effective for teaching of mathematics. Moreover, findings from teachers' interview proved that proposed instructional design for differentiated instruction has positive effect on higher-order thinking skills and lower-order thinking skills.

Discussion for Contributions. It is important for mathematics teachers to manage learners with different learning styles. So, the role of differentiated instruction and their learning styles are important in teaching and learning situations. It is necessary for teachers to have teaching qualities to adapt the needs of the students.

It is hoped that using instructional design for differentiated instruction in middle school mathematics teaching can develop students' higher-order thinking skills and lower-order thinking skills. It is necessary to carry out more researches on differentiated instruction to investigate its effects or impacts on Myanmar students in different school levels.

Suggestions

Suggestions for Time Allocation. Sufficient time should be given to each learner to thoroughly explore, understand, and use ideas, information, and skills. A teacher should try to give the students adequate time to sort through the information, establish the meaning of it all, develop a mental program for using and remembering what is learned, and apply what is learned to their own personal life. In content areas, sufficient time should be devoted to instruction to allow students to become proficient with the concepts and skills outlined in the teaching-learning paths.

Suggestions for Class Size. According to Organisation for Economic Co-operation and Development (OECD, 2021), at the lower secondary level, average class size in OECD countries is 1:23. The class size should be small for implementing differentiated instruction. The teachers who taught the experimental groups reported that it was difficult to control the class and provide feedback individually. Therefore, it is suggested that teacher-student ratio should be about 1:30 according to Myanmar situation.

Suggestions for e-Learning. E-learning is a solution for individual learning. The levels differ in various grades of intellectual and practical mastery of the subject in question. So systems to grade learners into various levels such as novice level, advanced beginner level, competence level, proficiency level, expertise level for defining target groups for the development of instructions of different difficulty degrees are already well-known in e-learning community (Tavangarian, Leypold, Nolting, Roser & Voigt, 2004). Therefore, it can be suggested that teachers should try to study how to use e-learning to meet students' different needs in 21st century demands and explore different levels in e-learning for target groups to be effective teaching-learning classrooms.

Suggestions for Mathematics Teachers. Learning with mixed abilities creates learning opportunities for sharing knowledge. Mathematics teachers should try to force students to solve mathematics problems in different ways. Teachers should try to write a story for the mathematics questions and draw a picture to help the students' understand the problems. They should try to deliver lessons that develop students' theoretical and applied mathematics skills.

Conclusion

The results of quantitative study and the qualitative study support the objectives of the research study. According to the findings of the research, this proposed instructional design was useful to some extent for mathematics learning.

Regarding the need for further pedagogic studies, it is suggested that a merger of two theoretical constructs: the UDNR multimodal thought process model and German e-learning expert D. Tavangarian's flexible multi-dimensional data model, or the generation of individual content (Rostock University) should be considered. It is believed that the former's symbolizing and resynthesizing modes of capta processing and Re Catter's customized blends of differentiated document generation will, together, prove to be the optimal mathematics learning of all ages.

Finally, it can be concluded that this study also serves as a future reference for researchers in other subject areas. Not only in mathematics but also in other subjects, concepts are the basic building blocks of understanding. Based on these findings, further researches can be conducted on the effectiveness of mathematics through differentiated instruction.

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