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AN INVESTIGATION INTO THE EFFECTIVENESS OF DISCOVERY LEARNING IN TEACHING LOWER SECONDARY SCIENCE

Thida Wai[1] and Soe Than[2]

Abstract

The major purpose of this study is to investigate the effectiveness of discovery learning in teaching lower secondary science. The study was conducted with both quantitative and qualitative research methods. Firstly, a descriptive study was made to explore whether there is a link between the junior assistant science teachers' teaching-learning activities and the six stages of discovery learning cycle. The subjects for this study were selected from the Yangon City Development Area by using a stratified random sampling method. A total of (198) junior assistant science teachers from (36) schools were selected for the study. According to the results, the activities of the junior assistant science teachers are strongly linked with the engagement and readiness stage, but weakly linked with the exploration and discovery stage of the discovery learning cycle. Secondly, an experimental study was used to investigate the effectiveness of discovery learning. In this experimental study, the subjects were Grade Six students selected from the schools where there have moderate teachers' teaching-learning activities on discovery learning in each strata. The experimental design adopted in this study was one of the quasi-experimental designs, namely, nonequivalent control group design. The experimental group was treated with discovery learning and the control group was taught by using teacher-centered method. After that, a posttest was administered to two groups. Independent samples *t*-test was used to test whether there were significant differences between the two groups. Findings indicated that those who received a treatment by using discovery learning demonstrated significantly better than those who do not received it. Findings proved that discovery learning has positive contribution to the science teaching at the middle school level and could encourage the improvement of students' higher order thinking skills.

Keywords: Effectiveness, Discovery Learning, Science

Introduction

Today, the world is passing through rapid changes. In such a world, education cannot resist to change. Memorizing facts and information is not the most important skill in today's world. The important point is an understanding of how to get and make sense of the mass of data. In a society in which education has focused on transmitting "what we know," it is a challenge to develop a widespread view that "how we come to know" is very important in modern society. The teacher's role was to help raise the interest of learners, guide them in discovery and ensure relevance of the exercises.

Schools need to go beyond data and information accumulation and move toward the generation of useful and applicable knowledge. The child should make them his own, and should understand their application here and now in the circumstances of his actual life. From the very beginning of his education, the child should experience the joy of discovery. The discovery which he has to make is that general give an understanding of that stream of events which pours through his life, which is his life. Of course, education should be useful, whatever the aim of life (Whitehead, 1967).

[1] Dr, Lecturer, Department of Methodology, Yangon University of Education
2 Dr, Retired Professor, Department of Methodology, Sagaing University of Education

Education is the acquisition of the art, of the utilization of knowledge. This is an art very difficult to impart. In education, the broad primrose path leads to a nasty place. This evil path is represented by a book or set of lectures which will practically enable the student to learn by heart all questions likely to be asked at the next examination. It contains within itself the problem of keeping knowledge alive, of preventing it from becoming inert, which is the central problem of all education.

Instruction is geared toward helping the students to develop learning and thinking strategies that are appropriate for working within various subjects domains. In the discovery learning process, learners always personally construct their understanding. The key notion is that people learn best by actively constructing their own understanding. It is a very personal endeavor, whereby internalized concepts, rules and principles may consequently be applied in a practical real-world context.

Purposes

The purposes of this study are as follows:

1. To explore whether junior assistant science teachers' teaching-learning activities are linked with discovery learning.
2. To develop an instructional design for science teachers to apply discovery learning in science teaching.
3. To investigate the effectiveness of discovery learning in Grade Six students, whose science teachers' teaching learning activities are linked with discovery learning.
4. To give suggestion for improving middle school science teaching based on the data obtained from this study.

Research Questions

This study is intended to answer the following research questions:

1. What degree do junior assistant science teachers use the activities that are linked with discovery learning?
2. Do students from the discovery learning group perform better than those from the teacher-centered learning group on the overall science achievement test?
3. How do students and teachers feel towards discovery learning in science teaching?

Definition of the Key Terms

Effectiveness

Effectiveness (effective) means having power to produce, or producing, a desire result (Times-Chambers, 1992).

Discovery Learning

Discovery learning is the act of finding out something that before was unknown to mankind, including all forms of obtaining knowledge for oneself by the use of one's own mind (Bruner, 1997).

Discovery learning is the mental process of assimilating concepts and principles. Discovery learning occurs when an individual is mainly involved in using his mental process to mediate (or discover) some concept or principle (Trowbridge & Bybee, 1990).

Limitations

The following points indicate the scope of the study.

(1) This study is geographically restricted to Yangon Region.

(2) For the descriptive research design, participants are only junior assistant science teachers from the selected schools.

(3) For the experimental research design, participants are chosen from Grade Six students in the four selected schools in which junior assistant science teachers' teaching learning activities are linked with discovery learning.

Review of Related Literature

Theoretical Foundation of Discovery Learning

In developing the discovery learning for science teaching, constructivism is deeply taken into consideration. Constructivism is a way of teaching and learning that intends to maximize student understanding. Constructivism is defined as teaching that emphasizes the active role of the learner in building understanding and making sense of information (Cruickshank & Jenkins, 2006). Constructivists believe that to gain understanding requires students to engage in group experiences in which they learn through active involvement, by doing. Constructivists believe that the role of the teacher is to facilitate active involvement and to support groups and individuals to increase their likelihood for success. Social constructivists view the classroom as a community charged with the task of developing knowledge. Social constructivists view learning as an active process where learners should learn to discover principles, concepts and facts for themselves. Bruner's definition of "discovery" was not restricted to "the act of finding out something that before was unknown to mankind, but rather included all forms of obtaining knowledge for oneself by the use of one's own mind" (Bruner, 1977).

According to Dewey, education should not be separate from life itself that education should be child-centered, guided by a well-trained teacher who is grounded in pedagogical and subject knowledge. He advocated that child-centered learning must be based on real-world experiences. In his book "Democracy and Education", Dewey argued that it was critical for teaching to go beyond the presentation of facts. In the discovery learning process, students interact with the environment by exploring and manipulating objects, wrestling with the questions and controversies, or performing experiments, solving the problems and making decision. Discovery learning is a forerunner to constructivist thinking of learning and recognizes that knowledge is constructed by the learner in their own mind.

Developing Discovery Learning for Science Teaching

Today, science teaching is an important and vital topic in modern education. Science is the system of knowing about the universe through data collected by observation and controlled experimentation. It is a way of thinking, a way of understanding the world (Carin & Sund, 1989). Ways of thinking in science are called the process skills. In the discovery learning process, the learner uses the mind in logical and mathematical ways to organize and internalize concepts and principles of the world.

In 1962, Robert Karplus and J. Myron Atkin developed the three-phase learning cycle for discovery learning. Originally, the three phases of the cycle were referred to as exploration, invention, and discovery (see Figure 1).

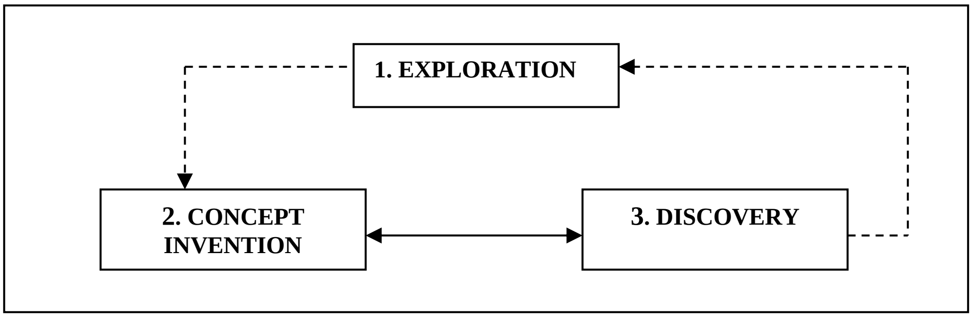
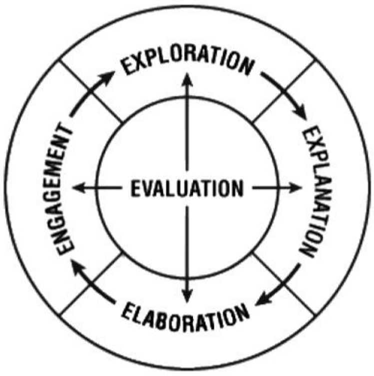


Figure 1: The Three-phase Discovery Learning Cycle
Sources: From Carin & Sund, (1989), p. 99

In the late 1980s, Rodger Bybee modified the learning cycle to include additional phases such as engagement, exploration, explanation, elaboration, and evaluation (see Figure 2).



Sources: From Moyre, Hackett & Everett, (2007), p. 12
Figure 2 The 5E Discovery Learning Cycle

In 2008, Page Keeley formulated the science assessment, instruction, and learning cycle consists of engagement and readiness, eliciting prior knowledge, exploration and discovery, concept and skill development, concept and skill transfer, and self-assessment and reflection. Based on the above consideration factors of discovery learning, researcher develops the proposed discovery learning model for science teaching in basic education.

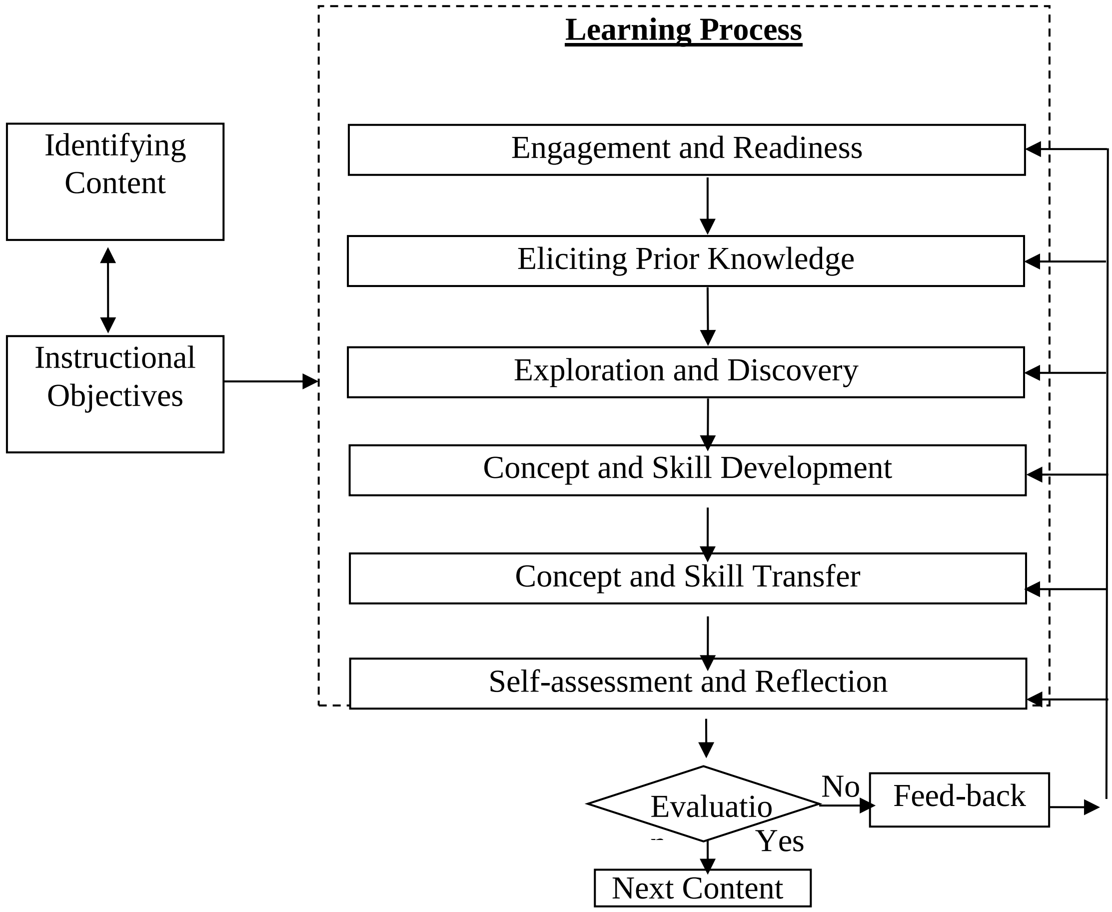


Figure 3 Proposed Discovery Learning Model for Science Teaching in Basic Education Methodology

The study was conducted with both quantitative and qualitative research methods. Quantitatively, it consists of both descriptive study and experimental study.

Quantitative Research Method

Descriptive Study

Subjects

The subjects for this study were selected from the Yangon City Development Area by using stratified random sampling method.

Table 1 Selected Townships and Subjects from Yangon City Development Area

Strata	No.of Townships	No.of Selected Townships	No.of Subjects from Each Township	No. of Selected Subjects from Each Strata
Inner City	8	2	22	44
Inner Suburb	9	2	22	44
Outer Suburb	6	2	22	44
Satellite	10	3	22	66
Total	**33**	**9**	**88**	**198**

Instrument

For this study, a set of questionnaires was used to find out whether junior assistant science teachers', especially Grade Six science teachers' teaching-learning activities were linked with the six stages of the discovery learning cycle. The six stages of the discovery learning cycle are (1) Engagement and Readiness (ER), (2) Eliciting Prior Knowledge (EPK), (3) Exploration and Discovery (ED), (4) Concept and Skill Development (CSD), (5) Concept and Skill Transfer (CST), (6) Self-Assessment and Reflection (SAR). It was developed by Page Keeley, (2008). The questionnaire include (44) items of questions to describe teachers' teaching-learning activities in science teaching comprising (42) items of five-point Likert-scale and two open-ended questions.

Procedure

First, literature study concerning with discovery learning was explored and a questionnaire was constructed based on the six stages of discovery learning cycle for junior assistant teachers' teaching- learning activities under the supervision of the supervisor and co-supervisor. For the validation of the research instrument, questionnaires were sent to teacher educators and junior assistant science teachers. Necessary modifications were made under the supervision of the supervisor and co-supervisor. After getting the validation, a pilot test was conducted with (50) junior assistant science teachers from schools in Sanchaung Township in June, 2013. After the pilot test, the major survey was conducted in July, 2013. Questionnaires were distributed to (198) junior assistant science teachers from selected schools. After collecting the questionnaires, data were analyzed by using the Statistical Package for the Social Science (SPSS 20).

Data Analysis

The data were analyzed by using descriptive statistics (mean, standard deviation, frequency, percentage) and one way ANOVA (analysis of variance).

Experimental Study

Subjects

In the experimental study, the subjects were Grade Six students selected from the schools in which the teachers' teaching-learning activities are moderately linked to discovery learning.

Table 2 Sample Size from Four Selected Schools

Strata	Name of School	No. of Subjects		
		Control	Experimental	Total
Inner City	BEMS (1),Mingalartaungnyunt	47	47	94
Inner Suburb	BEMS (4), Hlaing	50	50	100
Outer Suburb	BEMS (5), Mingalardon	43	43	86
Satellite	BEHS (3), North Okkalapa	56	56	112

Experimental Design

The experimental design adopted in this study was one of the quasi-experimental designs, namely, nonequivalent control group design.

Table 3 Experimental Design

Group	No. of Subjects				Pretest	Treatment	Posttest
	BEMS(1)	BEMS(4)	BEMS(5)	BEHS(3)			
Control	47	50	43	56	BSK	Teacher-Centered	SA
Experimental	47	50	43	56	BSK	Discovery Learning	SA

Note: BSK= Basic Science Knowledge, SA= Science Achievement

Instrument

(a) Pretest

The pretest consists of (30) multiple choice items. Test items were constructed based on Grade Five Basic Science textbook.

(b) Posttest

The posttest consists of two sections. Section (A) consists of (30) multiple choice items and section (B) consists of (10) short-answer items. Test items were constructed on Chapter (4), "Energy" from Grade Six General Science textbook.

Procedure

In order to measure the prerequisite knowledge of the selected sample students, a pretest was administered before the treatment was provided. All the selected students had to take it. After that the experimental group was treated with discovery learning and the control group was taught as usual. Posttest was conducted in order to identify whether there is any significant difference between those who did discovery learning and those who did not.

Data Analysis

The data were analyzed by using descriptive statistics, the independent samples *t*-test to compare the differences between the control group and experimental group.

Qualitative Research Method

A qualitative study was conducted to collect the information that could not be observed directly such as students' attitudes, feelings, experiences, and opinions towards discovery learning.

Subjects

To obtain the necessary qualitative data, students were selected from the experimental groups of four schools (see Table 4).

Table 4 Sample Size from Four Selected Schools

Strata	Name of School	No. of Subjects
Inner City	BEMS(1), Mingalartaungnyunt	47
Inner Suburb	BEMS (4), Hlaing	50
Outer Suburb	BEMS (5), Mingalardon	43
Satellite	BEHS (3), North Okkalapa	56

Instrument

To examine the students' attitudes, feelings, experiences, and opinions, a questionnaire was constructed with (15) items of four-point Likert-scale and (5) open ended questions. For four science teachers from the four selected schools, ten open-ended questions were also constructed to interview their attitude towards discovery learning.

Findings

Quantitative Research Findings

Findings of Descriptive Study

According to the finding, the mean score of the engagement and readiness stage is the highest and the mean score of the exploration and discovery stage is the lowest in the six stages of discovery learning (see Table 5). It can be interpreted that, the activities of the junior assistant science teachers are strongly linked with the engagement and readiness stage but weakly linked with the exploration and discovery stage of the discovery learning cycle.

Table 5 Mean and Standard Deviation of Junior Assistant Science Teachers' Teaching-Learning Activities on Six Stages of Discovery Learning Cycle

Teaching Stage	No. of Subjects	Mean	Standard Deviation
Engagement and Readiness (ER)	198	4.33	.470
Eliciting Prior Knowledge (EPK)	198	4.01	.609
Exploration and Discovery (ED)	198	3.67	.621
Concept and Skill Development (CSD)	198	3.89	.739
Concept and Skill Transfer (CST)	198	3.84	.733
Self-Assessment and Reflection (SAR)	198	3.90	.685
Total	**198**	**3.89**	**.488**

Findings of Experimental Study

Findings of Posttest

The mean score of the experimental group was significantly higher than that of the control group in each school (see Table 6). It can be interpreted that the use of discovery learning has significant effect on the overall science achievement of the students

Table 6 ***t*-values for Posttest Science Achievement Scores from Four Selected Schools**

School	Group	N	M	SD	MD	*t*	*df*	Sig(2tailed)
BEMS (1) Mingalar taungnyunt	Control	47	24.98	5.52	−11.74	− 13.91	92	.000***
BEMS (1) Mingalar taungnyunt	Experimental	47	36.72	2.43				
BEMS (4) Hlaing	Control	50	26.44	3.67	− 9.32	−13.54	98	.000***
BEMS (4) Hlaing	Experimental	50	35.76	3.19				
BEMS (5) Mingalardon	Control	43	25.07	4.41	− 9.46	− 11.63	84	.000***
BEMS (5) Mingalardon	Experimental	43	34.53	3.00				
BEHS (3) North Okkalapa	Control	56	27.82	3.71	− 9.86	−16.96	110	.000***
BEHS (3) North Okkalapa	Experimental	56	37.68	2.26				

Note: ***p<.001

There was a significant difference between the control group and experimental group in No. (4) BEMS Hlaing. But there was no significant difference between the control group and the experimental group in three schools. It can be interpreted that teacher-centered technique can also bring about the improvement of students' ability to remember previously learned materials as discovery learning (see Table 7).

Table 7 *t*-values for Scores on Knowledge Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig (2tailed)
BEMS (1) Mingalar-taungnyunt	Control	47	3.72	0.54	− 0.15	− 1.60	92	.112
	Experimental	47	3.87	0.34				
BEMS (4) Hlaing	Control	50	3.08	0.77	− 0.62	− 4.72	98	.000***
	Experimental	50	3.70	0.50				
BEMS (5) Mingalardon	Control	43	3.47	0.79	− 0.18	− 1.21	84	.238
	Experimental	43	3.65	0.62				
BEHS (3) North Okkalapa	Control	56	3.79	0.45	− 0.07	− 0.93	110	.356
	Experimental	56	3.86	0.35				

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

On the comprehension level questions, the mean score of experimental group was significantly higher than that of control group in each school (see Table 8). It can be interpreted that discovery learning can encourage the improvement of students' conceptual understanding.

Table 8 *t*-values for Scores on Comprehension Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig (2tailed)
BEMS (1) Mingalar-taungnyunt	Control	47	7.23	1.56	− 2.28	− 9.28	92	.000***
	Experimental	47	9.51	0.62				
BEMS (4) Hlaing	Control	50	7.60	1.37	− 1.42	− 6.05	98	.000***
	Experimental	50	9.02	0.94				
BEMS (5) Mingalardon	Control	43	7.49	1.50	− 1.30	− 4.61	84	.000***
	Experimental	43	8.79	1.08				
BEHS (3) North Okkalapa	Control	56	7.73	1.24	− 1.59	− 7.70	110	.000***
	Experimental	56	9.32	0.92				

Note: ****p*<.001

On the application level questions, the mean score of experimental group was significantly higher than that of control group in each school (see Table 9). It can be interpreted that discovery learning can bring about the improvement of students' ability to apply science concepts in new situations.

Table 9 *t*-values for Scores on Application Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig (2tailed)
BEMS (1) Mingalar-taungnyunt	Control	47	6.11	1.68	− 3.06	− 10.95	92	.000***
	Experimental	47	9.17	0.95				
BEMS (4) Hlaing	Control	50	6.64	1.27	− 1.92	− 7.71	98	.000***
	Experimental	50	8.56	1.21				
BEMS (5) Mingalardon	Control	43	6.40	1.61	− 3.13	− 10.65	84	.000***
	Experimental	43	9.53	1.08				
BEHS (3) North Okkalapa	Control	56	5.96	1.38	− 2.61	− 12.71	110	.000***
	Experimental	56	8.57	0.65				

Note: ***$p<.001$

On the analysis level questions, the mean score of experimental group was significantly higher than that of control group in each school (see Table 10). It can be interpreted that discovery learning can enhance the ability of students' analytical understanding of science concepts.

Table 10 *t*-values for Scores on Analysis Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig (2tailed)
BEMS (1) Mingalar-taungnyunt	Control	47	7.28	2.09	− 3.40	− 9.67	92	.000***
	Experimental	47	10.68	1.20				
BEMS (4) Hlaing	Control	50	8.06	1.79	− 2.86	− 9.76	98	.000***
	Experimental	50	10.92	1.04				
BEMS (5) Mingalardon	Control	43	7.05	1.86	− 2.42	− 7.41	84	.000***
	Experimental	43	9.47	1.05				
BEHS (3) North Okkalapa	Control	56	8.41	1.42	− 2.77	− 11.59	110	.000***
	Experimental	56	11.18	1.08				

Note: ***$p<.001$

On the synthesis level questions, the mean score of experimental group was significantly higher than that of control group in each school (see Table 11). It can be interpreted that discovery learning can enhance the students' ability to synthesize their science concepts and ideas.

Table 11 *t*-values for Scores on Synthesis Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig (2tailed)
BEMS (1) Mingalar-taungnyunt	Control	47	0.98	0.49	− 0.91	− 10.82	92	.000***
	Experimental	47	1.89	0.31				
BEMS (4) Hlaing	Control	50	1.04	0.40	− 0.82	− 10.87	98	.000***
	Experimental	50	1.86	0.35				
BEMS (5) Mingalardon	Control	43	1.33	0.61	− 0.62	− 6.41	84	.000***
	Experimental	43	1.95	0.21				
BEHS (3) North Okkalapa	Control	56	1.27	0.56	− 0.66	− 8.06	110	.000***
	Experimental	56	1.93	0.26				

Note: ***p<.001

On the evaluation level questions, the mean score of experimental group was significantly higher than that of control group in each school (see Table 12). It can be interpreted that discovery learning can bring about the improvement of students' evaluation skill.

Table 12 *t*-values for Scores on Evaluation Level Questions

School	Group	N	M	SD	MD	*t*	*df*	Sig (2tailed)
BEMS (1) Mingalar-taungnyunt	Control	47	0.87	1.01	− 1.73	− 9.82	92	.000***
	Experimental	47	2.60	0.65				
BEMS (4) Hlaing	Control	50	0.80	0.88	− 1.82	− 11.28	98	.000***
	Experimental	50	2.62	0.72				
BEMS (5) Mingalardon	Control	43	0.30	0.51	− 2.12	− 17.79	84	.000***
	Experimental	43	2.42	0.59				
BEHS (3) North Okkalapa	Control	56	0.88	0.83	− 1.94	− 15.53	110	.000***
	Experimental	56	2.82	0.43				

Note: ***p<.001

In summary, there was a significant difference between the control and experimental groups for the scores on the overall science achievement in all the selected schools. It can be interpreted that the use of discovery learning has significant effect on the overall science achievement of the students.

Qualitative Research Findings

In this research study, the qualitative study for the students from the experimental group of four selected schools was carried out with a questionnaire. It consists of (15) items four-point Likert-scale and five open ended questions. In this study, it was found that learning by doing makes the students develop their self-reliance and self-confidence. Most of the students expressed that they were very happy by using teaching learning materials in the discovery learning. They learned their classmates' opinions during discussion. They gained the habit of cooperation with others. Moreover, this learning was really new experiences as they had never worked in groups, they had a good chance to cooperate with their classmates in doing the activities.

For the qualitative study for the teachers from the experimental group of four selected schools, ten open-ended questions were constructed to interview their attitudes towards discovery learning. Most of the science teachers described that the discovery learning has many advantages for students, science lessons become very alive by using teaching aids effectively in this learning. Students can understand the learning materials very easily and clearly. But, some of the science teachers mentioned that there were some difficulties to perform this learning because of the limitation of time, over-crowded students in a classroom, the limitations of the space of classroom and shortage of teaching aids. Although there are some difficulties to perform the discovery learning effectively, most of the science teachers mentioned that the use of discovery learning had significant effect on the overall science achievement of the students. Thus, discovery learning has positive contribution to the science teaching and learning at the middle school level.

Discussion and Suggestions

Science teaching is an important and vital topic in modern education. In science teaching, teacher's role expands to helping students use various strategies to understand how well they are learning. When students are challenged by something they want to learn, they try to consider any incoming data in the light of related information from previous experiences. The more they are involved in solving problems, the more likely they are to learn to generalize what they have learned into a style of discovery that serves them best. In the discovery learning process, the students draw on their past experiences and existing knowledge to discover facts and relationships and new truths to be learned. Students interact with the world by exploring and manipulating objects and performing experiments.

According to the descriptive results, the mean score of the engagement and readiness stage is the highest and the mean score of the exploration and discovery stage is the lowest in the six stages of discovery learning. It can be interpreted that, the activities of the junior assistant science teachers are strongly linked with the engagement and readiness stage but weakly linked with the exploration and discovery stage of the discovery learning cycle.

According to the experimental results, there was no significant difference between the control and the experimental groups for the pretest in each school. It can be interpreted that, the students from the control group and experimental group in each school had the same prior knowledge before the treatment was provided. The posttest mean score of the experimental groups was significantly higher than that of the control group in each school. The findings point out that the discovery learning has significant effect on the science achievement of the students. This finding supports the research report of Holfwolt (1984): discovery learning produces significant learner achievement in science learning that compared to more traditional teacher and textbook centered.

In the responses of open-ended questions, most of the students describes that they were pleased when they could find the answer by doing the activities in the discovery learning. It can be interpreted that, most of the students want to learn the science lessons by doing the activities themselves. Bruner (1977) suggested that students are more likely to remember concepts if they discover them on their own. He stated that students could be more successful learners by working in environments that facilitated discovery, actively exploring information in order to find connections with what they already know and forming conclusions from this exploration.

The students expressed in the responses of open-ended questions that they were very happy in learning by using discovery learning, because they did not need to memorize everything in that learning. They gained the habit of self-reliance and self-confidence by answering the questions that are based on their own experiences. Some students (20%) from No. (4) BEMS Hlaing and (15%) from No. (3) BEHS North Okkalapa did not strongly agree to the item that learning by asking questions, answering questions and discussing their opinions make the students develop their desire to learn. Some of the students described that they had worries in asking questions and discussing their opinions because this experience was unusual for them. It is one of the responsibilities of the science teachers to cultivate the students to develop their interpersonal skill by making discussion, asking questions, expression and sharing their own opinions with others.

In the responses of open-ended questions, some science teachers mentioned that they realized that discovery learning is of great value for the teachers and students for science teaching and learning, but there were some difficulties to perform this learning because of the limitation of time, over-crowded students in the classroom, the limitations of the space of classroom and shortage of teaching aids. It is suggested that the arrangement of the space should be made easy and natural for the students to work together and talk to each other.

During the observation, it was found that there are not enough classrooms in some schools. The space of the classroom is also one of the difficulties for doing activities. If the schools have enough teaching learning materials, classrooms and teachers, discovery learning can be appropriately and effectively used in science classrooms. The trend towards hands-on learning cannot take place in science classroom in the absence of equipment and supplies. It is suggested that teachers should be encouraged to use a variety of instructional materials and resources. Moreover, the Ministry of Education should provide greater support for science education, particularly in terms of equipment and supplies budget.

At the last stage of the discovery learning cycle, reflection and self-assessment, the students from the experimental group were given the opportunity to think about how ideas have changed and how well one understands the concept and skills. Some students have difficulties to perform at this stage because this experience was unusual for them. Therefore, science teachers have to cultivate the students to develop this self-assessment and reflection skills. This skill is very important for students to successful learning in the discovery learning. Moreover, one of the difficulties of the teachers is that the content of the syllabus is to be taught for the final exam and all become exam-centered, that can hinder the use of discovery learning in science teaching. Another important issue is that the students' outcomes are associated with memorization of facts without understanding the concepts. Therefore, it is suggested that the focus of instruction and assessment should be changed from factual information to exploration of students' ideas and reasoning that emphasize understanding of science concepts. In doing so, teachers should evaluate students' understanding of cognitive processes by asking students "What, How, Why" questions related to the targeted skill.

The examination oriented system that determines the students' grade may not be the most appropriate and fair assessment of students' abilities and is conducive to rote learning. Therefore, it is suggested that the assessment system should be changed to the continuous assessment of the practical or activity based work and the weightage for continuous assessment be added to the final examination to calculate final grade or score to be awarded to a student. In the responses of open-ended questions, most of the teachers expressed that they have so many tasks to perform in the time available. They feel overloaded especially for monthly tests. Therefore, it is suggested that teachers need enough time to prepare the materials for their science activities. The degree to which teachers have preparation time positively influences the degree to which they use hands-on, minds-on, interactive teaching approaches to achieve students' science process skills. When curriculum is implemented, sufficient emphasis should be placed on the development of students' understanding, process skills and high level cognitive outcomes.

It is hoped that by using discover learning in the classroom, students can be well prepared to meet the challenges of their future in a rapidly changing world. Although discovery learning cannot solve all the problems faced by the teachers in teaching and learning science today, it is hoped that this learning can be useful to some extent for science teaching.

Conclusion

The main purpose of this research is to investigate the effectiveness of discovery learning in teaching lower secondary science. Both quantitative and qualitative studies were conducted to obtain the required data. Firstly, a descriptive survey was made to explore whether there was a link between the junior assistant science teachers' teaching-learning activities and the six stages of discovery learning cycle. Data were collected through a questionnaire. According to the descriptive results, the activities of the junior assistant science teachers are strongly linked with the engagement and readiness stage of the discovery learning cycle, but weakly linked with the exploration and discovery stage of the discovery learning cycle. Moreover, one way ANOVA was also used to examine the differences among the strata. It was found that there were no significant differences among the strata concerning junior assistant science teachers' teaching-learning activities on discovery learning cycle.

Secondly, an experimental research design was used to investigate the effectiveness of discovery learning. Posttest results showed that there was a significant difference between the control group and experimental group on the overall science achievement in each school.

Generalization can be drawn on the basis of the results. In terms of the statistical results, students' performance had significant difference on the overall science achievement and achievement of comprehension, application, analysis, synthesis, and evaluation level questions. Teacher and textbook centered techniques can also bring about the improvement of lower levels of cognitive domain as discovery learning. It can be interpreted that discovery learning can encourage the improvement of the students' higher order thinking skills.

The results of qualitative findings indicate that the attitude and values of students towards the subjects, towards themselves and towards others were also developed. Students described that they could express their own opinions in the discovery learning. Moreover, they learned their classmates' opinions during discussion. They gained the habit of cooperation with others. Some of the students described that they were afraid at the beginning and later became happy. They were pleased when they could find the answer by themselves.

Most of the science teachers described that the discovery learning has many advantages for students, science lessons become very alive by using teaching aids effectively in this learning.

Students can understand the learning materials very easily and clearly. It can be interpreted that, student become very active participant by using teaching aids effectively in discover learning. Most of the science teachers mentioned that the use of discovery learning had significant effect on the overall science achievement of the students. The qualitative data also supported the findings of the quantitative data.

To sum up, this study showed that discovery learning can provide teachers with many insights into how students can learn about and appreciate science. Moreover discovery learning is useful not only in improving achievement but also in helping students to construct their views about science and develop thinking ability. The effective use of discovery learning has significant effect on the overall science achievement of the students. Discovery learning surely has positive contribution to the science teaching at the middle school level.

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