THE EFFECTIVENESS OF HEURISTIC METHOD ON STUDENTS' MATHEMATICS ACHIEVEMENT AT THE LOWER SECONDARY LEVEL

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Abstract

The major purpose of this study is to investigate the effectiveness of heuristic method on students' mathematics achievement at the lower secondary level. Quantitatively, an experimental study was used to compare the mathematics achievements of the students between the control and experimental groups. The students from the experimental group were taught by heuristic method. The students from the control group were taught by formal teaching method. One of the true-experimental designs, namely, the posttest only control group design was used. In this experimental study, the participants were (120) Grade Seven students from two schools: Basic Education High School, Sintgaing and Basic Education High School, Hingu. Learning materials were selected from Grade Seven Mathematics Textbook. It contained Chapter (5) Algebraic Equations from Mathematics Textbook Volume I and Chapter (4) Symmetry from Mathematics Textbook Volume II. Independent samples *t* test was used to compare the differences between the two groups. Research findings revealed that teaching by heuristic method had a positive contribution to the improvement of mathematics teaching. It was interpreted that teaching by heuristic method was effective in raising students' mathematics achievement at the lower secondary level.

Keywords: heuristic method, mathematics, achievement, mathematic achievement lower secondary level

Introduction

Education is a tool that helps the formation and development of beliefs, knowledge, wisdom and thought. It can be certainly said that education is the only remedy to unindustrialization and the only solution to eradicate underdevelopment in today's industrialized world. The main aim of education is to help children to earn their livings and to make them self-dependent (Mishra, 2009). Every nation emphasizes the role of education and interests the effectiveness of education to face the challenges of life. There are many aspects of learning for the improvement of education. Among them, mathematics is one of the most important subjects in today's world schools.

Despite the Myanmar government's efforts to improve the teaching and learning of mathematics in secondary schools, teachers have traditionally used other teaching methods to increase students' interest in mathematics and bind them to mathematics. However, students' interest in mathematics remains low.

Heuristic approaches are alien to some mathematics teachers. Therefore, students were unable to develop the necessary skills to solve mathematics problems with or without the teacher's supervision. This has led to the problem of students' low performance in mathematics. Therefore, this study is intended to investigate the effectiveness of heuristic method on students' mathematics achievement at the lower secondary level.

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Aims of the Study

The major objectives of this study are described as follows:

1. To study the heuristic method in mathematics teaching at the lower secondary level.
2. To investigate the effectiveness of the heuristic method on students' mathematics achievement at the lower secondary level.
3. To make suggestions and recommendations based on the results of the study.

Research Hypotheses

The research hypotheses are described as follows:

1. There is a significant difference in mathematics achievement between the students who receive heuristic method and those who do not.
2. There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not in solving knowledge level questions.
3. There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not in solving comprehension level questions.
4. There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not in solving application level questions.
5. There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not in solving analysis level questions.

Scope of the Study

The following points indicate the scope of the research study:

1. This study is geographically restricted to two selected Basic Education High Schools, Sintgaing and Hingu in Sintgaing Township, Mandalay Region.
2. Participants in this study are Grade Seven students from the selected schools in the 2023-2024 academic year.
3. This study is limited to the content area of algebraic equations and symmetry from Grade Seven Mathematics Textbook Volume I and II prescribed by Ministry of Education (MOE).

Definition of Key Terms

In this study, the definitions of key terms are described as follows.

Heuristic Method

Heuristic method refers to "a particular method of teaching that allows the students to learn by discovering things by themselves and learning from their own experience rather than telling them things" (Wang, Han, Zhang, Fan & Zhang, 2011).

Mathematics

Mathematics is the branch of human inquiry involving the study of numbers, quantities, data, shape, and space and their relationships, especially their generalizations and abstractions and their application to situations in the real world (Clapham & Nicholson, 2009).

Achievement

Achievement is the competence of a person in relation to a domain of knowledge (Algarabel & Dasi, 2001).

Mathematic Achievement

Mathematics achievement is the competency shown by the student in the subject of mathematics (Pandey, 2017).

Lower Secondary Education

Lower secondary education refers to the educational level that typically includes grades 6 to 8, following primary education and preceding upper secondary education (Shaikh, Pal & Shah, 2021).

Review of Related Literature

This section is concerned with the theoretical foundation of the heuristic method.

Theoretical Foundation of the Heuristic Method

Holubová (2010) stated that the heuristic method is based on learning by discovering, on constructivism, and on the active interaction of teachers and pupils. In this section, the foundation and theory of constructivism, Piaget's cognitive developmental stage theory, social constructivism and Vygotsky's zone of proximal development (ZPD) are described as follows:

McLeod (2023) expressed that constructivism is a learning theory that emphasizes the active role of learners in building their own understanding. Rather than passively receiving information, learners reflect on their experiences, create mental representations, and incorporate new knowledge into their schemas. This promotes deeper learning and understanding. The earliest votary of the constructivism was the Italian philosopher Giarnbattista Vico (1668 - 1744), who proposed a constructivist theory of knowledge.

Theory of cognitive development by Jean Piaget recommended that children pass through four different mental development stages: the sensorimotor stage (birth to 2 years), the preoperational stage (ages 2 to 7), the concrete operational stage (ages 7 to 11), and the formal operational stage (ages 12 and up). According to Berk (1997), Piaget considered that children develop steadily and progressively across life at different stages, and the experiences gained from one stage form the basis for shifting to the next. In this study, the participants' level is under the formal operational stageff (Mady, 2019).

The sociocultural theory was developed by Russian psychologist Lev Vygotsky (1896-1934). Vygotsky proposed the concept of the Zone of Proximal Development, which is built on the concept that there is a difference between what an individual can achieve on his own and what he can do with help. According to Vygotsky (1978), learning happens in this zone. Finally, Vygotsky believed that teachers should assist the students to learn and gain knowledge within their zone of proximal development (ZPD) (Mady, 2019).

Heuristic Method

A heuristic is a simple but useful method for problem-solving, decision-making, and discovery. The origin of the term goes back to the Ancient Greek verb 'heuriskein', which means 'to find out' or 'to discover'. According to Huiqin, Kejun, and Qingrui (2013), a heuristic method is particularly used to rapidly come to a solution that is hoped to be close to the best possible answer, or 'optimal solution'. Heuristics are "rules of thumb," educated guesses, intuitive judgments, or simply common sense. It is a general way of solving problem. This method was originally introduced by Armstrong for the learning of science. In this method, a good deal of importance has been given to experiments.

The main aim of teaching by the heuristic method is not so much to teach facts of science, mathematics, grammar, or history as to teach how knowledge of those may be obtained, systematized, and used. In short, the process is considered more important than the product. On closer study, the method appears to be a second form of the "inductive method." Dumvilla defines this method as "Heurison is nothing other than Herbert Spencer's inductive method of teaching."

Objectives of the Heuristic Method

Pathak (2023) stated the objective of the heuristic method of teaching that

- Objective: Encourage students to become independent learners and critical thinkers in life.
- Focus: Emphasize the learning process rather than just gaining knowledge.
- Applicability: Suitable for various subject areas.
- Effectiveness: Particularly effective in fields requiring problem-solving, critical thinking, and creativity.

Steps of the Heuristic Method

According to Polya (1945), there are four steps in the heuristic method. They are -

(a) Understanding the problem,
(b) Making a plan,
(c) Implementing the plan, and
(d) Evaluation and adaptation.

Method

Research Design

In this study, one of the true experimental designs; the posttest only control group design was used.

Participants

The participants were Grade Seven students from the two selected schools in Sintgaing Township, Mandalay Region. The population and sample size of the selected schools are presented in Table 1.

Table 1 ***Population and Sample Size***

Name of Schools	No. of Population	Sample Size
BEHS, Hingu	60	60
BEHS, Sintgaing	60	60
Total	120	120

Note. BEHS = Basic Education High School

Instrument

Instruments used for this study were a prerequisite test and a posttest. These were used after examining the reliability coefficient.

The prerequisite test was developed to measure the basic mathematical knowledge of the selected samples. Test items were constructed based on the Chapter (1) to (4) from Grade Seven Mathematics Textbook Volume I and the Chapter (1) to (3) from Grade Seven Mathematics

Textbook Volume II. There were (25) multiple-choice items in this test, and the given marks were (25) marks. The allocated time for this test was 45 minutes.

The posttest question consisted of three sections. Section (A) consisted of 10 multiple-choice items. Section (B) consisted of five short answer questions and section (C) consisted of five long answer questions. Test items were constructed based on the content areas of Chapter (5) Algebraic Equations and Chapter (4) Symmetry from the Grade Seven Mathematics Textbook Volume I and II. This test was constructed based on Bloom's Taxonomy: knowledge, comprehension, application, and analysis levels. The allocated time for this test was 1:30 hours, and the given marks were (50).

Procedure

For this study, two basic education high schools: Basic Education High School, Hingu and Basic Education High School, Sintgaing were randomly selected from Sintgaing Township, Mandalay Region. In this study, a true experimental design was used. There are (30) students in the experimental group and (30) students in the control group in each selected school. All the selected sample students have to take the prerequisite test. The prerequisite test was used to measure students' basic mathematical knowledge and to examine the equivalence of the two groups.

In each selected school, the experimental group was given treatment using the heuristic method and the control group was taught using formal instruction. At the end of the treatment period, all the students were tested in the posttest.

Analysis of the Data

In order to find out whether there is a significant difference between the experimental and control groups, the prerequisite test scores of the two groups were compared using an independent samples *t* test. After finding that the two groups were essentially the same on the prerequisite test, posttest scores were compared directly using independent samples *t* test.

Findings

The findings of the study in each selected school are presented as follows.

Table 2 shows the results of t Values for prerequisite test of Grade Seven students in the two selected schools.

Table 2 ***Results of t Values for Prerequisite Test***

School	Group	*n*	*M*	*SD*	*MD*	*t*	*df*	Sig. (2-tailed)
S1	Experimental	30	11.87	4.84	0.07	0.05	58	.958 (ns)
	Control	30	11.80	4.90				
S2	Experimental	30	13.43	4.96	0.30	0.24	58	.813 (ns)
	Control	30	13.13	4.83				

Note. S1 = Basic Education High School, Hingu;
S2 = Basic Education High School, Sintgaing;
ns = not significant.

According to the *t* value of S1, *t* (58) = .958, and the *t* value of S2, *t* (58) = .813, it showed that there was no significant difference between the experimental and control groups for

the scores on the prerequisite test in each school. Thus, it can be interpreted that the prior knowledge of the experimental groups and the control groups was equivalent.

Table 3 shows the results of t Values for overall posttest mathematics achievement of Grade Seven students in the two selected schools.

Table 3 ***Results of t Values for Overall Posttest Mathematics Achievement***

School	Group	*n*	*M*	*SD*	*MD*	*t*	*df*	Sig. (2-tailed)
S1	Experimental	30	34.03	5.29	13.30	6.31	58	.000***
	Control	30	20.73	10.26				
S2	Experimental	30	31.10	7.24	6.90	4.42	58	.000***
	Control	30	24.20	5.54				

Note. S1 = Basic Education High School, Hingu;
S2 = Basic Education High School, Sintgaing;
$^{***}p < .001$.

The results showed that the mean of the experimental group was significantly higher than that of the control group in each school (see Table 3). According to the *t* value of S1, $t\ (58) = 6.31$, $p < .001$ and the *t* value of S2, $t\ (58) = 4.42$, $p < .001$, it showed that there was a significant difference between the experimental group and control group for the scores on the mathematics achievement in each school. According to the results, it can be interpreted that the students who received the heuristic method performed better than those who received formal instruction. It means that using a heuristic method in mathematics teaching at the lower secondary level resulted in positive effects.

Table 4 ***Results of t Values for Scores on Knowledge Level Questions***

School	Group	*n*	*M*	*SD*	*MD*	*t*	*df*	Sig. (2-tailed)
S1	Experimental	30	2.50	0.69	0.63	2.99	58	.004**
	Control	30	1.87	0.94				
S2	Experimental	30	2.23	0.97	0.90	3.91	58	.000***
	Control	30	1.33	0.80				

Note. S1 = Basic Education High School, Hingu;
S2 = Basic Education High School, Sintgaing;
$^{**}p < .01$, $^{***}p < .001$.

Table 4 presents the results of knowledge level questions. It showed that the mean of the experimental group was significantly higher than that of control group in each school (see Table 4). According to the *t* value of S1, $t\ (58) = 2.99$, $p < .01$ and the *t* value of S2, $t\ (58) = 3.91$, $p < .001$, it showed that there was a significant difference between the control group and experimental group for the scores on knowledge level questions in each selected school. The findings indicated that there is a significant difference in learning, knowledge skills and information absorption. It can be interpreted that the heuristic method could positively improve students' ability to remember basic mathematical knowledge.

Table 5 ***Results of t Values for Scores on Comprehension Level Questions***

School	Group	*n*	*M*	*SD*	*MD*	*t*	*df*	Sig. (2-tailed)
S1	Experimental	30	4.57	0.77	0.74	2.34	58	.023*
	Control	30	3.83	1.55				
S2	Experimental	30	5.80	0.71	0.30	1.10	58	.274 (ns)
	Control	30	5.50	1.31				

Note. S1 = Basic Education High School, Hingu;
S2 = Basic Education High School, Sintgaing;
$^{*}p < .05$, ns = not significant.

According to the scores on the comprehension level questions, the mean of the experimental group was higher than that of the control group in S1. According to the *t* value of S1, $t\ (58) = 2.34$, $p < .05$, it can be inferred that there was a significant difference for scores on comprehension level questions in S1. But the mean was not significantly different between the two groups in S2. According to the *t* value of S2, $t\ (58) = 1.10$, it can be concluded that there was no significant difference for the scores on comprehension level questions in S2. Therefore, it can be interpreted that the heuristic method could have a positive effect on students' understanding of mathematics at the lower secondary level.

Table 6 ***Results of t Values for Scores on Application Level Questions***

School	Group	*n*	*M*	*SD*	*MD*	*t*	*df*	Sig. (2-tailed)
S1	Experimental	30	9.23	4.44	4.10	3.18	58	.002**
	Control	30	5.13	5.49				
S2	Experimental	30	12.27	2.33	1.60	2.68	58	.010*
	Control	30	10.67	2.29				

Note. S1 = Basic Education High School, Hingu;
S2 = Basic Education High School, Sintgaing;
$^{**}p < .01$, $^{*}p < .05$.

In terms of application level questions, the experimental groups achieved a significantly higher mean than the control groups in both schools. According to the *t* value of S1, $t\ (58) = 3.18$, $p < .01$ and the *t* value of S2, $t\ (58) = 2.68$, $p < .05$, it can be concluded that there was a significant difference for scores on application level questions in each selected school. So, it can be interpreted that teaching through the heuristic method positively contributed to the application level of mathematics teaching at the lower secondary level. Therefore, teaching by heuristic method could help students to improve higher-order thinking skills and problem-solving skills in learning mathematics at the lower secondary level.

Table 7 ***Results of t Values for Scores on Analysis Level Questions***

School	Group	*n*	*M*	*SD*	*MD*	*t*	*df*	Sig. (2-tailed)
S1	Experimental	30	17.73	4.40	7.83	6.24	58	.000***
	Control	30	9.90	5.29				
S2	Experimental	30	11.40	7.27	6.00	4.03	58	.000***
	Control	30	5.40	3.68				

Note. S1 = Basic Education High School, Hingu;
S2 = Basic Education High School, Sintgaing;
***$p < .001$.

Table 7 presents the results of the analysis level questions. It showed that the mean of experimental group was significantly higher than that of the control group in each selected school (see Table 7). According to the *t* value of S1, $t\ (58) = 6.24$, $p < .001$ and the *t* value of S2, $t\ (58) = 4.03$, $p < .001$, it can be concluded that there was a significant difference for scores on analysis level questions in each school. Thus, it can be interpreted that the use of the heuristic method could also bring about an improvement in students' ability to remember facts, rules, and previously learned materials.

Discussion

Discussion on Hypothesis (1): There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not.

According to the findings of this study, students from experimental groups got higher achievement than students from control groups in the two selected schools. It showed that there was a significant difference in mathematics achievement between the students who are taught by the heuristic method and those who are taught by formal instruction. This result is consistent with the findings of Abonyi and Umeh (2014) who found that the mean of the students who were taught by the heuristic method was higher than the mean of the students who were taught by formal instruction. Their result described that the heuristic method fostered better achievement in linear algebra than formal instruction. They recommend the application of the heuristic method in teaching mathematics both in primary and secondary schools. Heuristic method could motivate, stimulate, and sustain students' interest in mathematics.

Discussion on Hypothesis (2): There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not in solving knowledge level questions.

According to the findings of this study, students from experimental groups got higher achievement than students from control groups in the two selected schools. It showed that there was a significant difference in mathematics achievement between the students who are taught with the heuristic method and those who are taught with formal instruction in both schools at the knowledge level. Therefore, it can be concluded that students can remember and recall the relevant knowledge from long-term memory at the beginning of the lesson.

There may be a variety of reasons that caused significant achievement for students in the two selected schools. It can be said that the teacher could provide students with accurate instructions to think collaboratively and to understand independently. The other thing is that

students from control groups were less likely to learn ahead of new lessons, and so experimental groups achieved higher results than control groups.

Discussion on Hypothesis (3): There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not in solving comprehension level questions.

According to the findings of this study, the achievement of the experimental group was significantly higher than that of the control group in S1. It showed that there was a significant difference in mathematics achievement between the students who are taught with the heuristic method and those who are taught with formal instruction in S1 at the comprehension level. It can be concluded that students in the experimental group could classify, discuss with each other, and use collaborative behavior in solving problems to improve their performances.

This study also revealed that the achievement of the experimental group was not significantly higher than that of the control group in S2. It showed that there was no significant difference in mathematics achievement between the students who are taught with the heuristic method and those who are taught with formal instruction in S2 at the comprehension level. It may be due to the fact that students in the experimental group were more likely to be familiar with the teacher's instructions and explanations than studying on their own.

Discussion on Hypothesis (4): There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not in solving application level questions.

According to the findings of this study, the achievement of the experimental group was significantly higher than that of the control group in each selected school. It showed that there was a significant difference in mathematics achievement between the students who are taught with the heuristic method and those who are taught with formal instruction in both schools at the application level. It can be interpreted that the heuristic method in teaching mathematics helped students as a foundation to get higher-order thinking skills from the lesson. Moreover, teaching by the heuristic method could encourage students to construct their own understanding, meaning, and thinking critically. And students can solve the problems by using the concepts and rules through the heuristic method.

Discussion on Hypothesis (5): There is a significant difference in mathematics achievement between the students who receive the heuristic method and those who do not in solving analysis level questions.

According to the comparison of mean on analysis level questions, the findings showed that the mean of experimental groups was significantly higher than that of the control groups in the two selected schools. It showed that there were significant differences between the experimental and control groups in both schools. According to this result, students in experimental group are interested in learning geometry, shapes, sizes, and mass, and they can perform well in drawing, measuring, summarizing, and concluding. It can be interpreted that the heuristic method could improve the students' ability to remember facts, rules, and previously learned materials.

Suggestions

Suggestions for the Mathematics Teachers

- Before implementing the heuristic method, the teachers should know the procedures and prepare the lessons with the appropriate teaching learning materials that can effectively meet the needs of the students.
- Teachers should create a classroom atmosphere that encourages open communication and active engagement, where students feel comfortable asking questions, sharing their ideas, and exploring new concepts on their own.
- Teachers should offer guidance and feedback throughout the learning process, helping students reflect on their experiences.
- Teachers should provide students with opportunities to participate actively in the teaching-learning process.
- Teachers should design activities that encourage students to explore and experiment with new concepts.
- Teachers should carefully manage classroom conditions to reduce time constraints **(Maheshwari, 2016 &** Pathak, 2023).

Suggestions for the School Administrators

Administrators should support and encourage in-service trainings, workshops, and seminars so as to inculcate the rudiments of the heuristic method in teaching mathematics at the lower secondary level. In addition, the government, in conjunction with curriculum developers and mathematics teachers, should establish mathematics resource centers in each local government area of the state for the procurement and storage of relevant heuristic instructional materials.

Recommendations

Based on the findings of the study, there are some recommendations for further study.

- In this study, the sample schools were randomly selected from Sintgaing Township, Mandalay Region. It may not be able to generalize to the whole country. So, further research should be conducted in other states and regions.
- This study dealt with lower secondary level in the 2022-2023 academic year. Thus, further study should be carried out at the primary or upper secondary level or in higher education to obtain exact and specific results.
- In this study, the content areas were limited to Grade Seven Mathematics Textbook. Therefore, further study should be tried out for the other content areas at the lower secondary level to improve the teaching of mathematics.
- To study the effectiveness of heuristic method in teaching mathematics, more time should be spent in implementing this method.

Conclusion

Heuristic approaches are alien to some mathematics teachers in Myanmar Education. Therefore, students were unable to develop the necessary skills to solve mathematics problems with or without the teacher’s supervision. This has led to the problem of students' low performance in mathematics. In terms of statistical results, students’ performance between the

experimental and control groups showed a significant difference in overall mathematics achievement. It can be concluded that using the heuristic method has positively contributed to the improvement of mathematics teaching at the lower secondary level. This study will assist teachers and students in having a pleasurable learning experience and a successful outcome. Furthermore, further research into alternative teaching approaches are needed in order to continuously enhance Myanmar Education.

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References

Abonyi, O. S., & Umeh, V. O. (2014). Effects of heuristic method of teaching on students' achievement in algebra. *International Journal of Scientific & Engineering Research*, *5*(2), 1735-1740.

Algarabel, S., & Dasi, C. (2001). The definition of achievement and the construction of tests for its measurement: A review of the main trends. *Psicologica*, *22*(1), 43-66.

Clapham, C., & Nicholson, J. (2009). *The concise oxford dictionary of mathematics* (4th ed.). Oxford University Press.

Holubová, R. (2010). Improving the quality of teaching by modern teaching methods. *Problems of Education in the 21st Century*, *25*, 58-66.

Huiqin, S., Kejun, S., & Qingrui, L. (2013). Heuristic teaching method on innovative talents cultivation of electrical engineering. In P. Li (Ed). *International Conference on Education Technology and Management Science (ICETMS 2013)* (pp. 862-864). Atlantis Press.

Mady, M. A. (2019). *Impact of cognitive developmental theories on the teaching and learning process at a private US curriculum school in Dubai, UAE* **(Unpublished master thesis). The British University in Dubai.**

Mcleod, S. (2023). *Constructivism learning theory and philosophy of education*. Retrieved from https://www.simplypsychology.org/constructivism.html

Mishra, L. (2009). *Teaching of mathematics*. New Delhi: APH Publishing Corporation.

Pandey, B. D. (2017). A study of mathematical achievement of secondary school students. *International Journal of Advanced Research (IJAR)*, *5*(12), 1951-1954.

Pathak, S. (2023). *Heuristic method of teaching: How is it helpful for teachers?* Retrieved from https://classplusapp.com/growth/heuristic-method-of-teaching/

Polya, G. (1945). *How to solve it; a new aspect of mathematical method.* Princeton University Press.

Wang, S., Han, R., Zhang, M., Fan, X., & Zhang, S. (2011). Improving teaching efficiency with heuristic teaching method in information technology. In Tan, H., & Zhou, M. (Eds.), *Advances in Information Technology and Education* (pp. 454-458). Berlin: Springer.