Effect of highlighting-illustration-translation strategy (HITS) on the mathematics problem solving performance of students with varied learning styles

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ABSTRACT

Most students are often taught "what they should learn" in mathematics, but seldom "how to learn" it using multiple strategy, so they perform poorly, despite their varied learning styles. The paper aimed to investigate the effect of Highlighting-Illustration-Translation (HITS) in mathematics problem solving performance of students with a quasi-experimental design, it used the one-shot single group design method. The sample of the study was chosen through convenience sampling from the population of Grade 8 students of Pedro E. Diaz High School, Muntinlupa City, Metro Manila. Two intact sections from Strengthening Technical Vocational Education Program (STVEP), handled by the teacher-researcher, were chosen. The first section came from TVE 5, whose specializations were Automotive (boys) and Food Trades (girls), while the second section from TVE 7, with specializations in Furniture Cabinet Making (boys) and Garments (girls). The study used four research instruments: Two-tier Performance Test; VARK (visual, aural, read/write, kinesthetic) Questionnaire; Perception Survey Questionnaire; and the Interview Guide.

Based on the gathered data, the results of the paired t-test revealed that there was a significant difference between the pre-test and post-test in solving word problems after using HITS. The result suggests that the students' problem solving skills had improved after using HITS. However, the result of the One-Way ANOVA showed that there was no significant difference in the students' performance across varied learning styles. Based on the findings, the study concludes that HITS may be an effective multiple strategy in solving word problems in mathematics applicable to all students, regardless of their learning styles.

Keywords
Highlighting-Illustration-Translation Strategy (HITS), Problem Solving Process, Mathematics Students' Performance, Learning Styles

Introduction

Most students are often taught "what they should learn" in mathematics, but seldom "how to learn" it using multiple strategy, so that they perform poorly, despite their varied learning styles. Carter (2006) held that students are poor in solving problems, because they do not learn the strategies in solving problems.

Instead of being engrossed in covering the topics in the lesson plan, teachers should teach the students the process component of problem solving. In this way, they will also learn its other key components.

Furthermore, instead of teaching the students a single learning strategy which has its respective intrinsic limitations and might not fit the varied learning styles of the students (NCTM, 2014; *Douglass, Koedlinger & Tabachneck*, 1994), they had better be taught the multiple strategies. *Koedlinger* and *Tabachneck* (1994) observed that there is a high frequency of three strategies used by college students solving simple algebra word problems and the use of multiple strategies within a single problem is significantly correlated to success.

Highlighting-Illustration-Translation Strategy (HITS) exemplifies multiple strategies. It is composed of three distinct strategies developed to augment the limitations of one strategy over the other to fit the students' varied learning styles as much as improve their performance.

Mainly, the study seeks to investigate the effect of HITS on the mathematics problem solving performance of Grade 8 students at Pedro E. Diaz High School in Muntinlupa City, Metro Manila. The data were gathered using four instruments: the two-tier pretest and posttest, VARK Questionnaire adopted from Fleming (2011), Perception Survey Questionnaire based on the learning subtasks by Koedlinger and Tabachneck (1994), and Interview Guide based on the learning subtasks by Koedlinger and Tabachneck (1994). The findings of the study would be beneficial to mathematics students, mathematics teachers, school administrators and future researchers.

Research Questions

Specifically, the study attempted to answer the following questions:

1. What is the performance of the students in problem solving before and after their exposure to HITS?

2. Is there a significant difference between the students' performance in problem solving before and after their exposure to HITS?

3. What are the students' preferred learning styles?

4. Is there a significant difference in the problem solving performance of the students with varied learning styles?

5. What is the students' perception about HITS?

Literature Review

As a multiple learning strategy, Highlighting-Illustration-Translation Strategy (HITS) comprises three strategies - highlighting, illustration, and translation. When considered separately, in highlighting and translating strategies, the students are taught the keywords in the story problems and the list of words signifying which operation to perform when they translate it to solve the problem (Alexander, 2012). In the illustration strategy, the students are taught to use graphs, shapes, and drawings to represent key components of word problems by removing all of the excess language from the story.

Unfortunately, when the strategies are taken separately from the other strategies, each strategy might not be successful in helping the students solve a problem, because of its own intrinsic limitations. By contrast, when the three strategies are taught as one, they might be able to augment the limitations of one strategy to fit the learning styles of the students who construct their knowledge differently, also they get motivated to continue performing the different subtasks in solving a problem successfully, since they understand what they are doing (*Vygotsky, Piaget, Dewey, Vico, Rorty, & Bruner*, 2011; *Watso*n, 1913; *Pavlov*, 1987; *Skinner*, 1936; *Thorndike*, 1905; & *Bandura*, 1963).

According to *Koedlinger & Tabachnec*k, (1994), the problem solving process is composed of three subtasks:1) Comprehension, 2) Transformation and 3) Calculation. The Comprehension Subtask is the process of understanding and analyzing the words and numbers being put together in a sentence; the Transformation Subtask is the process of formulating and solving equations; and the Calculation Subtask is the process of applying previously learned concepts to reach the correct final answer through a logical way of thinking.

Since problem solving means engaging in a task for which the solution is unknown in advance, it requires both analysis and synthesis to successfully solve a problem (*Galera*, 2005). To help the students in analyzing and synthesizing, they should be taught in each subtask of the process with the help of HITS.

Teaching HITS may improve the students' level of performance when guided properly, because of their varied learning styles or learning preferences. A special project under the Individuals with Disabilities Education Act (IDEA) made a Research-Based Strategies for Problem-Solving in Mathematics K-12. The research suggested the use of visualization in mathematics by creating pictorial representations of mathematical problems.

Based on the results of the study by Pretti (2003), the students who had been taught the method of key words performed more poorly on the posttest than those in the control group. He suggested the following: 1) That more practice in translation of words into mathematical symbols be utilized before the method of key words is taught, and that 2) The method of key words should be applied at the onset of students' work with story problems.

On the other hand, Jackson (2012) on Singapore mathematics lessons suggested that teachers begin by engaging students in hands-on learning experiences followed by pictorial representations, to help them form a mental image of mathematical concepts. The Singapore Model Method for Learning Mathematics develops students' understanding of fundamental mathematics concepts and proficiency in solving basic mathematics word problems by constructing a pictorial model to represent the known and unknown quantities and their relationships in a problem.

HITS is sensitive to the different learning styles of the students and their learning preferences because it affects performance. Kopsovich (2001) concluded in her research that the fifth grade students' learning preferences had a direct correlation to their math achievement scores. According to Mukisa (2012), many children have a dominant learning style, so every parent should have some tricks up their sleeve to address these different styles. Each parent needs to be flexible when dealing with different learning strategies. Drilling can work, but we cannot just rely on the drill method with math worksheets and flashcards. When children are taught with the process that suits them best, their performance can improve dramatically.

Finally, HITS fits the different modalities of learning from visual, aural, read/write, and kinesthetic sensory modalities that are used for learning information (Fleming and Mills (1992). Julialеs (2013), also concluded that mathematics teaching with ICT Integration favored students whose preferred learning styles are read/write, aural/auditory and kinesthetic. Others may also be visual, tactile and auditory math learners. They have differing requirements to learn optimally, hence the need to teach them a variety of techniques.

Conceptual Framework

The diagram below shows the relationshp of Highlighting-Illustration-Translation Strategy (HITS), Problem Solving Process, Mathematics Students' Performance and Learning Styles that guide the researcher in determining the effect of HITS on the mathematics problem solving performance of Grade 8 students at Pedro E. Diaz High School in Muntinlupa City. Figure 1 shows the conceptual framework of the study.

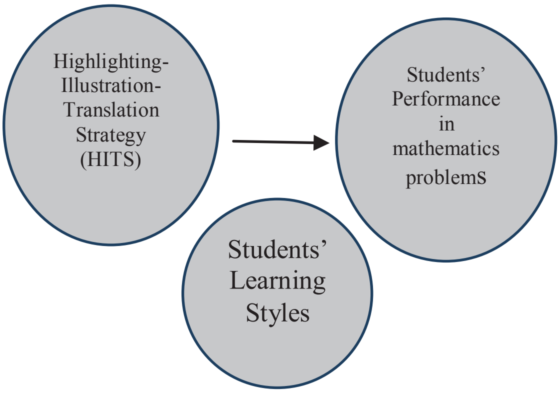

Figure 1. The Conceptual framework of the Study

Research Hypothesis

Based on the conceptual framework, the following hypotheses of the study were tested at a 0.05 level of significance:

1. There is a significant difference in the pre-test and post-test mean scores of the students in the achievement test before and after implementing HITS in solving Algebra problems.

2. There is a significant relationship between the students' performance and their learning styles in solving word problems.

Methods

Participants

The sample of the study was chosen through convenience sampling from the population of Grade 8 students of Pedro E. Diaz High School. Two intact sections from Strengthening Technical Vocational Education Program (STVEP), handled by the teacher-researcher, were chosen. The first section came from TVE 5, whose specialization is Automotive (boys) and Food Trades (girls) and the second from TVE 7, with specialization in Furniture Cabinet Making (boys) and Garments (girls).

Based on learning styles, 21 out of 67 students or 31 % aural/auditory learners; 17 or 25 % read/write; 7 or 10 % kinesthetic; 5 or 8 % visual; and 17 or 26 % have multiple learning styles.

Research Design

The design of the study is quasi-experimental, one-shot single group using a pretest-posttest to determine the effect of HITS in learning Algebra. Figure 2 shows the research design.

Q_1 ----------------X-----------Q_2

Figure 2. Research Design of the study

Q_1 represents the pretest, X stands for HITS as a learning strategy, and **Q_2** the posttest. Quantitative analysis was used to determine the performance of the students in problem solving by interpreting the results of the pretest and posttest scores. It was also used to find out its effect in the learning styles. Furthermore, qualitative analysis helped gather a more in-depth validation of the effect of HITS to the performance of the students.

Research Instruments

The research instruments of the study were the following: 1) The two-tier pretest and posttest, 2) VARK Questionnaire adopted from Fleming (2011), 3) Perception Survey Questionnaire and 4) Interview Guide based on the learning subtasks by Koedlinger and Tabachneck (1994).

The Two-Tier Mathematics Performance Test was a 61-item test selected from the mathematics course outline provided by the Department of Education for Grade 8 teachers for school year 2013-14 pilot tested twice. The final two–tier performance test composed of 8 problems with 30 questions about solving problems involving system of linear equations and inequalities. For each problem, the students were required to write their solution from comprehension, transformation, and calculation subtasks, applying HITS to guide them in computing the correct final answer. The criteria for scoring HITS were based on the rubrics in mathematics by Zara (2003).

The VARK Questionnaire designed to identify the students' learning styles was adopted from Neil Fleming (2011). It is a multiple choice test consisting of 16 items each of which has four choices ranging from letters A – D. The students were allowed to choose more than one answer. The scoring sheet consists of four columns namely V for visual, A for aural/auditory, R for read/write, and K for kinesthetic. The highest total score in any category was considered their preferred learning style.

The Perception Questionnaire was based on Koedlinger and Tabachneck (1994), validated by the experts, and used to determine the perceptions about HITS. It used a 5-point Likert scale which is composed of 12 items namely: Comprehension subtask, numbers 1 – 4; in Transformation subtask, numbers 5 – 8: and in Calculation subtask, numbers 9 – 12.

Finally, the Interview Guide was developed based on the subtasks identified by Koedlinger and Tabachneck (1994). Modified and validated by experts, it has 10 questions divided into 3 subtasks: Questions 1 – 3 for Comprehension; questions 4 – 6 Transformation; and questions 7 – 10 Calculation. The Interview Guide has a Filipino translation so that the students can better understand the questions. They could also write their answers in Filipino.

Before conducting the study, the researcher had asked permission from the Principal of Pedro E. Diaz High School to administer the mathematics performance test, after which she started gathering the data in three phases: (1) Pretesting and Orientation, (2) Actual usage of HITS in teaching mathematics, and (3) Post-testing, administration of the Perception Questionnaire, and interview. The data gathered were encoded using Statistical Package for Social Sciences (SPSS) Software for all statistical and data analyses. The data were analyzed using various tests.

Statistical Tests

The paired *t*-test was used to determine the significant difference in the pretest and posttest results based on individual gain scores. The scores were tabulated and compared to show if there is a significant difference in the mean average scores. A One – Way ANOVA was also used to determine if there is a significant difference in the students' performance across learning styles after exposure to HITS. All tests of significance were evaluated at 0.05 level of confidence. The weighted mean was used to describe the students' opinion of HITS based on the result of the Perception Questionnaire.

Qualitative analysis was also conducted to confirm the results of the quantitative analysis. Finally, triangulation was performed based on the results of the pretest and posttest scores, perception questionnaire and the interview guide.

Results and Discussion

Based on the performance test scores in Algebra, the mean score of the respondents in the pre-test is 10.37 and 58.52 in the post-test, as shown in Table 1. It means that the respondents performed better in problem solving after they had been exposed to HITS in the comprehension, transformation, and calculation subtasks in problem solving.

Table 1
Summary of the Performance Test Scores of the Respondents in the Pretest and Posttest (n=67)

Descriptive statistics	Pretest Scores	Posttest Scores
Highest Score	22	112
Lowest Score	3	6
Mean	10.37	58.52
Standard Deviation	3.284	22.392
Mean Percentage Score	6.82	37.04

Based on Table 1, the highest score in the pre-test is 22 and 112 in the post-test; the lowest score in the pre-test is 3 and 6 in the post-test; the standard deviation in the pre-test is 3.284 and 22.392 in the post-test; and the mean percentage in the pre-test is 6.82 and 37.04 in the post-test. The better performance of the respondents could be reflected in the ability to understand the problem using HITS; hence, motivated to solve the problem until they set the correct final answer.

The results also showed that the difference before and after their exposure to HITS is significant. The *t*-value is 18.193 with a mean difference of 47.74 and a *p* value of .004 below the level of confidence at 0.05, so the difference is significant, as shown in Table 2 on the next page:

Table 2
Paired t-test Result of the Students' Pretest and Posttest Scores

Paired t-test	Mean	Std. deviation	t-value	Mean diff	p-value	Remark
Pretest	10.78	3.284	18.193	47.74	.004	Significant
Posttest	58.52	22.392				

**p<0.05*

Based on Table 2, the significant difference may be attributed to the effect of HITS in the learning process of the students. Unlike in a traditional classroom, HITS guided the students throughout the process of comprehension, transformation, and calculation subtasks until they could compute the final correct answer. The findings of the study resemble those of Koedlinger and Tabachneck (1994) who observed the improvement in the students' performance in solving simple algebra word problems using multiple strategies.

Furthermore, the results showed that the respondents preferred learning is aural. The aural learning style got the highest mean score in the post-test (70.38) with a mean difference of 58.76. Table 3 shows the mean scores of the students based on their preferred learning styles.

Table 3
Mean Scores of Students Based on their Preferred Learning Styles

Learning Styles	No. of Students	Pretest	Posttest	Mean Difference
Visual	5	12.8	51.8	39
Aural	21	11.62	70.38	58.76
Read-Write	17	8.59	52.53	43.94
Kinesthetic	7	11.86	53.29	41.43
Aural / Kinesthetic	1	11	53	42
Aural / Read – Write	6	12	58.67	46.67
Aural / Visual	2	10	69	59
Read – Write / Kinesthetic	4	10	51.5	41.5
Visual / Kinesthetic	4	10.5	42.25	31.75

Based on Table 3, the second highest learning style is the Aural/Visual with a mean score of 69 and a mean difference of 59; third is the Aural/Read-Write with a mean score of 58.67 and a mean difference of 46.67; fourth is Kinesthetic with 53.29 with a mean difference of 41.43; fifth is Aural/kinesthetic with a mean score of 53 with a mean difference of 42.

Using the respondents' performance across varied learning styles, as basis, there is no significant difference between the mean scores in the problem solving test of the students with varied learning styles after their exposure to HITS. The *p*-value of 0.199 associated with the computed *F* ratio of 1.441 is more than the adopted level of significant (*p>0.05*), as shown in Table 4 on the next page:

Table 4
One-Way ANOVA Result of Mean Difference Across Varied Learning Styles

	Sum of squares	df	Mean square	F	P-value	Remaks
Between groups	5488.217	8	686.027	1.441	.199	Not significant
Within groups	27604.500	58	475.940			
Total	33092.716	66				

Based on Table 4, it means that HITS compliments the students' different learning styles. It does not favor a particular learning style, in contradiction with the results of the study of Juliales (2013) claiming that mathematics teaching with ICT Integration favoured Read/Write Kinesthetic and Aural/Auditory learning style.

The students performed better in the post-test, because they have a positive perception towards HITS with an overall weighted mean of 3.76, as revealed in Table 5 below.

Table 5
Weighted Mean of the Respondent's Perception Toward HITS

Statement	Weighted Mean	Verbal Interpretation
Comprehension		
1. Extract / Highlight the key words in a problem.	4.03	Agree
2. Translate the word problem from mathematical sentences to mathematical symbols.	3.54	Agree
3. Gain self confidence in solving problem.	3.99	Agree
4. Motivate to continue solving the problem	3.74	Agree
Average	**3.84**	**Agree**
Transformation		
5. Construct picture, bar model, graph or table	4.06	Agree
6. Utilize a representation that is appropriate in solving the problem.	3.82	Agree
7. Convert the concepts needed.	3.62	Agree
8. Visualize the needed mathematical ideas in looking at possible solutions.	3.63	Agree
Average	**3.74**	**Agree**
Calculation		
9. Gain clearer understanding of the problem.	3.94	Agree
10. Apply previous knowledge in calculation.	3.85	Agree
11. Make me a good problem solver	3.54	Agree
12. Have a positive learning attitude toward problem solving	3.87	Agree
Average	3.70	Agree
Overall Weighted Mean	**3.76**	**Agree**

5-Stongly agree, 4-Agree, 3-Moderately agree, 2-Moderately disagree, 1-Strongly disagree

Based on Table 5, the respondents agree that they performed the various subtasks in Comprehension with an average mean of 3.84. The respondents agree that they extract/highlight the key words in a problem with a mean of 4.03; that they translate the word problem from mathematical sentences to mathematical symbols with a mean of 3.54; that they gain self-confidence with a mean of 3.99; and that they are motivated to continue solving the problem.

In the Transformation Subtasks, the respondents agree that they also perform it with an average mean of 3.74. Also they agree that they construct picture, bar model, graph or table with a mean of 4.06; that they utilize a representation appropriate in solving the problem with a mean of 3.82; that they convert the concepts needed with a mean of 3.62; and that they visualize the needed mathematical ideas in looking at possible solutions.

Equally, in the Calculation Subtasks, the respondents agree that they perform it with an average mean of 3.70. They agree that they gain clearer understanding of the problem with a mean of 3.94; that they apply previous knowledge in calculation with a mean of 3.85; that they are developed to be a better problem solver with a mean of 3.54; and that they have a positive learning attitude toward problem solving.

Based on the respondents' interview in the Comprehension Subtasks, 16 out of 17 respondents agreed that the Highlighting Strategy in HITS helped them comprehend the word problem. The reasons given by the respondents were the following: "…*Clues can be found… eliminates confusion… points out the given… the problem gets colorful…and gives clues", as shown in* Table 6.

Table 6
Interview Responses on Highlighting Strategy in the Comprehension Subtask

Answer	Frequency (f)	Reasons	Frequency (f)
Agree	16	Gives clues	9
		Eliminates confusion	4
Disagree	1	Points out the given	5
		Can easily determine the question	2
		The problem gets colorful	3
		Can have focus	1
		Problem is easier to understand	4

Based on Table 6, three out of 17 respondents agreed that the strategy helped them comprehend the word problem, 10 answered that the strategy sometimes helped, and 4 said it did not.

One of the reasons of the respondents who agreed that the Translation Strategy in HITS helped them was: *"… the equation is seen in the highlighted part"*. The reasons by those who answered that the strategy sometimes helped them were: *"…it is confusing… and difficult".* Lastly, the reason by those who answered that the strategy did not help them was: *"… it is difficult".*

In the Transformation Subtasks using the Illustration Strategy, 15 out of 17 respondents agreed that the Illustrating Strategy in HITS helped them transform the word problem, while only one respondent answered sometimes, and another it did not, as shown in Table 7.

Table 7
Interview Responses on Illustration Strategy in the Transformation Subtask

Answer	Frequency (f)	Reasons	Frequency (f)
Agree	15	It's colorful	3
Disagree	1	Gives emphasis to the problems	1
Sometimes Agree	1	Less confusing	1
		It is easier to do	8
		It is enjoyable	1
		It is relaxing	1
		Answers can be visualized from the diagram	3
		It's difficult to draw	1

Based on Table 7, the reasons of the respondents who agreed that Illustration Strategy in HITS helped them were the following: "…*the colors give emphasis to the problem… they help solve the problem… the answers can be visualized… it is easier to explain when there are illustrations…. draws and illustrations are relaxing…. answers can be visualized from the diagram/ illustration*". The reason given by those who disagreed was: *"… it is difficult to draw".*

In the Calculation Subtasks, 11 out of 17 respondents agreed that HITS helped them get the correct answer while six answered sometimes, as revealed in Table 8.

Table 8
Interview Responses in Calculation Subtask

Answer	Frequency (f)	Reasons	Frequency (f)
Agree	11	Illustrations help to find the solution	3
Disagree	0	Illustrations and equation help to find the solution	3
Sometimes Agree	6	Lack of time	7
		It is difficult	6

Based on Table 8, the reasons of the respondents who agreed that HITS helped them get the final correct answer were the following: "….*Illustrations help them find the answer… answers can easily be seen if they could get the correct illustrations…. while others who had both correct illustrations and equations said these could help them get the correct calculation".* The reasons given by those who answered sometimes were: *"… it was difficult…they were not able to finish the test because of lack of time".*

Though HITS could have improved the students' level of performance still, many failed to calculate the final correct answer. One possible explanation to this lies in the intrinsic limitations of HITS. Given that it is an effective strategy, HITS could only affect learning to a certain extent that is common to all strategies. Specifically, it is effective in the comprehension and translation subtasks, but is limited in the Calculation Subtasks where the students need to use their previous knowledge in mathematics to construct their knowledge on the problem at hand. Hence, HITS should be integrated with other learning strategies to enable the others to use other strategies when HITS has reached its maximum limit and not to depend on it alone.

Practical Implications

The results of the study, imply that: 1) There is a significant difference in the pretest and posttest mean scores of the students in the performance t test before and after implementing HITS in solving problems in Algebra; and 2) There is no significant difference between the students' performance and their learning styles in solving word problems.

Conclusions and Recommendations

In light of the above findings, these conclusions are drawn: 1) Students' performance in solving word problems tends to improve using HITS; however, basic skills such as calculation, should be developed first among students to reduce any competence gap; and 2) Students with varied learning styles performed equally well after using HITS; thus, it is an effective strategy in improving problem solving performance.

The study recommends that: 1) Students should not only be taught what to learn in mathematics solving problem, but also be taught multiple learning strategies in each subtask in solving problem until they get the final correct answer; 2) Mathematics teachers should be encouraged to use multiple learning strategies such as HITS in teaching and solving word problems; 3) School administrators need to incorporate multiple learning strategies like HITS in the curriculum or classroom activities and organize programs for teachers to acquire more learning strategies; 4) This study should be replicated by future researchers to improve the body of knowledge about multiple strategies in mathematics solving problem.

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