Research Paper E-ISSN NO : 2455-295X | VOLUME : 4 | ISSUE : 3 | MARCH 2018

THE RELATIONSHIP BETWEEN STUDENT AWARENESS OF ROUTINE AND NON-ROUTINE QUESTIONS AND ACHIEVEMENT

SIBEL KAYA [1] | ZEYNEL KABLAN [2]

[1] FACULTY OF EDUCATION, KOCAELI UNIVERSITY, 41380 IZMIT/KOCAELI, TURKEY.

[2] FACULTY OF EDUCATION, KOCAELI UNIVERSITY, 41380 IZMIT/KOCAELI, TURKEY.

ABSTRACT

The purpose of this study is to examine the relationship between student awareness of routine and non-routine questions and their achievement levels. Student achievement on international tests relies on non-routine problem solving skills. Previous studies on non-routine questions focused on mathematics learning. However, non-routine questions can be found in other fields. In both PISA and TIMSS, there are non-routine science questions that are unfamiliar to students and that they require upper level science process skills, such as analyzing, synthesizing, hypothesizing and evaluating to reach the answer. Therefore, the current study focused on science learning. The participants were 121 undergraduate students (97 female, 24 male) enrolled in Primary Education program of a large university in western Turkey. The participants received a two-hour training from researchers on routine and non-routine questions. After the training, they completed an achievement test that consisted routine and non-routine questions, followed by a checklist in which they identified the question type as routine or non-routine. Study findings showed that, students are more successful on routine questions compared to non-routine ones. They also identified routine questions easier. There was a significant corelation between student awareness of non-routine questions and achievement. In order to increase student achievement on non-routine questions, their awareness of these questions need to be increased. However, the awareness is not adequate for success. Students also need to be informed about how to use their upper level cognitive skills in solving non-routine questions.

Keywords: Routine Questions, Non-Routine Questions, Science Achievement.

Introduction

Programme of International Student Assessment (PISA) mainly tests student achievement on non-routine problems in various fields (OECD, 2003). Similarly, in Trends in Mathematics and Science Study (TIMSS), the complete section of reasoning is composed of non-routine questions (Garden et al., 2006; Kolovou, van den Heuvel-Panhuizen, & Bakker, 2009). Unfortunately, the performance of Turkish students in these tests are not at desired levels (Milli Eğitim Bakanlığı, 2016).

According to Polya, in order to learn certain procedures and definitions, using routine problems is necessary; however, they are the non-routine problems that truly improve students' problem solving skills (Polya, 1962). Routine questions can easily be found in textbooks and they consist of basic computations and definitions (Santos-Trigo, & Camacho-Machín, 2009). The main purpose of asking routine questions is to improve students' basic problem solving skills and to rehearse definitions (Ulu, 2008). Non-routine problems on the other hand, cannot easily be found in textbooks. These questions are unfamiliar to students and they require using several advanced cognitive skills simultaneously (Jurdak, 2005; Lee, Yeo & Hong, 2014; Mullis et al., 2003). Students need to use their prior knowledge and experiences (Kolovou et al., 2009; Schoenfeld, 1999) and they are expected to analyze the problem and come up with different ways for solution (Nancarrow, 2004).

Students can easily solve routine problems by using the rules and strategies shown by teacher or textbook (Harskamp & Suhre, 2007). Teaching these strategies does not require a lot of time and effort from teachers. However, teachers often do not want to deal with the instructional load of non-routine problems. Therefore, they avoid using these problems in their classrooms. It is inevitable for students to be more successful on routine problems since they are exposed to these problems in classrooms frequently. Neverthless, routine problems do not improve students' problem solving skills (Silver, Ghousseini, Gosen, Charalambous & Strawhun, 2005). When students encounter a new and unfamiliar problem they might have difficulty in applying their knowledge and skills. Thus, introducing new and unfamiliar problems in classrooms would not only interest students but also allow them to use their reasoning skills and produce different ways for solution (English & Halford, 1995; Stein, Grover, & Henningsen, 1996). Students' failure in problem solving often stems from not knowing how to use their knowledge and skills (Schoenfeld, 1987; Slavin, 2000; Van Streum, 2000). Moreover, students usually fail to identify and understand the problem. Since non-routine problems have a different structure from routine problems students may have difficulty in identifying, understanding and solving this type problems (Zakaria, 2002).

Even though non-routine questions are emphasized by the curricula students are constantly exposed to routine problems in textbooks and exams. Therefore they develop

a familiarity for routine problems and their solutions (Artut & Tarım, 2006, 2009; Kolovou et al., 2009; Marchis, 2012; İncebacak & Ersoy, 2016). Teachers support the idea of asking non-routine problems in classrooms since they improve students' cognitive skills; however, they do not approve asking non-routine problems in exams (Asman & Markovitz, 2009).

Previous studies showed that there is a positive correlation between solving non-routine problems and student achievement (Altun & Memnun, 2008; Çelebioğlu, Yazgan & Ezentaş, 2010; De Hoys, Gray & Simpson, 2004). Non-routine questions not only improve students' problem solving skills but also their attitudes towards problem solving (Altun & Memnun, 2008). Pourdavood (2012) found that when non-routine questions are used in classrooms, students tend to be more attentive and excited; they discuss solutions and they question other ideas. These positive experiences in classrooms certainly influence students' out-of-shool experiences with problems in a positive way.

Observational studies showed that in general, teachers prefer routine, short answer questions in classrooms (Özmen, Taşkın & Güven, 2012; Teong et al., 2009; Kaya, Kablan & Rice, 2014). They hesitate to present unfamiliar problems and to plan and discuss the solution. Therefore, when students come across an unfamiliar problem, they often have difficulty in understanding it (Teong et al., 2009). According to Polya (1957), understanding a problem is an important step towards solving it. Understanding the problem involves understanding the statements and sentences presented, reformulating the problem and discovering the relations among variables.

Previous studies on routine and non-routine questions focused on mathematics learning. However, non-routine questions can be found in other fields too. In both PISA and TIMSS, there are non-routine science questions that are unfamiliar to students and they require upper level science process skills, such as analyzing, synthesizing, hypothesizing and evaluating to reach the answer. Therefore, the current study focused on science learning. The study specifically seeked answers to the following research questions:

1. Is there a difference between student achievement based on question types?

2. Is there a difference between student awareness based on question types?

3. Is there a relationship between student awareness of routine and non-routine questions and their achievement levels?

Method

The current study was conducted during 2016-2017 school year. The participants were 121 undergraduate students (97 female, 24 male) enrolled in Elementary Education program of a large university in western Turkey. The participants received a two-hour training from researchers on routine and non-routine questions. After the training, the participants completed an achievement test that consisted routine and non-routine questions, followed by a checklist in which they determined the question types.

Training

The first step of problem solving is to identify and understand the problem. In the training, the characteristics of routine and non-routine questions were presented and sample sicence questions were solved. Accordingly, routine questions are those that:

- can easily be found in textbooks.
- can be solved through a formula, rote memorization or a simple method.
- are in knowledge and comprehension level of Bloom's taxonomy.

And non-routine questions are those that:

- cannot easily be found in textbooks.
- can have different ways for solution.
- cannot be solved through a simple method or rote memorization.
- are in analysis, evaluation and creation levels of Bloom's taxonomy.

Two kinds of heat sources are usually available in the science lab; an electric hot plate and a Bunsen burner. Jack planned an investigation to test which of these sources heats water faster.

He poured 200 mL of water into each of two identical beakers and recorded the initial temperature of the water in each beaker.

- Where should Jack place the thermometer to accurately take his readings during his investigation?

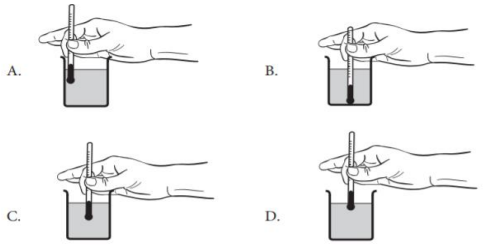
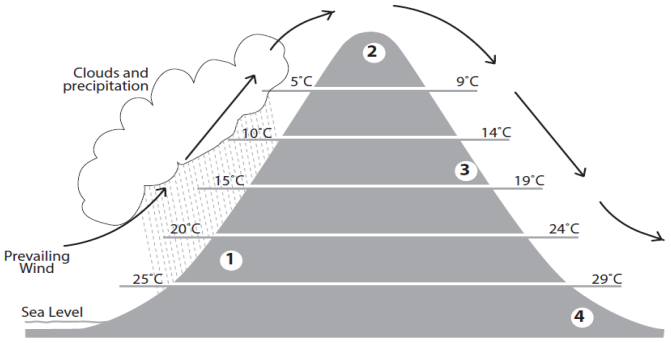


Figure 1. *Sample Routine Question (Multiple Choice) (IEA, 2013)*

In the sample question in Figure 1, the students are expected to know a common rule in taking temperatures for liquids. Accordingly, a person should place the thermometer in the middle of the container, not too close to the surface, bottom or sides. Therefore, the correct answer is C. Since this question does not require any advanced cognitive skills it is classified as routine question.



The diagram above shows the prevailing wind direction, precipitation, and average air temperatures at different elevations on both sides of a mountain. In which location are you most likely to find a jungle?

A. location 1 C. location 3

B. location 2 D. location 4

Figure 2.*Sample Non-routine Question (Multiple Choice) (IEA, 2013)*

In the sample question in Figure 2, students are expected to analyze several variables such as wind direction, precipitation, average temperatures and elevations of different locations. Location 1 has the best conditions for a jungle; therefore, the correct answer is A. Since students used their upper level cognitive skills, this question is classified as non-routine.

James put a pot of water on the stove and heated it. He took the temperature of the water as soon as it started to boil. The thermometer showed 100 °C. James turned the heat up and the water continued to boil for 5 minutes. He then took the temperature of the boiling water again.

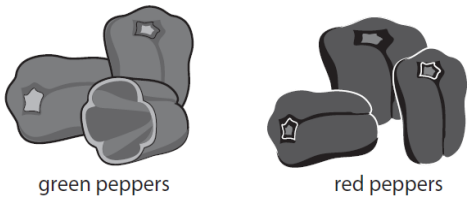
Would the thermometer show greater than, less than or equal to 100 °C?

Answer: _____

Explain your answer.

Figure 3. *Sample Routine Question (Open Ended) (IEA, 2013)*

In the sample question in Figure 3, the students are expected to know a common rule about boiling. Accordingly, the temperature of boiling water does not change even if heated further. By writing this answer students receive the full point. Since the question does not require upper level skills, it is categorized as routine.



Kayra and Emre are studying plants. They have learned that characteristics such as the height of plants and the color of fruit are inherited. They are looking at some green and red peppers.

Kayra thinks they are different kinds of peppers, because they are different colors. Emre thinks that they are the same type of pepper, and red peppers are red because they have been left on the plant longer and have ripened. Describe how you could set up an investigation to decide whether Kayra or Emre is correct.

Figure 4. *Sample Non-routine Question (Open-ended) (IEA, 2013)*

In the sample question in Figure 4, students are expected to design an investigation which requires upper level cognitive skills. Therefore, this question is categorized as non-routine.

Data Collection

Achievement Test: The questions in achievement test were compiled from the previous TIMSS assessments. There were a total of 28 questions, 14 of which were routine and 14 were non-routine. Of each type of questions half of them were in multiple choice and half of them were in open-ended format. The open-ended questions were graded using TIMSS rubric by each researcher separately. Inconsistencies were resolved through discussion. Four of the open-ended questions were worth 2 points; all the other questions were worth 1 point. The highest available score on the achievement test was 32.

In TIMSS assessments, there are three domains: knowing, applying and reasoning. Knowing questions assess the students' knowledge base in terms of science facts, information and concepts. Students are expected to recall, recognize, define or describe. Applying involves the application of scientific knowledge in different situations. Students are expected to classify, compare, contrast, use models, relate, interpret, explain, and find solutions. Finally, the reasoning domain involves more complex scientific tasks. Students may use a variety of strategies to solve such problems. They use skills such as analyzing, synthesizing, drawing conclusions, hypothesizing, generalizing and evaluating (Martin et al., 2008).

Questions in the knowing domain are characterized as routine and questions in the reasoning domain are characterized as non-routine (Garden et al., 2006). Questions in the applying domain can be difficult to categorize; therefore, these questions were not included in the current study. The distribution of achievement test questions are presented in Table 1.

Table 1. Distribution of Achievement Test Questions

Question Type	Routine (Knowing)	Non-routine (Reasoning)	**Total**
Multiple Choice	7	7	14
Open-ended	7	7	14
Total	14	14	28

Checklist: After taking the achievement test students were asked to determine the type of each question in the test. Accordingly, they checked whether each question is 'routine' or 'non-routine'. If the student checked the correct type he/she received 1 point, if not he/she received 0 (zero). Since there were 14 questions from each type, the maximum available score based on question type was 14 and the total available score on the checklist was 28. Student's score on the checklist was named 'awareness score' and it measured how good the student was at identifying the correct question type.

Data Analysis

In order to compare students' achievement on and awareness of routine and non-routine questions, paired samples t-test; in order to examine the relationship between their achievement and awareness, correlation analysis were conducted. SPSS 18 program was used for statistical analyses.

Results

First, in order to compare students' achievement scores on routine and non-routine questions in science, paired samples t-test was conducted and the results were presented in Table 2.

Table 2. Paired Samples T-Test Results of Routine and Non-routine Scores

Score	N	X	sd	df	t	p
Routine	121	8.01	2.08	120	2.98	0.000
Non-routine	121	7.51	2.05			

Paired samples t-test results showed that students' scores on routine questions were significantly higher than their scores on non-routine questions ($t = 2.98$; $p < .01$). The average score on routine science questions was X = 8.01 and the average score on non-routine science questions was X = 7.51 dir. This finding shows that on average, students are more successful on routine science questions compared to non-routine ones.

Second, students' awareness of routine and non-routine questions were compared through paired samples t-test. As seen in Table 3, routine and non-routine awareness scores differ significantly ($t= 2.33$, $p < .05$). Students' mean awareness score on routine questions was X = 8.94 and their mean awareness score on non-routine questions was X = 8.05. This finding shows that students identify routine questions easier compared to non-routine questions in science.

Table 3. Paired Samples T-Test Results of Routine and Non-routine Awareness

Score	N	x	sd	df	t	p
Routine	121	8.94	2.62	120	2.33	0.02
Non-routine	121	8.05	2.59			

Third, in order to examine the relationship between the scores on routine and non-routine questions and the awareness of routine and non-routine questions, correlation analysis was conducted and the results are presented in Table 4.

Table 4. Correlations Among Routine and Non-routine Scores and Awareness

		Routine Score	Non-routine Score
Routine Awareness	r	0.060	-0.047
	p	0.515	0.608
Non-routine Awareness	r	0.085	0.200
	p	0.354	0.043*

According to Table 4, there was a significant positive correlation between the awareness of non-routine questions and the scores on these type of questions ($r =0.200$; $p < .05$). There was no significant correlations between the awareness of routine questions and achievement on routine ($r = 0.060$, $p > .05$) and non-routine questions ($r = -0.047$, $p > .05$). The correlation between the awareness of non-routine questions and achievement on routine questions was also non-significant ($r = 0.085$; $p > .05$).

Discussion and Conclusion

The first finding of the study was that students are less successful on non-routine questions compared to routine questions. This finding was consistent with those of previous studies (Artut & Tarım, 2006, 2009; Dündar, 2015). Even though non-routine questions are emphasized in curricula in Turkey, routine questions are much more common in both nationwide tests and textbooks (Artut & Tarım, 2006, 2009; İncebacak & Ersoy, 2016). Students tend to be more successful on familiar questions in comparison to unfamiliar ones (Silver et al., 2005; Marchis, 2012).

Second, students can identify routine questions easier compared to non-routine ones. Previous studies that examined objectives of curricula in Turkey based on Bloom's taxonomy found that very few objectives cover upper levels of analysis, evaluation and creation. Most of the objectives were focused on lower level, knowledge, comprehension and application (Bekdemir & Selim, 2008;

Kablan, Baran & Hazer, 2013). Therefore, students are more familiar with lower level questions which tend to be routine questions and they have difficulty in differentiating upper level questions.

Another finding was that, there is a significant correlation between student awareness of non-routine questions and their achievement on these questions. When students were more aware of the non-routine questions, their achievement on these questions increased. This finding suggests that in order to solve a non-routine problem, students need to identify and understand the problem. The routine questions in the achievement test were compiled from the released TIMSS items that were in knowledge level. These were the questions that students encounter in the tests and in their textbooks regularly. Non-routine questions, on the other hand, are the ones students do not encounter in tests and textbooks very often. They were at the reasoning level of TIMSS assessment and they required complex cognitive skills such as analyzing, defining variables and relationships. The solution for these problems is not easy and obvious (Gök & Sılay, 2009; Polya, 1990; Altun, Memnun & Yazgan, 2007; Yenilmez & Yaşa, 2007). It is likely that students tried to solve non-routine problems as if they were routine, thus they failed to reach a correct answer. When students come across an unfamiliar problem, they often have difficulty in understanding it and formulating a solution (Salleh & Zakaria, 2009; Zakaria, 2002). Increasing student awareness of question types also increases the chance of understanding and solving it.

In conclusion, in order to increase student achievement on non-routine questions, their awareness of these questions need to be increased. One way to do this is to use non-routine questions in classroom instruction and in tests as much as possible. However, the awareness is not adequate for success. Students also need to be informed about how to use their upper level cognitive skills in solving non-routine questions. In general, students have the necessary knowledge and skills to solve a problem but they often fail to use them in solving a problem (Lee & Chen, 2009; Schoenfeld, 1987; Slavin, 2000; Van Streum, 2000). However, teachers prefer solving and asking routine problems in classrooms due to time constraint. Furthermore, they may not have the skills and knowledge to develop non-routine questions. Ho and Hedberg (2005) emphasize that when teachers receive in-service training and guidance on asking different types of questions, they ask non-routine questions in their classrooms more frequently. Therefore, in-service and pre-service teachers need to be informed about how to develop non-routine questions and how to use them in classrooms. Using unfamiliar, non-routine problems in classrooms not only improves students reasoning skills (English & Halford, 1995; Stein, Grover, & Henningsen, 1996; Özmen et al., 2012), but also their attitudes towards problem solving (Altun & Memnun, 2008; Pourdavood, 2012).

REFERENCES

1. Altun, M., Memnun, D. S., & Yazgan, Y. (2007). Primary school teacher trainees' skills and opinions on solving non-routine mathematical problems. Elementary Education Online, 6(1), 127-143.

2. Altun, M., & Memnun, D. S. (2008). Mathematics teacher trainees' skills and opinions on solving non-routine mathematical problems. Journal of Theory and Practice in Education, 4(2), 213-238.

3. Artut, P. D., & Tarım, K. (2006). İlköğretim öğrencilerinin rutin olmayan sözel problemleri çözme düzeylerinin çözüm stratejilerinin ve hata türlerinin incelenmesi. Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 15(2), 39-50.

4. Artut, P., & Tarım, K. (2009). Öğretmen adaylarının rutin olmayan sözel problemleri çözme süreçlerinin incelenmesi. Uludağ Üniversitesi Eğitim Fakültesi Dergisi, 22(1), 53-70.

5. Asman, D., & Markovits, Z. (2009). Elementary school teachers' knowledge and beliefs regarding non-routine problems. Asia Pacific Journal of Education, 29(2), 229-249.

6. Baykal, A. (2013). Ucu açıklar çoktan seçmelilere karşı. Artı Eğitim Dergisi, 9(101), 24-25.

7. Bekdemir, M. & Selim, Y. (2008). Revize edilmiş Bloom taksonomisi ve cebir öğrenme alanı örneğinde uygulaması. Erzincan Eğitim Fakültesi Dergisi, 10(2) 185-196

8. Celebioglu, B., Yazgan, Y., & Ezentaş, R. (2010). Usage of non-routine problem solving strategies at first grade level. Procedia-Social and Behavioral Sciences, 2(2), 2968-2974.

9. De Hoyos, M., Gray, E., & Simpson, A. (2004). Uncertainty during the early stages of problem solving. Proceedings of the 28th Conference of the International,2, 255-262.

10. Dündar, S. (2015). Öğretmen adaylarının seriler konusuyla ilgili alıştırmaları ve rutin olmayan problemleri çözme becerilerinin incelenmesi. Kastamonu Eğitim Dergisi, 23(3), 1293-1310.

11. English, L. D., & Halford, G. S. (1995). Mathematics education: Models and processes. Mahwah, NJ: Lawrence Erlbaum.

12. Garden, R. A., Lie, S., Robitaille, D. F., Angell, C., Martin, M. O., Mullis, I. V., ... & Arora, A. (2006). TIMSS Advanced 2008 Assessment Frameworks. International Association for the Evaluation of Educational Achievement. Herengracht 487, Amsterdam 1017 BT, The Netherlands.

13. Gök, T. & Sılay, İ. (2009). Problem çözme stratejilerinin öğrenilmesinde işbirlikli öğrenme yönteminin etkileri. Mersin Üniversitesi Eğitim Fakültesi Dergisi, 5(1), 58-76.

14. Harskamp, E., & Suhre, C. (2007). Schoenfeld's problem solving theory in a student controlled learning environment. Computers & Education, 49(3), 822-839.

15. International Association for the Evaluation of Educational Achievement (IEA). (2013).TIMSS 2011 assessment. TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College, Chestnut Hill, MA.

16. International Association for the Evaluation of Educational Achievement (IEA). (2009).TIMSS 2007user guide for international database. TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College, Chestnut Hill, MA.

17. İncebacak, B. B., & Ersoy, E. (2016). Problem solving skills of secondary school students. China-USA Business Review, 15(6), 275-285.

18. Jurdak, M. (2005). Contrasting perspectives and performance of high school students on problem solving in real world situated, and school contexts. Educational Studies in Mathematics, 63, 283-301.

19. Kablan, Z., Baran, T., & Hazer, Ö. (2013). İlköğretim matematik 6-8 öğretim programında hedeflenen davranışların bilişsel süreçler açısından incelenmesi. Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 14(1).

20. Kaya, S., Kablan, Z., & Rice, D. (2014). Examining question type and the timing of IRE pattern in elementary science classrooms. Journal of Human Sciences, 11(1), 621-641.

21. Kolovou, A.; van den Heuvel-Panhuizen, M. & Bakker, A. (2009). Non-routine problem solving tasks in primary school mathematics textbooks – A needle in a haystack. Mediterranean Journal for Research in Mathematics Education, 8(2), 31-68.

22. Lee, C. Y., & Chen, M. P. (2009). A computer game as a context for non-routine mathematical problem solving: The effects of type of question prompt and level of prior knowledge. Computers & Education, 52(3), 530-542.

23. Lee, N. H., Yeo, D. J. S., & Hong, S. E. (2014). A metacognitive-based instruction for Primary Four students to approach non-routine mathematical word problems. ZDM, 46(3), 465-480.

24. Marchis, I. (2012). Non-routine problems in primary mathematics workbooks from Romania. Acta Didactica Napocensia, 5(3), 49-56.

25. Martin, M. O., Mullis, I. V. S., & Foy, P., Olson, J. F., Erberber, E., Preuschoff, C., & Galia, J. (2008). TIMSS 2007 international science report. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

26. Milli Eğitim Bakanlığı (2016). PISA 2015 ulusal raporu. Erişim tarihi 21 Haziran 2017, http://pisa.meb.gov.tr/wp-content/uploads/2016/12/PISA2015_Ulusal_Rapor1.pdf

27. Mullis, I. V., Martin, M. O., Smith, T. A., Garden, R. A., Gregory, K. D., Gonzalez, E. J., ... & O'Connor, K. M. (2003). TIMSS Trends in mathematics and science study: Assessment frameworks and specifications 2003. International Association for the Evaluation of Educational Achievement.

28. Nancarrow, M. (2004). Exploration of metacognition and non-routine problem based mathematics instruction on undergraduate student problem-solving success (Unpublished doctoral thesis). The Florida State University, Florida.

29. OECD (2003).The PISA 2003. Assessment framework- mathematics, reading, science and problem solving knowlegde and skills. Erişim tarihi 21 Haziran 2017, http://www.oecd.org/education/school/programmeforinternationalstudentassessmentpisa/33694881.pdf

30. Özmen, Z. M., Taşkın, D., & Güven, B. (2012). İlköğretim 7. sınıf matematik öğretmenlerinin kullandıkları problem türlerinin belirlenmesi. Eğitim ve Bilim, 37(165), 246-261.

31. Polya, G. (1957). How to solve it: A new aspect of mathematical method (2nd ed.). New York: Double Day and Co.

32. Polya, G. (1962). Mathematical discovery: On understanding, learning, and teaching problem solving. New York, NY: John Wiley & Sons.

33. Polya, G. (1990). Mathematics and Plausible Reasoning: Induction and Analogy in Mathematics. New Jersey: Princeton University Press.

34. Pourdavood, R. R. (2012). Classrooms socio-mathematical discourse: two nine-grade-dyads' non-routine problem-solving engagement. American Journal of Human Ecology, 1(2), 44-50.

35. Salleh, F., & Zakaria, E. (2009). Non-routine Problem-solving and attitudes toward problem-solving among high achievers. International Journal of Learning, 16(5), 549-559.

36. Santos-Trigo, M., & Camacho-Machín, M. (2009). Towards the construction of a framework to deal with routine problems to foster mathematical inquiry.

Primus, 19(3), 260-279.

37. Schoenfeld, A. H. (1987). Cognitive science and mathematics education. Hillsadale, NJ: Lawrence Erlbaum.

38. Schoenfeld, A. H., (1999). Looking toward the 21st century: Challenges of educational theory and practice. Educational Researcher, 28(7), 4-14.

39. Silver, E. A., Ghousseini, H., Gosen, D., Charalambous, C. & Strawhun, B. T. F. (2005) Moving from rhetoric to praxis: Issues faced by teachers in having students consider multiple solutions for problems in the mathematics classroom. Journal of Mathematical Behavior, 24, 287-301.

40. Slavin, R. E. (2000). Educational psychology: theory and practice. 6th. Ed. Singapore: Allyn and Bacon.

41. Stein, M. K., Grover, B. W., & Henningsen, M. (1996). Building students' capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. American Educational Research Journal, 33(2), 455-488.

42. Teong, S. K., Hedberg, J. G., Ho, K. F., Lioe, L. T., Tiong, Y. S. J., Wong, K. Y. & Fang, Y. P. (2009). Developing the repertoire of heuristics for mathematical problem solving: Project 1. Final Technical Report for Project CRP1/04 JH. Singapore: Centre for Research in Pedagogy and Practice, National Institute of Education, Nanyang Technological University.

43. Ulu, M. (2008). Sınıf öğretmeni-sınıf öğretmeni adayı ve 5. Sınıf öğrencilerinin dört işlem problemlerini çözmede kullandıkları stratejilerin karşılaştırılması. Afyon Kocatepe Üniversitesi, Yayınlanmamış yüksek lisans tezi.

44. Van Streum, A. (2000). Representations in applying functions. International Journal of Mathematics in Science and Technology, 31(5), 703-725.

45. Yenilmez, K. & Yaşa, E. (2007). Creative problem solving skills of the primary school students. Education Sciences, 2(4), 272-287.

46. Zakaria, M. J. (2002). Relationship between learning approach and problem solving on the topic of fraction. Unpublished Doctoral Thesis. Universiti Kebangsaan Malaysia.