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**EXAMINING THE IMPACT OF GEORGE PULYA'S PROBLEM SOLVING MODEL
ON CREATIVE THINKING**

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ABSTRACT

Problem-solving has attracted a significant position in mathematics education in the developed countries in recent decades. But unfortunately, there is no sign of such an importance in the developing countries. Certain procedures to produce science and technology are created by the change and development of different affairs of life, and emphasize on thinking methods and styles of creative thinking. This study aims to examine the impact of George Pulya's problem-solving model on creative thinking and the students' math performance. This is a quasi-experimental study with two groups including experimental and witness groups, as well as obtaining pre-test and post-test. The statistical population of the study includes the third grade female students of high schools in Kermanshah's third district and a mass sample of 120 people. To collect the study's data a standard creative thinking skills' questionnaire has been used to measure the students' creative thinking skills and math test is used to obtain information on the performance of students in mathematics. The results showed that the implementation of George Pulya's problem-solving model improves the students' creative thinking. The result was also obtained that there is a significant positive correlation between creative thinking skills of students and their performance in mathematics.

Keywords: Problem-solving, skills, mathematics, creative thinking, performance

INTRODUCTION

Many of the problems people are encountered with in everyday real life, including science issues to social, cultural, political, economic, and in all aspects of life, are basically categorized as a problem-solving situation. People undeniably encounter these types of issues in work and study and they must be prepared to provide their solution. Problem-solving and thinking are considered as issues which have time and again regained their place in the education system with intensity and weakness and sometimes through reforms. The main purpose of education is to help pupils and students to solve problems well and provide useful solutions when they come up with new issues (Farhadian, 2009). Problem solving is considered as one of the main goals of mathematics education. National Council of Teachers of Mathematics in America and Canada stresses the need for (problem-solving) in mathematics, and describes problem-solving as the main and most important part of the mathematics (Mathematics, 1980). Without it, math would be just a set of exercises and skills and a lure for students. In addition to its critical value in mathematics, problem solving has many applications in other branches of science, and

these applications often result in raising important issues in mathematics; in other words (problem-solving) could enhance the relationship between mathematics and other branches of science. Mentally, problem-solving enjoys movement and activity, and it is considered as a source of encouragement and driving force behind the students' activity. Problem-solving creates happiness and it plays an effective role in fostering a sense of human creativity, so that it could be mentioned as an (art). Besides art, (problem-solving) is necessary to understand and appreciate mathematics (Wilson, Fernandes, & Hadaway, 1993). After completing problem-solving courses, and analyzing his observations, Schoenfeld reported that students and scholars had to change their belief about mathematics and believed that math has helped them to think more clearly and be creative. They also claimed that the learned math is much better than the preserved math (Schoenfeld, 1985). Nagasaki (1990) describes the main role of problem solving as to enhance the ability of students to understand the content of mathematics. He then names three approaches to problem-solving including: 1) Problem-solving as an educational objective 2) problem-solving as

an educational process, 3) problem-solving as an educational content. In the first approach, the educational objective is to increase students' problem-solving ability or their ability to think. In this approach, every learning situation can be considered as a problem-solving situation (Nagasaki, 1990). However, (problem-solving) carries different definitions, which affect the methods provided for it, therefore it is better to define problem-solving first. Jones (2000) quotes Kantusky (1977) as considering problem-solving as a situation people face and they lack a prepared algorithm at hand to solve the problem. Jones also quoted Treisman as defining problem-solving as (doing something though you do not know what you do). According to Jones (2000), Lash (1981) considers problem-solving with a wider perspective, beyond the results obtained, and in fact considers it as a tool, a way of thinking, a philosophy and a willingness to learn through accessible opportunities (Jones, 2000). Schoenfeld (1985) has gone further considering all mathematics as problem-solving. According to these definitions, it is clear that problem-solving could not be taught through memorizing special rules, but as Schoenfeld says, it could be obtained through a person's immersion into the process of solving and his/her ability to

properly apply knowledge resources including definitions, concepts, procedures, algorithms and relevant capabilities. The ability to properly use knowledge resources, as cited by Schoenfeld (1985) is called the control factor. According to the definitions provided for (problem-solving), it can be concluded that the problem is a new and unfamiliar situation of which the one who solves problems has no example and clue in mind and as a result, he/she does not know the method to rapidly provide a solution. The problem plays an effective role in the creation of constructive ideas, because it requires the use of a variety of capabilities to be resolved.

However, the practice is repetitive situation and it may be different in comparison with previous experience in details. Thus, the solution is already prepared. (In practice), there is less creativity and initiative but mastering the already learned skills is more required. In fact, the problem has no absolute concept. A (problem) may be a task for a student, while the same task is considered as practice for other students. Therefore, a problem enjoys a relative concept. There are strategies and different approaches to teaching (problem-solving) in the classroom, and this teaching does not fall into a specific format (Schoenfeld, 1985).

An in Pulya model, there are four basic steps to solve every problem including: 1) Understanding the problem, 2) Planning a roadmap, 3) Implementing the roadmap and 4) review. Those people who are involved in solving the problem could learn appropriate individual and strategic skills within this framework and develop their knowledge. It should be noted that all components of this model are interacting with each other.

For example, someone might understand in the third phase of the provided plan that it would not yield any results or there are obstacles in the way of its implementation. As a result he/she must return to the first and second stages, and design a new roadmap and implement it upon a fresh understanding. In the classroom, based on the problem-solving method, for effective but non-intrusive and normal, it is required for the teacher to repeat some questions and frequently remind the steps that should be taken. In Pulya's point of view, it is worthwhile to collect and categorize the questions and suggestions when discussing issues rose about the problem. These groups of questions are useful for the one who solves the problem alone. Here we refer to some useful questions and suggestions that could be helpful in each of the stages. In the first stage some proposals are effective

including reading the problem repeatedly, expressing the problem in familiar terms, drawing figure, appropriate modeling to the situation of the problem, the assessment of the adequacy of the problem's data, determining the hidden assumptions but useful for solving the problem. In the second phase, such recommendations could be provided as dividing the problem into various subgroups and solve them separately, controlling the problem's underlying assumptions, guessing the answer and testing it, solving a relevant problem to the main problem. In the third and final phase of the plan to solve the problem, you could raise the following questions to try and check the steps taken: Does the plan I prepared lead me to problem-solving? Can you see clearly that the step taken is correct? Can you prove it to be true? And other questions can be directed in the review, which can be beneficial: Is my answer sufficiently documented? Can you check the result? Can you get the same result using other ways? Could you use the result or method in another problem? (Polya, 1983)

The problem-solving methods are considered as synonymous to raising creativity in many books and resources related to creativity. Having the ability to recognize, explain and elaborate on the problem and the environment and conditions in which the

problem has been raised, and also forecasting solutions and selecting the best solution are considered as prerequisites to thinking (Flood, 1996). Practically, creative thinking leads to solving problems and providing new solutions to resolve the conflicts in life.

Ganiyeh also uses the same angle to look at the creativity and says, "Creation is a kind of problem-solving in which the opinions and ideas of various fields could be interrelated (Saif, 1984).

To create a situation in which a person had to experience life affairs and study causes creativity and innovation. Dewy's biggest message to Education repeatedly seen in his writings and books, is to give students the opportunity to experience (Dewy, 1968). Training is very effective in developing and promoting creativity and it increases or reduces the ability. All psychologists and researchers believe there is creative thinking in human nature and it is the trainer who must help the talent to blossom through using innovative and creative ways (Mohammad nezhad, 2009).

The philosophy of vision and the methods used in schools as well as the atmosphere or conditions that govern them largely influence creative thinking. The teachers' belief and readiness to accept new content and new issues play a very important role in the

development of creative thinking. Schools traditionally and normally rely heavily on people's memory and teachers prefer to repeat already given responses to thinking. In fact, as Tolstoy said, there is a difference between schools where teaching is easy for teachers with schools where learning is easy for the kids (Budo, 1979).

Since the early 1980s, the cultural perspective of creativity has effectively and applicably entered the fields of study and research into creativity. Despite having a long history, this perspective has attracted the attention of many researchers of education and training in this decade. The ruling atmosphere of the training centers, a lot of criticism because of the low level of the institute's performance and criticizing individualistic methods of education led to ultimate training of self-centered, maverick people with a marginalized thinking and thus much attention began to be paid to assumptions of cultural theory of creativity (Zentmehylie, 2003).

Ekval (1993) found after conducting extensive research that cultural factors are associated with creativity more than any other factor. In one of his articles, he states that wherever there is a much open atmosphere in a society, people would carry

on with greater freedom and more responsibility (Ekval, 1993).

Baron (2003) has found in his consecutive studies that all the theories raised in the context of creativity have an individual aspect and they consider the source of creativity to be inside the person himself. But today it is clear that the social factor has a much greater influence on creativity than individual factors and in many cases it is the driving force behind this phenomenon. In view of the social context, individual and science and social context join hand in a communicative network and create behavioral contexts (Baroon, 2003).

The history of research

Cano Garcia and Hughes (2000) conducted a research on 210 college students entitled "ways of learning and thinking methods: Analyzing the relationship between the two and their impact on their academic success". The results showed a significant correlation between the two methods. Meanwhile, the results of regression analysis showed that students' academic achievement was linked to their way of thinking. According to the results of educational psychologists, the need to encourage thinking was an important part of the learning process (Cano Garcia & Hughes, 2000).

Donnelly (2004) has also carried out a research called raising creativity under a higher education curriculum. In an institution of higher education in Ireland, he has developed a creativity training course for teachers of different disciplines. The result was that teachers increased the efficiency of teaching to their students after getting to know these methods of raising creativity and transferred the advantages to students (Donnelly, 2004).

Yang and Cheng (2009) concluded in their study that observation, research, analysis and problem-solving by students had a positive impact on creativity and its components, such as flexibility and initiative (Yang & Cheng, 2009).

Dorin and Korb (2009) concluded in their study that in the traditional teaching of the sciences, students failed to use the sciences they had learned in their daily lives.

They believed that the traditional systems must be transformed and move towards creative training in order to have a constructive educational system. But a number of teachers do not take advantage of creative teaching methods in the classroom due to lack of mastery and understanding of the practices (Dorin & Korb, 2009).

Rooney (2010) has stated in his study that most high school students cannot use their

knowledge to explain and predict phenomena and they are unable to solve new problems. The problem stems from the fact that classroom teachings lack required quality strategies to argue them (Roni, 2010)

Shokrkon et al (2002) conducted a research entitled simple and multiple study of creativity, motivation and self-esteem and entrepreneurship among students of Shahid Chamran University of Ahvaz. The results showed the mean scores of boys in tests of entrepreneurship, creativity and self-esteem were more than that of girls, but girls had higher mean scores in motivation. There was also a significant positive relationship between the students' creativity and entrepreneurship (Shokrkon, H; et al, 2002).

Hosseini nasab et al (2003) conducted a study on 500 students including boys and girls of Tabriz University entitled "studying methods and learning strategies among students and their relation to intelligence, creativity, gender and field of study". The findings include: whenever people enjoy higher IQ and more creativity, they have a higher internal locus of control. In addition, the creative students act much better in using of learning strategies than students with low creativity (Hosseini nasab, D; et al; 2002).

Hamidi (2010) concluded in a study entitled examining the impact of problem-solving

methods on increased creativity that teaching by method of problem-solving increases creativity (Hamidi, 2011).

Fathi Azar and Heidari Farfar (2010) examined in their study the impact of problem-solving on the creativity of third grade students of Maragheh. They concluded that problem-solving method had a positive impact on students' creativity (Fathi azar & Heydari farfar, 2011).

The present research questions can be expressed as follows:

1. Is the implementation of George Pulya's problem-solving method effective on students' creative thinking?
2. Is there a significant relationship between creative thinking skills and mathematical performance of students?

Research Tools:

A standard creative thinking skills' assessment questionnaire has been used in this study to obtain data on students' creative thinking. The questionnaire consisted of 20 items. Standard score of creative thinking in this study means that the people answer the questionnaire's 20-item questions. Scoring the questionnaire is based on the 5-point Likert range. For options "no", "rarely", "sometimes", "often" or "always" scores 1, 2,

3, 4 and 5 are considered respectively. To obtain a total score of the questionnaire, all scores of the items will be gathered together. Welch and Mc Dowall have reported the validity of the questionnaire as favorable and put its reliability according to Cronbach's alpha above 80%. Therefore the questionnaire enjoys an acceptable reliability (Welch & Mc Dowall, 2002). To obtain information on the math performance of students, a math test was used which was prepared by experienced teachers.

Participants:

The statistical population of this study includes all the third year female students of high schools in Kermanshah province's third district in the 2014-2015 school year. Sampling method in the study was cluster-like sampling so that two high schools were selected from among girls' high schools in Kermanshah's third district and an analysis was carried out on a number of third year students of the high school. From among the statistical population, a mass sample of 120 third year students was obtained using Cochran formula.

Methods of Conducting Research

To collect the data, the considered classes were selected from among chosen schools. Two classes formed the experimental groups and two others formed the witness groups.

To obtain the required information, the creative thinking skills' assessment questionnaire was used. After entering the class, first a list of students was prepared and then they were briefed about the purpose of the research. At this point, they were also briefed about the number of the questionnaire's questions and the time they need to respond, then the questionnaires were distributed among them and they were asked to respond to questions carefully and patiently. After about 30 minutes the questionnaires were collected at once. After collecting the questionnaires, the students' math test scores list of the end of the first semester was taken from the teacher. Then George Pulya's problem-solving model was conducted in the experimental group, i.e. two classes of students in the second semester of the academic year. After the second semester, we returned to the schools and both students of the experimental and the witness groups were asked to once again respond to the creative thinking questionnaire. Then math scores list of second semester was taken from the teacher.

FINDINGS

The obtained points were examined from the creative thinking's questionnaire in both experimental and witness groups before and after the implementation of George Puglia

model. As shown in Table 1. The data in both groups follow a normal distribution; therefore parametric tests can be used.

Table 1: Checking the normality of the data in the experimental and witness groups

		The experimental group's creative thinking	The witness group's creative thinking
Normality of pre-tests data	mean	71.1500	59.7500
	Standard deviation	9.14949	8.37839
Pre-test figure-P		.726	.197
Normality of post-tests data	mean	76.2000	62.2000
	Standard deviation	9.07048	8.58763
Post-test figure-P		.921	.126

T-test is used to examine creative thinking of the experimental and witness groups. According to Table 2 in both groups before and after the implementation of George Pulya's model based on the obtained -P, which is more than 0/05 and the assumption of variances' equality is accepted. As you see, because -P is less than 0/05, the two groups' mean should be examined in Table 3.

As seen in Table 3. The creative thinking mean scores of the experimental group before and after the implementation of George Pulya's model is better than that of the witness group. Of course given the

comparison between the values in Table 3 it can be concluded that the amount of points' increase in the experimental group after the implementation of the model was more than the increased value in the witness group. Therefore, the implementation of the George Pulya's model causes a bigger growth in the students' creative thinking average score and generally improves their creative thinking.

In Table 4, the correlation between creative thinking and math performance in both experimental and witness groups are examined.

Table2. T-test results to evaluate differences in creative thinking between experimental and witness groups

		Leon test for variances equality		T-test for means equality		
		Statistics - F	Quantity-P	Statistics - T	Degree of freedom	Quantity-P
Pre-test Creative thinking	If variances are equal	1.221	.276	4.109	38	.000
	If variances are not equal			4.109	37.709	.000
Post-test creative thinking	If variances are equal	.987	.327	5.012	38	.000
	If variances are not equal			5.012	37.887	.000

Table3. Checking creative thinking means points of the experimental and witness groups

	Code	Mean	Standard deviation
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Pre-test thinking	Experimental group	71.1500	2.04589
	witness group	59.7500	1.87346
Post-test thinking	Experimental group	76.2000	2.02822
	witness group	62.2000	1.92025

Table4. Correlation between students' creative thinking and math performance

		Creative thinking	Math performance
Creative thinking	Pearson correlation coefficient	1	.257
	Value - P		.019
Math performance	Pearson correlation coefficient	.257	1
	Value - P	.019	

Table 4 shows there is a positive correlation between creative thinking and students' mathematical performance. Then it can be concluded that if a person gets more points for creative thinking, he/she will have a better performance in mathematics.

CONCLUSION

One of the problems in the educational system of most of the developing nations is their little use of dynamic teaching methods such as exploratory, collaborative, group discussions and case study (Jahani, 2008). The conducted researches show that teachers often used passive teaching methods and active methods are less used (Sharifi & Davari, 2009). This is while that the content and structure of some lessons require that active teaching methods be used in their training. Therefore, teachers should note that the students should be encouraged to have convergent thinking (where there is one right answer), as well as having divergent thinking (where there are multiple correct answers). Because there is not a single solution for

problems in the real world, and that they are allowed to provide several solutions even strange and unusual to every question that arises, even students should have the opportunity to learn how to comment on their favorite content and their favorable teaching method (Shabani, 2011).

As far as the impact of the implementation of Puglia problem-solving model on creative thinking skills is concerned the findings show this model has a positive and increasing impact on creative thinking skills and improves the skill. In fact, the implementation of this model in class will bolster the creative thinking skills in students and increase their creative thinking scores. It should be noted that conclusions about the findings are consistent with the findings of internal investigations carried out by Hamidi (2011) and Fathi Azar and Heidari Farfar (2011). Their research also showed that teaching through problem-solving has a positive impact on students' creativity. Yang and Cheng (2009) also concluded that

observation, research, analysis and problem-solving by students had a positive impact on creativity and its components, such as flexibility and initiative, which are consistent with the result of the present research.

The results obtained from this study show there is a positive correlation between creative thinking skills and mathematical performance of students. So the greater the students' points in creative thinking skills, they would do a better mathematics performance and they act better at solving math problems and answering the test questions.

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