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Education Programs for Talented Students Model (EPTS) and its Effectiveness on Gifted Students' Mathematical Creativity*

Üstün Yetenekliler Eğitim Programları Modeli (ÜYEP)ve Üstün Yetenekli Öğrencilerin Matematiksel Yaratıcılıkları Üzerindeki Etkisi

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Abstract

The purpose of this article is to present an overview of the Education Programs for Talented Students (EPTS) and their effectiveness on gifted students' mathematical creativity. The EPTS is a university-based, six-component program model. Its effectiveness was investigated using one-group pretest-posttest research design. Participants included 102 sixth and seventh-grade gifted students in middle schools in a mid-western city in Turkey and who were identified to be talented in mathematics and science by the EPTS identification system. Findings showed the EPTS mathematics instruction had medium to large effects on students' fluency, flexibility and creativity in mathematics after attending the spring and summer programs of the EPTS. Results of the two-year research studies imply that the EPTS is an effective, new program model in the education of gifted students.

Keywords: Education Programs for Talented Students (EPTS), gifted students, effectiveness, creativity

Öz

Bu makalede Üstün Yetenekliler Eğitim Programları modeli (ÜYEP) ve programın üstün yetenekli öğrencilerin matematiksel yaratıcılıkları üzerindeki etkisi incelenmiştir. ÜYEP, üstün yetenekli ilköğretim öğrencilerine yönelik üniversite tabanlı, altı bileşenli bir programdır. Programın etkisi, tek grup öntest-sontest araştırma tasarımı kullanılarak incelenmiştir. Araştırma grubunu, ÜYEP tanılama sistemi ile matematik ve fen bilimleri alanlarında üstün yetenekli olarak tanılanan ve 6. ve 7. sınıflara devam eden 102 öğrenci oluşturmuştur. Araştırma, ÜYEP bahar ve yaz dönemlerini kapsamış, öğrenciler bu süreçte ÜYEP modeline göre matematik eğitimi almışlardır. Araştırma, ÜYEP matematik eğitiminin öğrencilerin matematik alanında akıcı düşünme, esnek düşünme ve yaratıcı düşünme yetenekleri üzerinde orta ve yüksek düzeyde etkisinin olduğunu ortaya koymuştur.

Anahtar Sözcükler: Üstün Yetenekliler Eğitim Programları (ÜYEP), üstün yetenekli öğrencilerin eğitimi, yaratıcılık eğitimi.

Introduction

In order to be considered a well-designed program, an education program for gifted students should have certain design parameters such as identification, curriculum and assessment (Borland, 1989; VanTassel-Baska, 1998) otherwise, it would be what Tomlinson (2009) calls a "patch-on" program. A patchy program is detached from the general curriculum, does not have a coherent scope and sequence of content and skills across the grades, and lacks articulated

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elements such as well-defined learning outcomes (Tomlinson, 2009). The Education Programs for Talented Students (EPTS) is a university-based program for gifted students at Anadolu University in Turkey. This article deals with an overview of the EPTS model and presents research studies carried out on the effectiveness of the EPTS on gifted students' mathematical creativity. The EPTS consists of six components: identification, curriculum, program format, instruction, assessment, and teacher training.

EPTS Program Format

A number of factors contribute to the design and selection of program formats such as talent domain, level of giftedness, cultural and family values, funding (Moon & Roselli, 2000), grade level of target population, attitudes and expectations of students and their parents, and educational systems. The EPTS is an after-school program offered in the weekends and summers. This program format is one of the best options for educational systems, such as the one in Turkey, which does not have enough flexibility for radical and systematic accelerations (Sak, 2006, 2007, 2010b). When students and teachers do not have enough time and resources for acceleration and when some acceleration approaches, such as grade skipping and advanced placement, are very limited in an educational system, one of the best acceleration approaches is to teach advanced content in out-of school programs.

EPTS Identification Model

Having clear conceptions of the nature of giftedness and talent is a prelude to identification and assessment of gifted students (Feldhusen & Jarwan, 2000). An identification practice would have serious handicaps without a conception of giftedness; because the definition of giftedness adopted by decision-makers generally determine what tests and procedures are used to identify gifted students. The definition of giftedness underlying the EPTS identification model is that giftedness is high potential in well-defined ability domains that are *essentially* valuable for human life. This definition is not entirely new; yet it is rather contemporary reflecting current paradigms in conceptions of giftedness. Several forms of this definition can be found in current conceptions (e.g., Sternberg & Davidson, 2004). The EPTS identification system has four components:

1. assessment of domain-specific abilities,
2. use of multiple criteria,
3. use of sample-based identification, and
4. use of natural selection-adaptive retention model (Sak, 2011).

Sample-Based Identification

The EPTS identification system utilizes a sample-based model contrary to most programs that use nomination-based and norm-based models. That is, students are referred by their teachers, and then, their intellectual strengths are assessed by norm-referenced tests. This method of identification has two serious problems. The use of teacher nominations to identify students is thought to be an age-old practice (Hunsaker, Finley & Frank,1997) and has been found to be ineffective and inefficient (Pegnato & Birch, 1959). For example, Chan (2000) found teachers' ratings of gifted behaviors not to be much related to creativity and teacher rating scales not to be good predictors of IQ and creativity.

Second, the use of norm-referenced tests may be the best option to identify gifted students if identification is carried out across a country. However, just like every country has its own high ability students, so does every region and city because a region has its own local characteristics and norms. Major differences might even exist within regions. If demographics of a country vary greatly from region to region, each region should develop its own norms for the identification of gifted students. That is, giftedness cannot be decontextualized, and thus assessment of giftedness should be contextual. Sample-based identification is a good method for contextual assessment of giftedness. For example, if we are to identify students for an education program for gifted students in a town that has about one thousand students at each grade level, we should compare intelligence of these students within the group not to that of a national normative group and select the most able students from this student population as many as the program can serve. The comparison of children of a town to those of a national normative group in terms of their intelligence can produce misleading results for the education of the most able students of that town; because, as research studies show (Ceci, Barnett, & Kanaya, 2003; Stanovich, 1986), the effect of environment on intelligence is so great, and gene-environment correlations multiply this effect. Sample-based identification is most appropriate for micro-level programs such as the EPTS when the purpose of a gifted education program is to offer advance and enriched learning experiences to the most able students of a region, city, or school.

Natural Selection-Adaptive Retention Model of Identification

There are two processes, *natural selection and adaptive retention*, that are distinguishing characteristics of the EPTS identification system (Sak, 2011). Students are selective in learning environments that fit their individual characteristics. For example, students who like to and good at playing soccer prefer to join soccer clubs whereas those who have skills and interest in the arts prefer to attend arts clubs or arts activities. Likewise, students who have high ability, keen interest and learning motivation in mathematics and science search for best environments or opportunities that could nurture their ability and satisfy their learning needs in these subjects. This type of preference is called "*natural selection*" in the EPTS identification system. Natural selection plays an important role in the process of the EPTS identification system by a) allowing any sixth-grade students to apply to the EPTS while b) reducing the number of applicants by self-selection. Because students are aware that the EPTS is an education program for highly able students and has rigorous curriculum in science and mathematics, only those who have learning motivation, keen interest and believe that they have high ability in science and mathematics apply for admission to the EPTS. Because the process of natural selection greatly reduces the number of applicants, it makes pre-identification practices, such as teacher nominations, unnecessary for student selection.

Some students could select inappropriate learning environments for themselves. Like in the theory of natural selection, these students are likely to experience maladaptation because their intellectual, motivational or interest profiles do not fit the learning environment they select. It is highly likely that students who experience maladaptation leave this environment because they hardly get satisfaction from it. Otherwise, the environment itself excludes these students. Applied in the EPTS, if some students previously identified as gifted demonstrate successive failures and low interest and learning motivation in the program, they eventually drop out of the program or are recommended to do so; because they do not get learning satisfaction and benefit from the program. This whole process is called "*adaptive retention*" in the EPTS identification system. The natural selection-adaptive retention model of identification creates a good match between high-ability students and education programs for gifted students.

Domain-Specific Identification

The best predictor of any criterion is a performance sample of that criterion (Anastasi & Urban, 1997). For example, if soccer players are to be selected for a team, the best way to predict their future performance is to assess their current performance in soccer games. In essence, measures of identification select students who can meet the goals of the program and exclude students who would fail to achieve the goals (Feldhusen & Jarwan, 2000). Therefore, identification tools and procedures should align with the goals of the program; otherwise, identification would fail to select students whose intellectual strengths would not fit program goals. Because the EPTS emphasizes excellence in mathematics and science, a combination of mathematical ability, scientific creativity and math and science academic achievement is used in the EPTS identification model. The EPTS identification model creates a good match between students' intellectual strengths and program services.

Use of Multiple Criteria

There exists no perfect predictor of excellence. In fact, any single predictor account for no more than 30% of outstanding achievement. But, a combination of more than one predictor can explain about 50% of the variance in later achievement (Trost, 2000). In line with research findings, recent trends in the identification of gifted students support the use of multiple selection criteria (Feldhusen & Jarwan, 2000). Selection criteria also should align with program goals. Because the EPTS offers enriched-accelerated courses in science and mathematics, its identification includes the use of domain-specific instruments. These instruments includes the Test of Mathematical Talent (Sak, Karabacak, Akar, Sengil, Demirel & Turkan, 2008; Sak, Turkan, Sengil, Akar, Demirel & Gucyeter, 2009; Sengil, 2009), Creative Scientific Ability Test (Ayas, 2010; Ayas & Sak, 2008; Sak, 2010a, 2011) and math and science end-of-school grades. The Test of Mathematical Talent contributes %70, the Creative Scientific Ability Test contributes %25, and the arithmetic mean of math and science end-of-school grades contributes 5% to the total score.

EPTS Curriculum Model

The EPTS curriculum model was developed based on an integration of the teaching principles of the theory of successful intelligence (Sternberg, 1997; Sternberg & Grigorenko, 2000, 2007) and research on problem solving and creative thinking (e.g., Guilford, 1977; Runco, 1991, 1994, 1997). The EPTS Curriculum is composed of analytical, creative, practical, and knowledge components and includes forty-four defined problem solving and thinking skills (Sak, 2009, 2011). Each component has a variety of problem solving and thinking skills, called EPTS skills. The analytical component includes ten skills, such as defining problems and forecasting. The creativity component has fifteen skills, such as fluent idea generation and creative imagination. The practical component consists of nineteen skills, such as initiating, setting priorities and completing tasks. Finally, the knowledge component contains one year or more accelerated content standards of the general curriculum at each grade level.

The EPTS curriculum model reflects a combination of enrichment and acceleration approaches. One of the key beliefs guiding the most curriculum models in gifted education is that gifted students are best served by a confluent approach that allows for both advanced content learning and enriched experiences (VanTassel-Baska, 2000). Indeed, acceleration and enrichment have been the dominant approaches for differentiating the education for gifted students. Meta-analytic studies have shown the both approaches to have positive learning effects when they are well-designed (Kulik & Kulik, 1992). However, according to some researchers, acceleration is viewed to be the most ideal model in educating gifted students (Stanley, 1977; VanTassel-Baska, 2005) whereas enrichment is so deemed by others (Renzulli & Reis, 2000).

EPTS Acceleration

EPTS acceleration is a content acceleration. As students take their regular math and science courses in their schools, they already learn some contents of the regular curriculum before they come to the EPTS classrooms. They have a level of readiness in each subject matter, which is used as a starting point for the EPTS lessons. Acceleration is carried out by transferring higher-grade level contents and linking these contents to students' prior knowledge. One and half-a-year acceleration is made from the sixth grade to the eighth grade. That is, a student successfully completing the sixth, seventh and eighth grades of the EPTS, learns all contents of the ninth grade curriculum and most of the contents of the tenth grade curriculum in science and mathematics. Any content acceleration also contains enrichment activities designed by integrating the EPTS skills into the accelerated content. This way of acceleration and enrichment promotes both the development of advanced content knowledge and enhancement of higher-order thinking skills.

EPTS Enrichment

The integration of the EPTS skills into accelerated contents is the enrichment model of the EPTS. The purpose of the enrichment of the EPTS is to develop process skills in students and to make their knowledge applicable outside the learning situation. Acquisition of knowledge that is transferable in different situations is a complex learning leading to cognitive flexibility (Gruber & Mandl, 2000). EPTS units are designed in a way students are exposed to a concept in different units, with different problem solving goals, at different times, and from different perspectives. Students could see the same concept in many units but with different levels of abstraction and use it for different purposes. Transferability of knowledge also is the basis of interdisciplinary learning, a principle recommended for the education of gifted students (VanTassel-Baska, 1992; Maker, 1982; Maker & Schiever, 2010). Transferability of knowledge increases by the use of multiple perspectives on problem solving rather than through abstract context-free learning (Gruber & Mandl, 2000). Applied in gifted education, the single use of acceleration with an emphasis primarily on learning advanced content helps students learn those contents, but could lead to decontextualized learning, and therefore may not result in the acquisition of transferable knowledge. This idea is one of the rationales for combining enrichment and acceleration in the EPTS.

Combination of Acceleration and Enrichment in EPTS Units

Accelerated-enriched units of the EPTS are developed in the following order. In the first stage, a unit and its content, objectives and national standards at a particular grade level are identified. This unit is called the *original unit*. In the second stage, a similar unit, its content, objectives and national standards at a higher grade level are identified and integrated into the original unit. This unit is called the *accelerated unit*. In the third stage, appropriate EPTS skills are identified and integrated into the accelerated unit. This unit is called the *accelerated-enriched unit*. Finally, in the fourth stage, teaching techniques and strategies are identified and instructional materials are developed and/or adapted based on the content and objectives of the accelerated-enriched unit. This unit is called the *EPTS unit*.

EPTS Instructional Format

The EPTS mathematics and science courses consist of units of six to nine lessons. Each unit has three sequential components: a) a documentary movie, b) a lecture given by an academician (e.g., a scientist or mathematician), and c) learning activities guided by teachers. The first lesson of each unit begins with a documentary movie related to the content. For example, the documentary might be related to the structure of atom or life of a genius in an atom unit in science. The purpose of this lesson is to ignite students' curiosity and interest, elicit prior knowledge and raise their motivation in learning the content of the unit. The second lesson is taught by an academician/scientist. The academician makes connections between real life and theoretical knowledge of the content of the unit and raises questions in students' minds and discusses these questions. The rest of the unit (4 to 6 lessons) is guided by the teacher and includes learning activities developed based on an integration of the EPTS skills and accelerated national standards at each grade level.

The EPTS instructions include a variety of learning activities, teaching strategies and techniques to help students develop analytical, creative and practical abilities, and a reservoir of domain-specific knowledge and skills. Specific teaching techniques are systematically used in all units to help students learn problem solving strategies and enhance their problem solving skills. The Hilda Taba teaching strategies are used for concept development, data interpretation and generalization; The DISCOVER Problem Matrix is used for problem generation and problem revision activities; Creative Reversal Act is used for generating creative paradoxical metaphors and ideas through the use of a variety of analytical and creative skills at successive steps; Selective Problem Solving is used for solving problems through the use of analogies and for identifying, defining and constructing analogous problems; and Creative Problem Solving is used for problem finding, problem redefining and solution finding activities.

EPTS Teacher Training

Even the best program for gifted students would fail to achieve its goals if its teachers are not well trained about the education of gifted students. Teacher training constitutes an integral component of the EPTS. The entire training takes three graduate-level courses: a) Conceptions of giftedness, b) curriculum development and differentiation, and c) teaching models, techniques and strategies. Embedded in the graduate level-courses, teacher training includes: a) observing, learning and application of the EPTS skills and teaching techniques used in the EPTS lessons (eg., Creative Reversal Act and Selective Problem Solving); b) developing and piloting lesson plans using the EPTS skills and teaching techniques; and c) developing comprehensive unit plans by integrating the EPTS skills and the national curriculum standards at a particular grade level.

EPTS Assessment

A particular attention should be paid to the match between instructional goals and the outcome measures to ensure valid results in evaluating the outcomes of instruction in programs for gifted and talented students (Callahan, 2009). In line with this idea and the instructional goals of the EPTS, its assessment system consists of objective measures of progress and perceptions. Because one of the major goals of the EPTS instruction is to promote the development of creativity in mathematics and science, three types of measures are used for examining the effectiveness of the EPTS: a) Measure of mathematical creativity; b) measure of scientific creativity; and c) measure of students' perceptions. Mathematical and scientific creativity are measured on pretest and posttest conditions through the use of Creative Mathematical Ability Test (Şengil, Sak & Türkan, 2009; Türkan, 2010) and Creative Scientific Ability Test (Ayas, 2010; Ayas & Sak, 2008; Sak, 2010a). The EPTS Evaluations Student Form (Sak & Karabacak, 2010) is used to examine students' perceptions about some aspects of the EPTS instruction.

Purpose of the Study

The purpose of this study was to examine the effectiveness of the EPTS on 6^{th} and 7^{th} grade gifted students mathematical creativity. Guided by this purpose the following research question was investigated: Do students' pretest fluency, flexibility and creativity scores on the Creative Mathematical Ability Test differ significantly from their posttest scores after they attend the EPTS mathematics instruction for four months?

Method

Participants

Participants (N= 102) included two groups of students from 2008 and one group from 2009. The groups included 42 sixth-grade students (f=15; m=27) and 34 seventh-grade students (f=6; m=28) who attended the EPTS in 2008 and 26 sixth-grade students (f=4; m=22) who attended the EPTS in 2009. All of the students were identified to be talented in mathematics and science by the EPTS identification system. Some of the students were attending public schools and some were to private schools in the city of Eskisehir in Turkey while they were attending the EPTS weekend and summer programs. Because some of the students could not participate either in the pretest or in the posttest, the data analysis included 22 participants from the 2009 sample.

Research Design

One-group pretest-posttest design was used to carry out the research studies. There were convincing reasons for choosing this research design. Indeed, these reasons apply to most education programs for gifted students that are in their initial years and have long-term goals (e.g., Stanley, 1977). Some of these reasons were the followings. First, it would not be fair to withhold some good opportunities from some gifted students who would be assigned randomly to a control group but who were expecting to benefit from the opportunities the EPTS offered. Secondly, because the EPTS was in its initial years during the research studies, its prestige would be weakened if it offered ordinary experiences to students of the control group who would expect extraordinary experiences.

Instruction

The EPTS curriculum and mathematics instruction are discussed in detail before. Here, only the mathematics instruction used in the current study will be reviewed shortly. EPTS mathematics program was developed based on an integration of the EPTS curriculum and national standards at each grade level. In this study, EPTS mathematics lessons were used in all mathematics instructions. Instructions were carried out both in the weekends of the spring semester and during the summer school of the EPTS. The spring semester included 36-hour instruction in 12 weekends. Three-hour mathematics instruction was offered in each weekend. The summer school lasted two weeks and included 18-hour instruction, with each week having 9-hour instruction. All instructions in 2008 and 2009 were carried out by the same teacher who had EPTS teacher training.

Instrument

Creative Mathematical Ability Test. Creative Mathematical Ability Test (C-MAT) was used as the pretest and posttest to examine any change in students' creative mathematical ability. The C-MAT is a test of creative thinking and problem solving in mathematics for sixth through eighth grade students. It consists of five subtests. They contain open-ended problems in numbers, algebra, statistics, and geometry. The test measures fluency, flexibility and creativity in problem construction and problem solving tasks. It produces fluency, flexibility and creativity scores for each subtest as well as a total score for fluency, flexibility and creativity. Total creativity score is obtained using log2. Research on the psychometric properties of the C-MAT shows sufficient internal consistency and inter-scorer reliability and criterion validity evidences (Şengil, Sak & Türkan, 2009; Türkan, 2010).

Data Collection

The Creative Mathematical Ability Test (C-MAT) has standard administration procedures. The pretests were administered in the first classes of the EPTS mathematics courses in the spring semesters of 2008 and 2009. The posttests were administered in the last classes of the summer school four months after the pretests. The testing sessions took 40 minutes.

Data Analysis

Students' responses on the C-MAT were scored by a trained researcher using the standard scoring procedures. Paired-samples t-test was used to test the significance of differences between students' pretest and posttest scores. Because a separate t-test analysis was run for each grade and year, in all comparisons statistical significance level was set at .016 by dividing the conventional level ".05" by the number of tests to be run. Effect sizes of differences between pretest and posttest scores were calculated using Cohen's "d" with pooled standard deviations (Cohen, 1988).

Results

The effectiveness of the EPTS in improving students' creative mathematical ability was examined using their performance on the Creative Mathematical Ability Test (C-MAT) in pretest and posttest conditions. Table 1 presents students' mean scores by year and grade in fluency, flexibility and creativity components of the C-MAT, differences between the means and Paired Samples t-test results.

Comparison of Creative Performance on the C-MAT

As seen in table 1, both the 2008 students and the 2009 students scored much higher on the posttests than in the pretests. Performance growth was observed in all dimensions of the C-MAT including fluency, flexibility and creativity. Paired Samples t-test analysis yielded that all of the mean differences between pretest and posttest scores of both the sixth graders and the seventh graders were statistically significant.

For the effect size of index "d" (Cohen, 1988), a value of 0.5 is considered to indicate a moderate effect and a value of 0.8 to indicate a large effect. The Cohen's "d" effect size analysis showed large effect sizes in six comparisons and medium effects in three comparison. Effect sizes obtained from pretest-posttest differences in fluency, flexibility, and creativity showed that flexibility had the highest overall effect size (Mean= .89), followed by creativity (Mean= .83) and fluency (Mean= .82). The mean of all of the effect sizes was .85, a large effect. Also, the mean of effects of the EPTS on fluency, flexibility and creativity was larger in the sixth grade (Mean= .913) than in the seventh grade (Mean= .723). 0

Table 1

Pretest and Posttest Scores on the C-MAT, t-test Results and Effect Sizes

				Pretest		Posttest		Paired Samples t-test					
Year	Grade	N	Measure	Mean	SD	Mean	SD	Mean Diff.	SD	t	df	p	d
2008	6	42	Creativity	6.04	2.95	9.08	3.65	3.04	3.63	5.43	41	.000	.92
			Fluency	9.09	4.87	15.15	7.68	6.05	6.44	6.09	41	.000	.96
			Flexibility	4.19	2.02	6.14	2.59	1.95	2.95	4.28	41	.000	.98
2008	7	34	Creativity	9,25	3,62	12,21	4,21	2,95	3,75	4,59	33	,000	.74
			Fluency	14,55	7,51	22,11	10,42	7,55	8,58	5,13	33	,000	.84
			Flexibility	6,67	2,19	7,94	2,08	1,26	2,70	2,73	33	,010	.59
2009	6	22	Creativity	8.73	4.07	12.02	3.70	3.29	2.59	6.10	21	.000	.85
			Fluency	11.27	6.40	15.64	6.88	4.37	4.38	4.67	21	.000	.66
			Flexibility	6.41	2.48	9.09	2.31	2.68	2.05	6.11	21	.000	1.11

Discussion and Conclusions

In this article the Education Programs for Talented Students (EPTS) is reviewed first, and then, research carried out on its effects on gifted students' mathematical creativity in two years are presented. Overall results show that the EPTS mathematics instruction significantly contributes to the development of gifted students' creative capacity in mathematics. Research findings in three studies are quite consistent; because the effectiveness of the EPTS was found to be medium to large both in sixth graders and in seventh graders and both in 2008 and in 2009.

The EPTS is a new program model for gifted students; but its use has been limited with sixth through eighth-grade gifted students in mathematics and science education for the last three years. It also can be used in other grades and can be applied in other subject areas. Work on the EPTS model continues to grow, with specific studies to make use of modern curriculum models in gifted education and to apply the EPTS program model in other subject areas along with mathematics and science. Currently, the Parallel Curriculum (Tomlinson, Kaplan, Renzulli, Purcell, Leppien & Burns, 2002; Tomlinson, Kaplan, Renzulli, Purcell, Leppien, Burns, Strickland & Imbeau, 2009) has been used as a new curricular framework to classify the EPTS skills. The core, connections, practice and identity components of the Parallel Curriculum together with those of the theory of successful intelligence are used as design parameters to identify new skills that could be integrated into the EPTS Curriculum. Furthermore, research on the EPTS model continues to grow, with specific studies to investigate its effects on scientific creativity and participants' perceptions about the program.

Limitations

A number of limitations inherent to most research should be discussed here. In this study, one-group pretest-posttest research design was used for some convincing reasons that were pointed out in the method section. Because of the limitations of the research design used in this study, the effects of the EPTS could not be validated by a control data. This research design presents a number of confounded variables that could jeopardize internal validity of research studies (Campbell & Stanley, 1963). Particularly important and related to this study are maturation and testing. Because of the research design, one can claim that maturation also might contribute to the findings. Yet, a significant growth in creativity of teenagers in four months cannot be expected due to maturation. Indeed, this much growth rate cannot be expected even in children who show faster cognitive development than teenagers. Moreover, the use of the same test as the pretest and posttest, another limitation of the study, might contribute to the findings. Scores on multiple-choice tests are often influenced from prior experience because test takers remember answers between testing sessions. However, it happens seldom that prior experience on ill-structured problems that have more than one correct solution greatly improves students' creative ability for future tasks. Also, it was hard for students to remember the items of the test because there was a four-month time interval between the pretest and posttest. Thus, it is rational to assert that experience with the pretest of this study is hardly reflected on performance in the posttest.

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