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Assessment of prospective science teachers' metacognition and creativity perceptions and scientific toys in terms of scientific creativity

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Abstract

Creativity is a talent. On the other hand, opportunities should be given starting from young ages for its appearance and development. Creativity should be described as skills that involve working alone and cooperatively, giving time for listening, thinking and focusing, acting seriously when facing problems (Dağlıoğlu, 2010). The fundamentals for the development of scientific creativity can be defined as "a secure place, physiological freedom, a discipline that frees the person, intellectual argumentation methods, thinking of critical and creative thinking, authentic assessment" (Duman, 2009). A need, a necessity or desire for solving a problem comes forward in scientific creativity (Terzioğlu, 1993, cit. by Aktamış and Ergin, 2006). Hu and Adey (2002) define scientific creativity as a process that consists of imagination, thinking, fluency, flexibility, originality, scientific knowledge, scientific problem, scientific fact and technical product components. The aim of the study is to assess prospective science teachers' metacognition and creativity perceptions and scientific toys in terms of scientific creativity. The qualitative and quantitative data gathered from the study were assessed comparatively with each other. The quantitative data were shown with percentages as well as qualitative data gathered from scientific toys were assessed in terms of scientific creativity dimensions: "fluency, flexibility, originality and scientific knowledge". The results are shown in terms of four dimensions of scientific creativity for prospective science teachers' metacognition and creativity perceptions and scientific toys as a result of qualitative and quantitative data of the study. In the light of these results, recommendations were made for researchers.

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*Keywords:*scientific creativity; creativity; prospective teacher; metacognition.

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1.Introduction

As it can be seen from the rich context of creativity education, inquiry based teaching is important for this education. Inquirer science students are the ones that conduct open-ended researches, investigate and understand scientist' study systems. Inquiry means exploring, creativity and investigation (Lucas, 1977; cit. by. Kind and Kind, 2007). Alexander (1992) and Amabile (1987) stated all of creativities have a specific field and therefore, it is important to distinguish scientific creativity from common creativity (cit. by Lin, Hu, Adey and Shen, 2003). As a matter of fact, Hu and Adey (2002) developed "scientific creativity model" that is context based by stating there is a need for scientific creativity besides other creativity tests. Park (2011) underlined that scientific creativity has three dimensions: creative thinking, scientific knowledge and scientific inquiry skills. Zhang, Liu and Lin (2012) stated some sort of fundamental features like inner motivation, self-determination and attempt are necessary for scientific creativity but they are not adequate as well. Human needs take precedence and most of the time, there is a need to transfer and apply knowledge that has already known to new situations (Can, 2007; cit. by Kılıç, 2011). Creativity involves both scientificity and daily life (Farooq, 2008). As a matter of fact, problem solving, constructing hypothesis and experiment and technical innovation require specific form of scientific creativity (Lin, Hu, Adey and Shen, 2003). According to Demir (2014), scientific creative thinking ability can be defined as "thinking ability that brings together interdisciplinary areas of science, technology and art (aesthetic) and provides individuals' unique solution ideas of a challenging problem from these areas' points of views". As it can be seen from this definition, scientific creativity brings together both the uniqueness of the discipline and different disciplines' aesthetic aspects. It is considered as a multidimensional and sophisticated field (Demir, 2014).

Problem based learning is used for learning science concepts and developing decision making and critical thinking abilities in schools. It enhances designing products and devices that develop planning, designing, decision-making and assessment skills technological education programs. One of these programs is STEM (Science-Technology-Engineering or Mathematics)'dir (Rowell, Gustafson ve Guılbert, 1999; Zubrowski, 2002; Coll ve Eames, 2008; Silver and Rushton, 2008; LeBeau, Harwell, Manson, Dupuis, Medhanie and Post, 2012). Toys are technological constructions that can be designed in a creative way (Demir and Şahin, 2013). According to Amir and Subramaniam (2005); toys can be used for children to understand and view science in their daily lives. Teachers who use toys in their lesson plans think that their students' creativities, problem solving and creativity thinking abilities will develop.

Especially imagination is important for games, drama and toys. Imagination is mostly defined as seeing things mentally. Imagination is important for having new ideas. There is an important place for creativity in cognitive development and learning (Kind and Kind, 2007). Scientific toys are interesting and amusing methods to teach physics, chemistry and biology concepts. Toys are harmless, intriguing designs that develop creativity and problem solving ability and also reveal children's creativity (Amir and Subramaniam, 2005). Scientific toys help comprehending science concepts and relating science concepts with daily lives in early childhood. Scientific toys help learning scientific concepts and relating them with daily lives in early childhood. In primary and secondary education, students can design scientific toys and projects based on their toys from their early ages (Amir and Subramaniam, 2005).

From moving this on, the research questions of this study are;

1. What is the adequacy level of scientific toys designed by prospective science teachers in terms of four criteria of scientific creativity?
2. How is the self-assessment of prospective science teachers' in terms of metacognition and creativity?

2.Method

The study has conducted with 30 prospective teachers who studied in science education department at second grade at a university in İstanbul. The prospective science teachers were expected to design scientific toys and their scientific toys were assessed in terms of four criteria of scientific creativity: "fluency, flexibility, originality and scientific knowledge". 5 point Likert type scale technique (rubric) designed by the researchers was used for the assessment of scientific creativity. The rubric consists of dimensions from quite adequate to quite inadequate.

Rubric's point range is determined between 30 and 150 for this study. The assessment was made between these points.

Along with this, the data were collected through "Metacognitive Awareness Inventory" developed by Schraw and Dennison and adopted and established its reliability (Cronbach Alpha value is 0,95) by Akın, Abacı and Çetin (2007) and "How Creative Are You Test" developed by Raudsepp; self-assesment for scientific creativity questionnaire adopted by Sungur and established its reliability (Cronbach Alpha value is 0,761) by Gülel (2006).

Mixed model in which qualitative and qualitative data gathering techniques were combined was adopted in this study. Quantitative data gathered from the questionnaires and quantified qualitative data gathered from the assessment of scientific toys were interpreted together.

3.Findings

The findings of the study were presented below in terms of assessments of metacognitive awareness inventory, how creative are you test and scientific toys.

Table1. Some findings of metacognitive awareness inventory

	1	2	3	4	5
• I think of alternative ways before I answer a problem		13,3	26,7	43,3	16,7
• When answering a problem, I ask myself if I take into consideration all of the alternative ways.		20,0	26,7	33,3	16,7
• I tried strategies that I used before if necessary.		6,7	26,7	50,0	16,7
• I learn better when I know something about the subject already.			13,3	33,3	53,3
• I think of different ways of solving a problem and pick the best one in them.		20,0	26,7	43,3	10,0
• I ask myself whether I take into consideration all options after I solve a problem	3,3	30,0	30,0	26,7	10,0
• I change my strategies when I can't grasp knowledge.		13,3	30,0	46,7	10,0
• I re-evaluate my assumptions when I am confused.		10,0	20,0	50,0	20,0
• I learn things that I am interested in much more easily.			6,7	33,3	60,0

Some of the data from metacognitive awareness inventory were presented in the table. The items such as "I think of alternative ways before I answer a problem. I tried strategies that I used before if necessary. I think of different ways of solving a problem and pick the best one in them." were answered as generally. The items like "I learn better when I know something about the subject already. I learn things that I am interested in much more easily." were answered as always. Lastly, the item "I ask myself whether I take into consideration all options after I solve a problem" was answered as rarely-often and generally in a positive direction.

Table2. The some findings of self assessments for scientific creativity

	T.D.	**L.A.**	**U.**	**M.A.**	**T.A.**
• In my opinion, asking questions which I expect not to get answers is waste of time.	13,3	30,0	13,3	23,3	20,0
• I sometimes form ideas on that surprises people.	3,3	36,7	10,0	30,0	20,0
• I believe that I can do something beneficial and unique for people.	3,3	10,0	33,3	36,7	17,7
• I trust my instincts and feelings when I am getting closer to a solution.		23,3	10,0	53,3	13,3
• Instead of trying to make others accept my opinions, I prefer to put unique ideas on for the same topic.		10,0	23,3	60,0	6,7
• I think people who want to form different ideas on aren't practical.	16,7	20,0	30,0	30,0	3,3

Table2. The some findings of self assessments for scientific creativity (Continue)

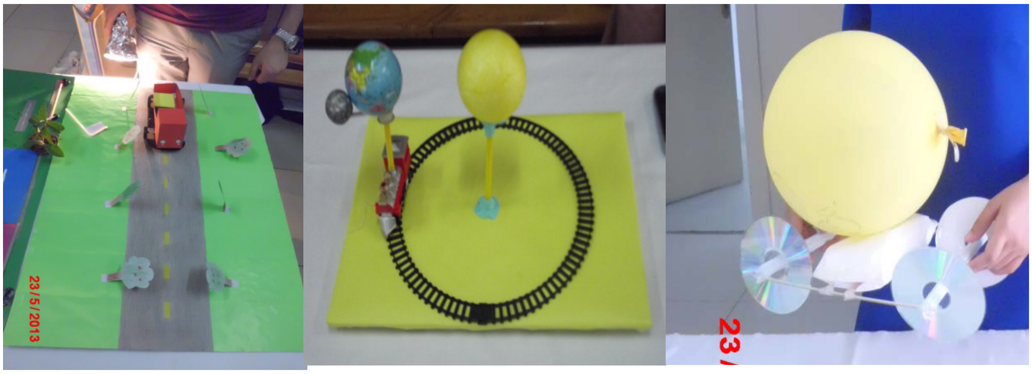
• I change my method easily if the method is not helpful.	3,3	10,0	10,0	63,3	13,3
• I think people who can' think clearly use metaphors.	30,0	26,7	26,7	13,3	3,3
• I often try to work on a problem that I don't understand much or explain yet.	6,7	33,3	20,0	20,0	20,0
• I know controlling what I am thinking about.	6,7	13,3	6,7	53,3	20,0
• I dislike things that are not precise and hard to perceive.	6,7	33,3	6,7	40,0	13,3
• I think over too much for others' thoughts of me.	30,0	30,0	10,0	26,7	3,3
• I think hunches are not trustworthy for solving problems.	43,3	23,3	30,0	3,3	
• I avoid situations that I feel inadequate in.	13,3	16,7	20,0	46,7	
• I think people who run after perfection are not wise.	36,7	20,0	10,0	16,7	16,7
• I don't like asking questions that don't have an answer.	6,7	26,7	20,0	23,3	23,3
• I think it is a waste of time for a person to analyze his/her mistakes.	63,3	16,7	6,7	10,0	3,3
• It is important for me to be accepted as a good group member.	3,3	10,0	16,7	50,0	20,0
• I often work on problems, I don't throw them away.		16,7	16,7	50,0	16,7
• If I were a college professor, I prefer teaching applied classes instead of theory-based classes.	3,3	6,7	6,7	26,7	56,7

Some of the data from self-assessment for scientific creativity questionnaire were presented in the table. The items such as "I think people who can' think clearly use metaphors. I like to be full of ideas even though there is no way out. Instead of trying to make others accept my opinions, I prefer to put unique ideas on for the same topic. If I were a college professor, I prefer teaching applied classes instead of theory-based classes. I often work on problems, I don't throw them away. It is more important for me to do the right thing than approval. I don't think too much over about others' thoughts of me. I change my method easily if the method is not helpful. Instead of trying to make others accept my opinions, I prefer to put unique ideas on for the same topic. I trust my instincts and feelings when I am getting closer to a solution." were answered in a positive direction. On the other hand, the items such as "I don't like asking questions that don't have an answer. It is important for me to be accepted as a good group member. I dislike things that are not precise and hard to perceive. I know controlling what I am thinking about." were answered in a negative way. They are not specific and fully decided enough, when answering items such as "In my opinion, asking questions which I expect not to get answers is waste of time. I often try to work on a problem that I don't understand much or explain yet. I avoid situations that I feel inadequate in. I think people who want to form different ideas on aren't practical. I sometimes form ideas on that surprises people."

Table3. Assessment of scientific toys

Scientific creativity assessment criteria	**Point**	**Dimension**
Fluency	106	Adequate
Flexibility	98	Partially
Originality	96	Partially
Scientific knowledge	112	Adequate

As it can be seen from the table, prospective teachers were adequate for the criteria of fluency and scientific knowledge whereas they are partially adequate for the criteria of flexibility and originality.



Quite adequate Inadequate Partially

Figure1. Examples from scientific toys in scientific toys exhibition

Above, there are some examples from scientific toys exhibited in scientific toy exhibition and these are the examples of the ones that have three criteria of scientific creativity. The originality points of the scientific toys designed by prospective teachers were calculated as 96.

4. Results and discussion

Successful creative projects involve activities that integrate science and art. Creative writing, drama, scientific poets, projects, scientific models, scientific toys can be given as examples to science and art activities (Kind and Kind, 2007). Scientific creativity skills are specific to the field and involve individual's personality, family, surroundings, thinking abilities, school surroundings, laboratory approach, different unique activities, appropriate learning processes and dimensions of subject matter knowledge. Subject matter knowledge and laboratory approach are considered as fundamentals for developing scientific creativity skills. It is necessary to prepare rich learning environments by using various learning approaches, methods and techniques with appropriate planning and applications for the development of scientific creativity. Also, learning process by giving priority to teacher leading should be planned and designed carefully (Demir, 2014).

The findings of the study show prospective teachers think of alternative ways before answering a problem, will use strategies again if necessary, they think of different ways and choose the best in them, form unique ideas on, prefer to give applied classes, trust their hunches, don't think over too much about others' ideas, change their method easily. On the other hand, they also mentioned that it is a waste of time to analyze mistakes, they avoid from situations which they feel inadequate in, don't like questions that don't have answers and are not adequate, control themselves and it is important to be accepted as a group member. In addition to this, they are not certain about asking questions that can't be solved is a waste of time or not, their ideas regarding people who put different ideas on, think over other options after solving a problem.

There is a consonance between their conflicted answers and their points for scientific toys. The assessment of scientific toys in terms of four criteria of scientific creativity revealed that prospective teachers are adequate in fluency and scientific knowledge criteria and partially adequate in flexibility and originality criteria. Prospective science teachers are not adequate enough in designing scientific toys, putting new ideas and products on by using their scientific creativity. But they prefer applied classes that they enjoy. For this reason, instead of numbered classes, some experience opportunities in which students can use scientific creativity abilities should be made.

Newton and Newton (2010) underlined teachers are generally creative but they are facing some difficulties in technology design and scientific creativity and they made recommendations about that matter. Buelin-Biesecker (2012) stated that researches of creativity teaching are best ways to help teachers instead of serving students. Emir (2001) told all lessons should be planned for developing prospective teachers' critical and creative thinking abilities in teacher education program. Demir and Şahin (2013) and Demir (2014) put emphasis on prospective teachers' development of scientific creativity skills for social progression in their studies. Moving from this study on, prospective teachers should met with experiences that involve applications and different activities in terms of development of scientific creativity skills.

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