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Examining Research Questıons on Germination from the Perspective of Scientific Creativity

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Abstract
This study was conducted with the participation of 31 pre-service science teachers. Participants were asked to develop various research questions on germination. The study aims to examine research questions on the subject germination from the perspective of scientific creativity. The research questions were examined using the fluency, science knowledge, flexibility, and originality dimensions of scientific creativity. The study thus provides an analysis of the research question developed by pre-service science teachers on germination from the perspective of scientific creativity. It was found that the research questions developed by pre-service science teachers on germination were very satisfactory in terms of fluency and science knowledge, but unsatisfactory in terms of flexibility and originality. This might be attributed to their lack of experience in creative thinking, making it difficult to see events from different and multiple perspectives.
Keywords: germination, scientific creativity, fluency, science knowledge, flexibility, originality

Introduction

Experts agree that thinking skills can be taught to students at all levels of education, in line with their abilities and intelligence (Özden, 2011). Creativity is present in every individual, and needs to be supported and developed (Turla, 2003). Creativity is a process that starts at birth and continues, without a break, until death (Duman, 2009). It is crucial for findings from neurological studies to be reflected in education policies and practices. A frequently made point is that neurologists and educationists need to come together and conduct studies cooperatively, but unfortunately both in Turkey and in other parts of the world making connections between the two fields is too often neglected (Demir, 2014). Parents', and especially teachers', attitudes towards mistakes can be an important factor determining children's risk-taking behavior. If there is a risk that it will be met with scolding, ridicule, or scorn, very few people show the courage to think intuitively (Güven, 2002).

It has been argued that innovation, technology, and design (e.g. of scientific toys) are important elements of creativity, and that creative skills and an interdisciplinary approach are required to integrate knowledge in these fields, as well as to create new products and generate new knowledge (Demir, 2014). Meador (2003) argues that thinking and debating like a scientist is necessary to develop creativity and scientific process skills, that creative thinking and scientific process skills are intertwined, and that people who are encouraged to practice their scientific process skills improve their scientific creativity. Scientific creativity depends on the steps followed in creating a new product or improving an existing one, that is to say, on the process of recognizing and solving a problem (Aktamış and Ergin, 2007). Park (2011) argues that creativity has three dimensions: creative thinking, scientific knowledge, and scientific research and investigation skills. To use Hu and Adey's scientific creativity model, which they developed in 2002, ideas created through imagination and rich thinking, made possible by the integration of the disciplines of science, art, and technology, are improved through the use of flexibility and originality, and turned into products in the form of knowledge, problems, phenomena and production (e.g. literary, visual, experimental, etc.) (Demir, 2014). Thus, this study aims to examine research questions on the subject of germination, from the perspective of scientific creativity.

Methodology

This study was conducted with the participation of 31 pre-service teachers attending the second year of the science education program of the faculty of education of a university in Turkey. Participants were asked to develop research questions on the subject of germination. Answers provided to the open-ended question were evaluated in terms of the fluency, science knowledge, flexibility, and originality dimensions of scientific creativity.

Results

Findings from the study are reported in Table 1, Table 2 and Table 3. Table 1 reports qualitative data on pre-service teachers' answers, in the form of the frequency distribution of the four dimensions of scientific creativity. Table 2 and Table 3 reproduce sample research questions developed by pre-service science teachers that meet the originality and flexibility criteria.

Table 1. Frequency distribution of the research questions into dimensions of scientific creativity

Dimensions of scientific creativity	N
Fluency	181
Science knowledge	177
Flexibility	14
Originality	32

As Table 1 shows, most of the research questions developed by pre-service teachers were satisfactory in terms of fluency and science knowledge, but very few were satisfactory in terms of flexibility and originality.

Table 2. Sample research questions that meet the criteria for originality

- If were to water the seed embryo regularly using water at different temperatures, such as 0^0 C, 25^0 C, and 70^0 C, how would that affect the development of the seed?
- Would a foam cup provide a more hospitable environment to the roots sprouting from the seed and result in faster development?
- During germination in a plastic cup washed by boiling water, does the plastic cup release materials that are toxic to the cottonseed?
- Are seed coats shed simultaneously in dicotyledonous seeds (such as lentils, chickpeas)?
- Would a foam cup accelerate germination?
- Does cold water affect the number of roots in monocots?
- Can plants germinate in pool water?
- Can plants germinate in dirty water?
- Would root development be visible during germination in a glass cup?
- Would temperature affect germination if we warmed up the environment?
- Do different cups affect the amount of water needed during germination?
- Does the size of the cup affect germination?
- Does the mineral density of the soil affect rate of germination?

Table 2 reproduces some of the more notable research questions developed by pre-service science teachers.

Table 3. Sample research questions that meet the criteria for flexibility

- Would a foam cup provide a more hospitable environment to the roots sprouting from the seed and result in faster development?
- During germination in a plastic cup washed by boiling water, does the plastic cup release materials that are toxic to the cottonseed?
- Does cold water affect the number of roots in monocots?
- Would root development be visible during germination in a glass cup?
- Would temperature affect germination if we warmed up the environment?

Table 3 reproduces some of the research questions developed by pre-service science teachers that meet the criteria for flexibility.

Conclusion and Discussion

Creativity is a challenge to develop and sometimes looks unattainable, but it is also a very important tool for students to discover their identities and chart their careers (Aaron, 2010). According to Sternberg (2012), creativity is affected by intellectual ability, knowledge, ways of thinking, personality, motivation, and social environment, and varies from person to person.

Scientific creativity always requires the enhancement of accumulated knowledge in order to create a new product (Liang, 2002). Park (2011) argues that scientific creativity comprises the dimensions of creative thinking, scientific knowledge, and scientific research and investigation skills. This study found that the research questions developed by pre-service science teachers on germination were very satisfactory in terms of fluency and science knowledge, but unsatisfactory in terms of flexibility and originality. The low scores in the dimensions of flexibility and originality might be attributed to pre-service teachers' lack of experience in creative thinking, making it difficult to see events from different and multiple perspectives. This, in turn, might have resulted from the fact that pre-service teachers do not have many creative scientific thinking experiences. Teachers have to use productive methods in order to develop their students' creative potential, (Lopatina, Borisov, Leyfa, Galimzyanova, Yatsevich, Demyanenko & Masalimova, 2015). Teaching practices generated by creative thinking have a big impact on the students' levels of scientific creativity and scientific process skills (Kurtuluş, 2012).

The opportunity to grow into creative scientists should be offered to students by their teachers at an early age (Cremin, Glauert, Craft, Compton & Stylianidou, 2015). In order to develop creative scientific thinking skills, multiple learning approaches, methods, and techniques should be constructed, rich educational environments should be created together with a well-structured learning process, starting with providing instructors with counseling (Demir, 2014). Views of science teachers should be taken into consideration order to encourage and facilitate scientific creativity in the classroom (Liu and Lin, 2014). Indeed, long-term goals for the development of scientific creativity are constrained by the knowledge, skills and abilities of science teachers, and the quality of the education and development opportunities offered to students at all levels of education (Schmidt, 2010). Thus, it could be argued that pre-service teachers should be taught creative thinking and creative scientific thinking skills during their training, and the encouragement to engage in activities to practice and develop these skills.

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