**Kastamonu Education Journal**, 2022, Vol. 30, No:3, 657-668
doi: 10.24106/KEFDERGI-2021-0007


| Research Article / Araştırma Makalesi |

# Training Primary School Science Teachers to be Conscious of Scientific Creativity

# İlköğretim Fen ve Teknoloji Dersi Öğretmenlerinin Bilimsel Yaratıcılık Bilincinin Geliştirilmesi

**Iclal Can[1], Sevinc Gelmez Burakgazi[23]**

**Keywords**
1. Scientific creativity
2. Creativity consciousness
3. Science education
4. Creativity
5. In-service teacher education

**Anahtar Kelimeler**
1. Bilimsel yaratıcılık
2. Yaratıcılık bilinci
3. Fen eğitimi
4. Yaratıcılık
5. Hizmet-içi eğitim

**Received/Başvuru Tarihi**
29.06.2021

**Accepted / Kabul Tarihi**
03.06.2022

## Abstract

*Purpose*: This qualitative case study explores whether and to what extent a scientific creativity training improved primary school science teachers' consciousness of scientific creativity, and how these changes in the teachers' scientific creativity consciousness were transferred into their classroom practices following the intervention.

*Design/Methodology/Approach*: A Scientific Creativity Training Program (SCTP) was developed by the researchers. Data were collected from seven primary school science teachers using semi-structured interviews, in-class observations, and document analysis. Data were analyzed using an inductive content analysis.

*Findings*: The results indicated that the SCTP (Scientific Creativity Training Program) seemed to improve the teachers' consciousness of scientific creativity. The results also indicated that all teachers integrated scientific creativity into their classroom practice as a result of the SCTP. The SCTP was found to enable teachers to reflect on the extent to which they employed creativity in their personal and professional lives and question the extent to which they taught creativity and/or used creative methods in the classroom. Furthermore, the analysis indicated that the SCTP improved the teachers' creativity consciousness and enhanced their pedagogical content knowledge. This was in turn found to affect the teachers' classroom practices, as it led them to believe that creativity is malleable and increased their motivation and self-efficacy to foster their students' creative consciousness and creative attitudes. The teachers seemed to use more creative activities and materials in their science classrooms following the intervention, despite the presence of hindrances that negatively impacted their practices.

*Highlights*: Our results indicated that creativity education can lead teachers to make significant changes to their classroom practice by gradually integrating scientific creativity. The present study also reveals that each teacher has a unique trajectory of change regarding creativity and creative teaching, which needs to be taken into consideration for more sustainable creativity education.

## Öz

*Çalışmanın Amacı:* Bu nitel durum çalışması, bir bilimsel yaratıcılık eğitiminin, ilköğretim fen ve teknoloji dersi öğretmenlerinin bilimsel yaratıcılık bilincini ne ölçüde geliştirdiğini ve eğitim sonrasında öğretmenlerin bilimsel yaratıcılık bilincindeki değişikliklerin öğretmenlerin sınıf uygulamalarına ne şekilde aktarıldığını incelemektedir.

*Materyal ve Yöntem:* Çalışmada, araştırmacılar tarafından Bilimsel Yaratıcılık Eğitim Programı (BYEP) geliştirilmiştir. İlköğretim düzeyinde görev yapan yedi fen ve teknoloji dersi öğretmeninden yarı-yapılandırılmış görüşme formu, sınıf-içi gözlem ve doküman analizi yolu ile veri toplanmıştır. Elde edilen veriler içerik analizi kullanarak incelenmiştir.

*Bulgular*: Araştırma sonuçları, BYEP'nin (Bilimsel Yaratıcılık Eğitim Programı) öğretmenlerin bilimsel yaratıcılık bilincini artırdığını göstermiştir. Araştırma sonuçları, ayrıca, tüm öğretmenlerin BYEP'nin bir sonucu olarak, bilimsel yaratıcılığı sınıf uygulamalarına aktardığını ortaya koymuştur. BYEP'nin, öğretmenlerin yaratıcılığı kendi kişisel ve mesleki hayatlarında ne ölçüde kullandıkları üzerine düşünmelerini, sınıfta ne ölçüde yaratıcılığı öğrettiklerini ve yaratıcı metodları kullandıklarını sorgulamalarını teşvik ettiği görülmüştür. Bunun yanı sıra, araştırma sonuçları BYEP'nin öğretmenlerin yaratıcılık bilincini ve pedagojik alan bilgilerini artırdığını ortaya koymuştur. Bunun da öğretmenlerin, yaratıcılığın şekillendirilebilir olduğuna inanmalarını sağladığı ve öğretmenlerin, öğrencilerinin yaratıcılık bilincini ve yaratıcı tutumlarını geliştirme konusundaki motivasyonlarını ve öz-yeterliliklerini artırdığı ve dolayısı ile öğretmenlerin sınıf-içi uygulamalarını etkilediği ortaya çıkmıştır. Öğretmenlerin eğitim sonrasında, uygulamalarını olumsuz yönde etkileyen engellere rağmen fen derslerinde daha çok yaratıcı etkinlik ve materyal kullandıkları görülmüştür.

*Önemli Vurgular:* Araştırma sonuçları, yaratıcılık eğitiminin, öğretmenlerin kademeli olarak bilimsel yaratıcılığı sınıf-içi uygulamalarına aktarmalarına katkı sağladığını ortaya koymaktadır. Bu çalışma ayrıca, her öğretmenin yaratıcılık ve yaratıcı öğretim konusunda özgün bir değişim yörüngesi izlediğini ve bunun sürdürülebilir yaratıcılık eğitimi için dikkate alınması gerektiğini ortaya koymaktadır.

[1] **Corresponding Author,** Guidance and Psychological Counseling Program, Middle East Technical University Northern Cyprus Campus, 99738, Kalkanlı, Güzelyurt, Mersin 10, Turkey. Email: iclal@metu.edu.tr, https://orcid.org/0000-0003-0466-9687
[2a] Department of Educational Sciences, Hacettepe University, Beytepe, 06800, Cankaya, Ankara, Turkey. Email:sevincgb@hacettepe.edu.tr
[2b] Department of Curriculum, Pedagogy & Assessment, University College London, Gower Street, WC1E6BT, London, United Kingdom. Email: s.burakgazi@ucl.ac.uk, https://orcid.org/ 0000-0002-4553-1433

**Citation/Alıntı:** Can, İ. & Burakgazi Gelmez, S. (2022). Training Primary School Science Teachers to be Conscious of Scientific Creativity, *Kastamonu Education Journal, 30*(3), 657-668. doi: 10.24106/kefdergi. KEFDERGI-2021-0007

## INTRODUCTION

In today's competitive world, with high-stakes exams like PISA and TIMMS and a focus on new educational directions like STEM or STEAM education, incorporating creativity and scientific creativity into teacher education and teacher practices stand out as an ascendant theme in curriculum development, particularly in OECD countries. However, although creative thinking is increasingly becoming a goal of educational reforms around the world, science curricula in most countries, including Australia, the UK, USA (Yang, Lin, Hong, & Lin, 2016) and Turkey, do not include the term "scientific creativity". While Turkish curricula do include some creative elements, integrating creativity and scientific creativity into classroom practice remains a challenge. There is still a need for policies promoting creativity and scientific creativity in education.

There is a growing body of literature highlighting the following major benefits of fostering creativity in education: "improved motivation, achievement, creativity, self-confidence, school attitudes" (Davis, Rimm, & Siegle, 2014, p.243); positive attitudes towards creative ideas, awareness of one's own creativity and creative situations, and encouragement of imagination, questioning, and humor (Colangelo & Davis, 2003); multiple forms of thinking, which in turn facilitates the development of unique ideas (O'Connor, 2012); and self-competencies such as self-esteem and self-efficacy (Sternberg, 2006).

Science class is one area where incorporating creativity into classroom applications ought to make a difference in teaching and learning processes. In light of the aforementioned potential benefits of creativity in education, there is a clear need for primary school science teachers to enhance students' creative growth in their classes, beginning when students are young (Craft, 1999; O'Connor, 2012; Prentice, 2000; Yates & Twigg, 2017). Given that creative teachers can serve as models for their students' creativity development (Sternberg, 2006), it is important to develop science teachers' consciousness of creativity and scientific creativity. According to Davis (2003), by means of creativity consciousness, individuals "can grasp the importance of creativity for their own personal growth and development-self-actualization" (p.319). Davis et al. (2014) argue that most creative characteristics can be developed by a creativity-conscious teacher. They claim that "attitudes and personality traits can be changed to produce a more flexible, creative, and self-actualized person" (p. 211). If teachers develop creativity consciousness and integrate creativity into their classroom practice, this is expected to foster creativity growth among students as well.

With this in mind, this study was designed primarily to explore whether and to what extent science teachers' consciousness of scientific creativity could be increased through a scientific creativity training program (the SCTP), and how the changes in the teachers' scientific creativity consciousness were transferred into their classroom practices following the intervention.

## BACKGROUND

### A Brief Look at Creativity and Scientific Creativity

Researchers agree that there is substantial confusion and a lack of consensus on the definition of creativity as a construct (Kind & Kind, 2007; Parkhurst, 1999). However, contemporary scholars argue that creativity can be defined (Beghetto & Kaufman, 2007; Runco, 2004; Sawyer et al., 2003; Sternberg, 2018). Torrance, the developer of the Torrance Tests of Creative Thinking (TTCT), defines creativity as follows:

> "I defined creativity as the process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty, searching for solutions, making guesses, or formulating hypotheses about the deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results" (1965, p. 663-664).

In Torrance's view, people who embrace this definition should endorse creative behavior, thinking and potential in both test and non-test procedures. Sternberg (2018) asserts that "creativity is viewed basically as an attitude toward life and one's work, but also has cognitive, affective, motivational, and environmental components" (p.50). Amabile (2011) believes that creativity is influenced by four factors: domain-relevant skills (expertise), creativity-relevant processes (personal approach to a given problem), task motivation (willingness to engage), and the social environment (outside the person).

Craft (2001) proposes a different classification based on the distinction between "little c" and "big C" creativity, which is similar to Boden's (2009) distinction between "historically creative" (H-creative) and "personally creative" (P-creative) persons. Little c or P-creative people are those who build moderate products. In contrast, big C or H-creative people tend to produce unique, revolutionary ideas, such as Picasso or Einstein. Taking a different perspective, Harris and de Bruin (2019) highlight the interdisciplinary side of creativity with a "whole-school creative ecology approach" combining science, technology, the arts, culture, and industry. In this approach, the arts and environmental subjects (STEAM) are also promoted alongside STEM subjects.

There are different types of creativity, including the major domains of scientific, artistic, and everyday creativity (Batey & Furnham, 2006). One can be creative in any given domain. That is why scientific creativity can be studied on its own. In the long history of science, certain individuals – including Stephen Hawking, Einstein, Tesla, Pastor, and Avicenna – have become legendary, towering figures known for their impressive scientific creativity. Scientific creativity is a domain that has gained more attention in recent years (Mukhopadhyay & Sen, 2013), and is of substantial importance for science education (Kind & Kind, 2007; Meyer & Lederman, 2013). However, early traces of the scientific creativity construct can be found in Feist's (1998) definition: "the capacity to have novel-original and useful-adaptive ideas in the domain of natural and social sciences" (p. 290). Based upon Guilford's (1956) "structure of intellect", Hu and Adey (2002) proposed the scientific creativity structure model (SCSM), which encompasses three dimensions: process (cognitive processes), trait (fluency, flexibility and originality), and product (science knowledge, science problems, etc.). Hu and Adey (2002) themselves defined scientific creativity as “a kind of intellectual trait or ability producing or potentially producing a certain product that is original and has social or personal value, designed with a certain purpose in mind, using given information” (p. 392). Lastly, for Ayas and Sak (2014), scientific creativity—as a domain-specific form of creativity— is “the ability to generate novel ideas or products that are relevant to context and have scientific usefulness or importance” (p. 195). Drawing upon all these definitions of creativity in general and scientific creativity in particular, we propose the following definition of scientific creativity, which integrates elements of science into the creativity process: Scientific creativity can be defined as the ability to find novel solutions to problems in the discipline of science and/or to develop original, useful and/or meaningful scientific ideas, designs or products rooted in scientific knowledge and methods.

## Can Teachers’ Creativity Consciousness Be Developed?

Creativity consciousness has a pivotal role in creativity education. A multitude of research suggests that effective creative teaching leads to development of creativity consciousness (Davis et al., 2014) and creative learning (e.g. Davis et al., 2014; Sternberg, 2006). “Creativity consciousness and creative attitudes include an awareness of creativity, valuing creativity, a predisposition to think creatively, a willingness to make mistakes, and others” (Davis et al., 2014, p.242). Promoting consciousness of scientific creativity necessitates a systematic approach incorporating many different facets, including teacher education.

Davis et al. (2014) recommend that the following objectives be addressed in creativity training. They further emphasize that “increasing creativity consciousness and creative attitudes is the single most important component of teaching for creative growth” (p. 225).

.“Raising creativity consciousness, teaching creative attitudes, and strengthening creative personality traits

. Improving students’ understanding of creativity;

. Strengthening creative abilities through exercise;

. Teaching creative thinking techniques;

. Involving students in creative activities; and

. Fostering academic creativity” (p. 224)

Similar to Davis et al. (2014), de Souza Fleith (2000) lists ways to foster students’ creativity: through teaching strategies (discovery learning, open-ended questions, student-centered views, engaging students in a variety of activities); teachers' attitudes (recognizing students, encouraging different responses, humor, questions and risk-taking, and providing students with different options) and classroom climate (a psychologically safe environment). Davis (2003) interprets Fleith’s list as ways to foster creativity consciousness.

Creativity-based teaching-learning processes may include fun, interactive activities, games, and similar classroom practices. Specific examples of such practices include student-centered activities like brainstorming, creative problem solving, and creative thinking activities such as painting and writing (Colangelo & Davis, 2003); as well as open-ended, student-oriented, exploratory and group-based learning strategies (Kind & Kind, 2007). For science, the list might also include 'hands-on' activities in the laboratory or outdoors. “These settings are regarded as inviting openness and freedom” (Kind & Kind, 2007, pp. 4-5).

When planning creativity training programs for teachers, it is important to keep in mind that effective professional development practices increase the sustainability of learning experiences. Effective staff development practices that could lead to positive changes in teachers’ attitudes, beliefs, and teaching practices might include the use of active learning (Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009), experiential learning (Guskey, 1986), the development of a learner-oriented approach (Sahin & Yildirim, 2015), and follow-up (Waters, 2006). Specifically with respect to in-service teacher training programs, Trnova and Trna (2014) recommend using inquiry-based learning to foster science teachers’ creativity.

Numerous studies of creativity in educational settings have been conducted in several countries (e.g. Bolden, Harries, & Newton, 2010; Gajda, 2016; Yoon, Woo, Treagust & Chandrasegaran, 2015). Specifically, there has been a growing interest in domain-specific creativity. One domain that has attracted the attention of researchers is science. There has been an increasing number of studies in scientific creativity in recent years (e.g. Li & Lin, 2014; Mukhopadhyay & Sen, 2013). A great number of these studies focus on science teachers’ perceptions about creativity and scientific creativity. For example, in their study, Akcanca and Cerrah-Ozsevgec (2016) investigated pre-service science education teachers’ beliefs about creativity. The researchers concluded that creativity might be developed but school curriculum was a hindrance as teachers thought the curriculum was ineffective to develop creativity.

In another study, Liu and Lin (2014) investigated science teachers’ views on scientific creativity and scientific creativity instruction in the classroom. The results indicated that the teachers were aware of many core features of creativity, and tended to emphasize divergent thinking, autonomy, and curiosity and interests. In contrast, they overlooked aspects such as convergent thinking, problem-finding, and linking the arts and science.

In an older study, Bore (2007) studied creativity development among five primary and three secondary school teachers using a grounded theory approach. The study underlined the importance of the “bottom-up” method for promoting creative science teaching, and four phases were identified from the teacher interviews: uncertainty, visioning, realization and readiness. Uncertainty referred to planning future creative learning experiences for students. Visioning was related to idea generation and collaboration within and between individuals. Realization was the phase in which the ideas acquired structure, while during the readiness phase, teachers were eager to practice their ideas with students.

Experimental studies that focus on the development of science teachers' scientific creativity and creativity have also attracted the attention of the researchers. An increasing number of the intervention studies focus on the effect of constructivist and innovative approaches in teaching science on science teachers' creativity and creativity consciousness. However, to the best of our knowledge, development of science teachers' creativity consciousness through scientific creativity trainings has only been marginally addressed in these studies. To illustrate, in an experimental study, Trnova and Trna (2014) applied inquiry-based science education to support students' and teachers' creativity development. The results showed that participants improved their "abilities (all participants created new materials), individual approach (teachers changed worksheets etc.) and process (teachers worked very hard, improvised, etc)" (pp. 58-59).

As seen, although there has been an increasing interest in scientific creativity studies in science education, most of these studies focus on perceptions of prospective science teachers, in-service science teachers and students about creativity and scientific creativity (e.g., Akcanca & Cerrah-Ozsevgec, 2016; Aktamis & Ergin, 2008). Therefore, there is a need to explore how science teachers' creativity consciousness can be developed through specifically designed scientific training programs which aim to raise science teachers' creativity consciousness through creativity and scientific creativity content and instructional activities. With this in mind, in this study, we aimed to explore whether and to what extent science teachers' consciousness of scientific creativity could be increased through a scientific creativity training program (the SCTP), and how the changes in the teachers' scientific creativity consciousness were transferred into their classroom practices following the intervention. In order to do so, we employed the SCTP, which was developed specifically for this purpose. While developing the SCTP, we applied the goals and objectives for effective creativity trainings identified by Davis et al. (2014). Our research questions are as follows:

1. How does the SCTP affect science teachers' consciousness of scientific creativity?
   1.1. What elements of the SCTP increased the science teachers' creativity consciousness in science?
2. What are the impacts of higher creativity consciousness on teaching?
   2.1. What elements of the SCTP facilitated the science teachers' integration of higher creativity consciousness in science into their teaching?

## METHOD

### Design

A qualitative case study was used to answer the research questions. A case study design was used to "explore a real-life, contemporary bounded system (a case) (…) through detailed, in-depth data collection involving multiple sources of information ... and report a case description and case themes" (Creswell, 2013, p. 97).

### Participants

Data was collected from seven science teachers (five female; two male) working in public primary schools in Northern Cyprus. In order to recruit participants, a text describing the purpose of the study and providing brief information about the creativity training program was sent to schools and shared with teachers through social media (Facebook) and local newspapers. Primary school science teachers were asked to contact the researchers and apply for the training program via a Google form on a voluntary basis. A purposeful sampling strategy was used to recruit the teachers, the criteria being teaching science classes at the primary school level and years of teaching experience. As Table 1 shows, the participants' teaching experience ranged between 6 and 17 years. Four teachers were teaching at village schools, while three teachers were teaching at inner-city schools.

**Table 1. Demographic Profiles for the Participants (n=7)**

| Pseudonyms | Gender | Teaching Experience | School Type | Grade Level |
|---|---|---|---|---|
| T1 | Female | 17 | Inner-city | 4 |
| T2 | Female | 7 | Inner-city | 2 |
| T3 | Male | 6 | Village | 5 |
| T4 | Female | 8 | Village | 4 |
| T5 | Male | 14 | Village | 5 |
| T6 | Female | 13 | Village | 5 |
| T7 | Female | 9 | Inner-city | 1 |

## Data Collection Instruments

Qualitative data was collected in the form of semi-structured interviews, in-class observations, and document analysis. The qualitative data enabled us to track changes in the teachers' instructional practices in terms of how and to what extent they transferred their new knowledge and skills into classroom practice. This data triangulation increased the internal validity of the study. Detailed information on data collection tools were explained below.

## Semi-structured Interviews

Three interview schedules were developed: one to be administered prior to the training program, one to be administered one to two weeks after the training program, and one to be administered one term after the training program. Although the three interview schedules were similar to one another, the post-seminar schedules also included questions about the effects of the training on participants and how the teachers were applying the training content in class. Two faculty members, one from the Department of Curriculum and Instruction and the other from the Department of Assessment and Evaluation, provided expert opinions on the appropriateness and clarity of the draft interview schedules and suggested adding further questions and/or removing unnecessary questions in some cases. The interview schedules were then revised and finalized on the basis of these expert opinions.

## In-Class Observations

A classroom observation schedule was developed to be used after the training program to determine whether and to what extent teachers transferred the knowledge and skills they acquired in the training program to their actual classroom practice. We obtained expert opinions on the observation schedule from the same experts who provided expert opinions on the interview schedules, and revised the observation schedule accordingly.

## Document Analysis

As part of the document analysis, instructional materials the teachers used as part of their classroom practices after the training program were collected and analyzed to supplement the data from interviews and classroom observations. Among these classroom documents were electronic and printed materials (e.g., PowerPoint presentations, handouts).

## Procedure

The study consisted of three phases, as defined below:

### *Phase 1: Developing Data Collection Instruments and Participant Selection*

In the first phase of the study, the data collection instruments were developed. Specifically, the researchers designed a novel in-service training program on scientific creativity, three semi-structured interview guides, and a classroom observation schedule. Then, necessary ethics permissions were obtained. After obtaining these permissions, participants were recruited and selected based on the criteria described before.

### *Phase 2. Scientific Creativity Training Program (SCTP) and Data Collection*

The second phase of the study comprised the implementation of the SCTP and the associated data collection process. The SCTP was designed as a four-week training program and was held on the campus of an international university in Northern Cyprus. The program took place over three Saturdays in November 2017. It lasted eight hours per session. In the SCTP, we focused on scientific creativity-based activities that reflected the objectives of creativity education proposed by Davis et al. (2014) , namely developing creativity consciousness and positive attitudes towards creativity, improving understanding of creativity and creative individuals, experiencing creative skills, teaching effective creative thinking techniques, and involvement in creative activities. The sessions incorporated hands-on activities and active learning environments to promote creativity, providing teachers with the opportunity to learn by doing. During the training sessions, the researchers collected observational data through semi-structured observation forms. Information about each week's session is presented below.

*Week I.* Prior to the first training, pre-interviews were conducted with the participating teachers in which they were asked about their understanding of creativity and scientific creativity as well as their in-class practices related to scientific creativity. The interviews lasted about 20 minutes each and were audio-recorded. After this data collection, the first training module of the SCTP began, which aimed to enhance the participants' creativity consciousness and attitudes as well as understanding of creativity, as recommended by Davis et al. (2014), through the use of various inquiry- and learner-based creativity activities. The instructional activities were conducted using easily found materials (e.g., toilet paper, wire coat hangers), video clips focusing on creativity (e.g., Mona Lisa Smile), stories about creative people, the experiences of inspirational teachers who had made creative changes to their instruction, and examples from daily life. We tried to enhance the participants' creative thinking by involving them in creative active learning environments in which they were encouraged to practice and exercise creative thinking skills (e.g., fluency, originality, elaboration) through related activities, as recommended by Davis et al. (2014) (e.g., 'what would happen if…?' activities, 'thinking of unusual uses for common objects', and 'thinking of product improvements') (p. 229).

*Week II.* The second training was held on the following weekend. This training module focused on scientific creativity and the link between scientific creativity and science education. Similar to the first week, this session also took the form of active learning environments that provided teachers with the opportunity to learn by doing. During Week II, similar to the first module, we aimed to enhance the participants' scientific creativity consciousness and attitudes, and enabled them to experiment with scientific creativity-based activities in creative environments, as suggested by Davis et al. (2014). The teachers participated in 10 creative science activities with links to the science curriculum (e.g. DNA extraction, draining a buckle, building a motorboat, egg in the box, etc.). The researchers conducted semi-structured observations during the session. At the end of the session, the participants were given an interesting and challenging science problem to discuss in the last training module and were asked to complete mini-projects involving scientific creativity-oriented activities in groups of 2-3 to present during the final week of the training. With these activities, we aimed to allow the participants to put their new knowledge and skills into practice.

*Week III.* The third week of the SCTP was the preparation week for the mini-projects. The participating teachers came together in groups of 2-3 to design mini-projects that would be presented in the final week of the SCTP.

*Week IV.* In the last week of the training program, the mini-projects were presented in creative and interactive learning environments. After each group presentation, a full group discussion was conducted concerning the use of the suggested activities in the classroom.

### *Phase 3: Follow up*

The researchers conducted the second interviews with participants one to two weeks after the SCTP ended. The participants reflected on the SCTP and discussed how they were integrating creativity into their classroom practice following the SCTP. After the interviews, in-class observations were conducted in the teachers' classrooms to supplement the interview data. In addition to interviews and observation, instructional materials the teachers used as part of their classroom practices after the training program (e.g., handouts, PowerPoint presentations) were collected. Each teacher's class was observed for 2 to 4 hours, depending on the teacher's availability using the observation schedule developed by the researchers. Finally, one semester after the SCTP, the third interviews with the teachers were conducted in order to track long-term changes in the teachers' classroom practices.

## Data Analysis

Inductive content analysis of the data collected from the teachers through semi-structured interviews, in-class observations, and document analysis was conducted. The content analysis was conducted simultaneously with the data collection. The researchers prepared a preliminary code list by taking the related literature and research questions into consideration, in accordance with Miles and Huberman's (1994) strategy. As the researchers coded the data, they added newly emergent codes to the preliminary code list. After the completion of the first round of coding, double coding was conducted as suggested by Creswell (2011) to "reduce overlap and redundancy of codes" and "collapse codes into themes" (p.244). Five major themes emerged from the data analysis.

## RESULTS

Five interrelated themes regarding the SCTP's contribution to the teachers' consciousness of scientific creativity and how and to what extent the teachers transferred their new knowledge and skills into practice emerged from the data analysis of the interviews, in-class observation, and document analysis. These themes are: (1) self-reflection, (2) development of creativity consciousness, (3) changes in teachers' pedagogical content knowledge, (4) increased teaching motivation and teaching self-efficacy to encourage students' creative growth, and (5) changes in classroom practice.

## Self-Reflection

The results indicated that self-reflection may be the initial stage of change in teachers' consciousness of creativity and transfer of creativity consciousness into their teaching. Teachers' engagement in inquiry-, creativity- and scientific creativity-based activities using easily found materials (e.g., toilet paper, a wire coat hanger, an orange, flowers, eggs) during the SCTP encouraged them to reflect on the extent to which they employed creativity in their everyday personal and professional lives and question the extent to which they taught creativity and/or used creative methods in the classroom. To illustrate, T6 stated when reflecting on the impact of the SCTP:

> The seminar (SCTP) helped me to see even a very simple thing differently. Well ... I told myself "Were we wearing blinders (before)? Why can't we see these details? Why can't we be happy with small things?". I started to look very differently. (Interview 2)

Likewise, the interview with T6 conducted at the end of the term showed that she had continued to self-reflect on her classroom practice:

I felt that I had to use more activities (as part of my instruction) after the seminar (SCTP). Because if I, as a 36-year-old individual, a teacher, have enjoyed these (activities in the SCTP), it is my responsibility to have my students experience the same feelings.

### Development of Creativity Consciousness

The results indicated that teachers may develop creativity consciousness following the SCTP as a consequence of the self-reflection process. The self-reflection process helped teachers identify the importance of creative thinking skills in their personal and professional lives. The teachers developed an awareness that they could improve their own creativity as well as the creativity of their students in the classroom. For example, reflecting on how the SCTP increased her creativity consciousness, T1 stated: "Well...originality is important for creativity. I have started to see creativity as an element that has to be present at every moment and everywhere. While getting dressed, watching TV, sitting…" (2nd interview). Likewise, T6 stated in her last interview: "I developed awareness that I did not notice anything when travelling in a car. We now see different things when we look out the (car) window". Similarly, reflecting on how the SCTP helped her develop creativity consciousness, and thus change her behavior in the classroom, T4 stated:

Previously (before the SCTP), I used to ask questions in line with my aims to elicit student ideas...such as brainstorming; however, I somehow tried to get the answers I desired. It might not have been deliberately, but I used to direct the students to what I would plan to discuss/do (in the classroom). Somehow I noticed that (after the SCTP). I mean in terms of enabling them to express their ideas freely, to produce ideas...It (the SCTP) increased my awareness of this. (Interview 2)

The results of the interview conducted with T4 one term after the SCTP seemed to indicate that she had transformed her classroom practice as a result of the change in her creativity consciousness, as seen in the following quote:

Well, most importantly, it (the SCTP) helped me to gain (creativity) consciousness. I have started to ask myself how I can ask more creative questions (in the classroom) or how I can encourage student creativity. Well, kids can be more creative than us. For example, even before I asked them what the shape we designed in the classroom looked like, they said that "Here is a spaceship, let's get in", and they entered the shapes (on the floor). If I hadn't attended the training program, I would not have allowed them to do so. I would have only said "No, we will be only calculating the shapes on the floor". But I allowed them to imagine that it was a spaceship and do something inside it.

### Changes in Teachers' Pedagogical Content Knowledge (PCK)

The next theme that emerged from the data analysis concerned changes in the teachers' PCK (pedagogical content knowledge). The results indicated that in parallel to the self-reflection process and the development of creativity consciousness, the SCTP may increase the teachers' PCK regarding integrating creative thinking into classroom practice. Several of the training methods utilized in the SCTP might facilitate an increase in the teachers' PCK with respect to creative thinking, namely the learner-centered approach; the use of simple, easily found materials; the enjoyable, curiosity-triggering, creative thinking-based science activities; asking thought-provoking questions; watching videos related to creativity; the researchers sharing the experiences of inspirational teachers who had made creative changes to their instruction; book and movie recommendations by the researchers on the topic of creativity; the use of icebreakers; high trainer competencies; the effective delivery of theoretical knowledge on creativity and creative thinking; the participants' development of creativity projects with their colleagues and presenting them in the last session of the SCTP; the use of examples from daily life; and the effective use of PowerPoint presentations. By way of example, reflecting on the use of learner-based training in the SCTP, T6 stated: "You involved us (in the SCTP). We noticed that we could see the things we could not in reality by being involved and sharing our ideas. It was great" (Interview 2). Similarly, reflecting on the use of materials, T6 stated in her last interview that: "I learned how to use materials while being involved in the activities there (in the SCTP). I created things I would never think about with the materials you gave".

### Increased Teaching Motivation and Teaching Self-Efficacy to Encourage Students' Creative Growth

The results indicated that the self-reflection process, development of creativity consciousness and attitudes, and changes in teachers' PCK seemed to in turn increase their teaching motivation and teaching self-efficacy with respect to encouraging students' creative growth. The data indicated that most of the teachers wanted to make changes to their instruction by employing more creative tasks and thinking-outside-the-box activities in order to teach topics in a novel way. To illustrate, in her second interview, T1 stated:

Well, now I have started to think about how I could use creativity or contribute to a child (a student's creativity) for every single topic. How can I help the child to demonstrate his/her own creativity? And it has been really effective.

Similarly, T3 stated: "I sometimes think: 'What kind of (creative) activities can I do about this topic? What kind of experiments can I conduct?' Well, there are activities in the textbook, but it (STCP) enabled me to think about different activities (Interview 2)". Similarly, reflecting on the program's impact on her PCK, T4 stated:

Well, I've started to ask different questions to myself. There has been a change in the things I read and watch. I've started to watch TedX talks you (researchers) )showed/recommended. There are updates from YouTube. I follow a classroom teacher you mentioned to be inspired to improve myself. I've started to think about how I could develop myself and my instruction. (Interview 2)

Another noteworthy comment is as follows:

Well, our self-confidence increased. We have started to apply most of the activities we conducted in the seminar in our classrooms. We also created more activities for classroom use. We have seen its benefits. (T2, Interview 2)

## Changes in Classroom Practice

The results of the second interviews, observational data and document analysis indicated that all teachers seemed to immediately begin to put their new knowledge and skills into practice in the classroom. They primarily tried out or adapted the activities and/or materials used in the SCTP to improve their students' scientific creativity. To illustrate, T6 said: "I have started to use the activities you used in the (SCTP) by adapting them to my own context" (Interview 2). Similarly, T1 explained how she conducted an activity used in the SCTP:

For example, I had a mandarin with me in class. There was an orange experiment we tried there (in the SCTP). Two participants (in the SCTP) used that activity. They first threw the orange into the water unpeeled, then peeled. When I used it in the classroom, the students shouted "wow" as if they had invented something. It is very easy but I believe students will no longer forget it. (Interview 2)

The data from the third interviews, classroom observations and document analysis indicated that the teachers' use of creativity in the classroom also increased in the long run. At this point, in addition to employing the activities and materials they had experimented with in the SCTP, the teachers had started to create new activities in line with their instructional goals (e.g., T3 made groundwater using a jar, gravel, sand, and empty toilet paper rolls in Grade 5). For example, T4 stated: "Well … I have started to reflect on the activities that I use and to think about how I can modify them" (Interview 3). Similarly, T2 stated: "We have used a lot of activities that students like including yours. In addition, we created more activities" (Interview 3).

The teachers reported that the changes in their classroom practice had a positive impact on their students' interest in science class, independently of grade level. In addition, the changes in classroom practice reportedly enhanced the students' knowledge retention and motivation to complete creative science tasks outside of school. For instance, reflecting on an experiment she had conducted with a toy car in the classroom, T1 pointed out the changes in students' attitudes as follows: "When I used activities, I noticed how effective it could be, how disinterested students enjoyed it, and those students participated in the lesson more" (Interview 3). Similarly, T1 described the impact of scientific creativity activities on their students' interest as follows:

Students have started trying out something new at home. I made a magnet. I gave them a list to show what a magnet could and could not attract. They (the students) were not limited to the list. They started to try out everything at home. At the end of the day, there were very interesting things. One student said that the magnet was attracted to the fork and knife. Another said "mine can't" insistently. Thus, they researched that and found that in some forks, the amount of iron was low, in others, it (the amount of iron) was higher. They were even able to reach this conclusion by themselves.

The interview data showed that these changes in the students' interest in science class, motivation to carry out creative science projects outside of school, and knowledge retention seemed to in turn further increase the teachers' motivation to continue to use creative methods in the classroom. To illustrate, reflecting on the impact of the SCTP on her classroom practice, T1 noted:

Well, it (the SCTP) helped me to overcome my pessimistic point of view. I mean there are children that you cannot reach whatever you do. They stay behind their friends. I mean we couldn't get their attention (before the SCTP). However, I now notice that when I use these activities, they (these children) have started to participate. Well, it is great to see that.

The results from qualitative interviews and observational data showed that the extent to which the teachers use creativity in class might depend on grade level. Teachers of lower grades seemed to use more creative activities, as they mentioned having fewer concerns related to high-stakes exams and curricular expectations. To illustrate, T3 stated:

I have had a chance to put some activities (that I learned in the SCTP) into practice. But there is a lot of content and college preparation. As I am behind schedule, I have not been able to use (creativity-based) experiments in all classes or topics. (Interview 3)

The results of the interviews indicated that alongside high-stakes exams and curricular expectations, inadequate parental support, students not bringing materials with them to class and a lack of knowledge of how to manage classroom discussions when students came up with lots of creative ideas were among the barriers to teachers fostering scientific creativity in the classroom. For example, T4 stated:

There are students who are not aware of their responsibilities … or due to their parents' background - even though I ask for simple materials, they forget to bring a balloon or a bottle ... This limits me, I have to bring extra materials, the materials they have to bring (Interview 2).

With respect to experiencing problems managing classroom discussions, T4 stated:

Well, children have a lot of ideas … I allow them (to share their ideas) so that I can get their creative ideas but then they might experience problems about focusing. Because they enjoy it. They think of other ideas too … I might have problems directing their attention to the topic again (Interview 3).

Nevertheless, the results indicated that the teachers continued to use creative methods in the classroom despite the obstacles they encountered. When discussing the chaos that creative tasks generated in the classroom, T1 stated: "I have started to enjoy (the activities) too. I used to regard this (noise) as a problem … There would be noise, chaos … But it is okay as our classes are crowded". Hence, the results indicated that although high-stakes exams and curricular expectations had a negative impact on teachers' creative practices, especially during the last two weeks of the term, most teachers seemed to continue to incorporate creativity into science instruction. For example, reflecting on his practices after the SCTP, T5 stated:

> In the fifth grade, we do not have sufficient time (for creativity-based activities). Well, we have to create time. Because there is an overloaded curriculum and a deadline ... But as I've mentioned before, I used to apply creativity-based activities with a percentage of 20, now I do my best to apply 50-60 percent. I have definitely seen its positive impact. (Interview 3)

The results further indicated that the teachers planned to continue to use scientific creativity in the classroom in upcoming years despite the roadblocks they encountered. To illustrate, T2 stated:

> Well, next year I will be teaching the first grade. From the very beginning, I plan to use similar activities every week ... I will say "Today is our Creativity Day", "Scientific Day", "Experiment Day". I plan to integrate this into my instruction. (Interview 2)

In line with their interest and motivation to continue to integrate creativity into instruction, the interviews showed that the teachers hoped to participate in similar in-service training programs in the future to update their knowledge and skills and further improve their teaching motivation and self-efficacy. One notable quote is as follows:

> Well, conducting these kinds of studies occasionally will motivate us, increase its (creativity's) importance and we won't forget ... It will be more permanent. I think this should be done from time to time to make a difference, like giving fresh blood. (T1, Interview 3)

## DISCUSSION AND CONCLUSION

This study set out to explore whether and to what extent science teachers' consciousness of scientific creativity could be increased through a scientific creativity training program (the SCTP), and how the changes in the teachers' scientific creativity consciousness were transferred into their classroom practices following the intervention. The results indicated that all teachers put the new knowledge and skills they had acquired during the SCTP into practice in their classroom instruction. Self-reflection seemed to be the initial stage of this process of transferring professional learning into practice. The results revealed that the teachers' engagement in inquiry- and creativity-based activities using easily found materials in active learning environments during the SCTP may have encouraged them to reflect on their use of creativity in their personal and professional lives as well as in their classroom practice. Alongside this self-reflection, teachers may develop creativity consciousness. The results indicated that this may have increased their awareness of scientific creativity and its importance and motivated them to further improve their own and their students' creativity. This finding is consistent with that of Sahin and Yildirim (2015), who found that the transfer of professional learning into classroom practice starts with self-reflection, which in turn leads to a change in teachers' pedagogical beliefs. It is also encouraging to compare these findings to those of Cheng (2016), who found in his study on personal transfer of creative learning from a toy course that the students who completed the course "used to relate creativity with something unusual, great, inborn and rather difficult to gain, but after the toy course they were aware that creativity could always be found in daily life (if one was sensitive enough) and that creative thinking could also be improved by learning" (p.63).

Our results further revealed that the SCTP may facilitate the development of teachers' PCK concerning how to deploy scientific creativity in the science classroom. The results indicated that certain practices employed in the SCTP may effectively promote the development of teachers' PCK concerning scientific creativity, confirming the results of previous studies. These effective practices included the use of an inquiry-based, learner-centered training (e.g., Colangelo & Davis, 2003; Kind & Kind, 2007; Sahin & Yildirim, 2015), active learning strategies (e.g., Sahin & Yildirim, 2015; Wei et al., 2009), and enjoyable, curiosity-triggering creative thinking-based science activities. These findings support the results of previous experimental studies revealing that inquiry- and learner-based professional development trainings in the field of science education positively affect participants' teaching practices (e.g., Trnova & Trna, 2014).

Another important finding was that the self-reflection process, development of creativity consciousness, and changes in teachers' PCK seemed to increase the teachers' teaching motivation and teaching self-efficacy with respect to encouraging students' creative growth. The results showed that most teachers were motivated to deploy creativity-based tasks in their science classes and immediately integrated the training content into their classroom practice following the SCTP. They seemed to initially replicate the activities and/or materials used in the SCTP to enhance their students' scientific creativity, either with adaptations or exactly as they were introduced in the training. As time went on, however, the teachers continued to focus on scientific creativity in the classroom and even started to design new activities and/or materials in accordance with their instructional goals. It is encouraging to compare our results with Davis' (2003) theoretical suggestion that "At the very least, we all can make better use of the creative abilities with which we were born" (p. 318). The results of this study lend further confirmation to previous studies' findings that creativity interventions can have a meaningful impact on creative thinking skills (e.g., Davis, 2003; Davis et al., 2014) and a variety of learner-based instructional techniques (Colangelo & Davis, 2003; Kind & Kind, 2007).

Although we did not collect data from students of the teachers who were involved in the study, the data from teacher interviews and classroom observations suggested that the changes in teachers' classroom practices may have positively affected their students' interest in science class, knowledge retention and motivation to conduct creative science tasks outside the school environment. This was in turn found to reciprocally enhance the teachers' motivation to continue to incorporate scientific creativity into the classroom. Hence, this study adds to the evidence from previous studies suggesting that there is a reciprocal relationship between teachers' beliefs and practices (e.g., Clarke & Hollingswoth, 2002; Cobb, Wood, & Yackel, 1990; Gelmez-Burakgazi & Can, 2020; Sahin & Yildirim, 2015). Furthermore, our findings on teacher motivation also support Amabile's (1983) Intrinsic Motivation Hypothesis by Creativity: "a primarily intrinsic motivation to engage in an activity will enhance creativity, and a primarily extrinsic motivation will undermine it" (p. 366).

However, the teachers experienced some barriers to integrating scientific creativity into their science classrooms, namely high-stakes testing, curricular expectations and related time management concerns. These posed a particular hindrance for fifth-grade teachers. Other obstacles the teachers encountered were students not bringing the requested materials to class, a lack of parental support, and a lack of know-how among the teachers on how to manage classroom discussions when students came up with lots of creative ideas. Nevertheless, the results showed that the teachers continued to incorporate creativity into the classroom despite these challenges and planned to continue to foster scientific creativity in upcoming years. Hence, this finding provides support for the premise that changes in teachers' creativity consciousness, PCK and teaching motivation and teaching self-efficacy to integrate creativity into their classroom instruction may lead them to sustainably foster scientific creativity in the classroom in the long run, despite the associated challenges.

## FINAL REMARKS

The findings reported in this study may be able to contribute to teachers' creativity consciousness. Our results indicated that creativity education can lead teachers to make significant changes to their classroom practice by gradually integrating scientific creativity. Although our data reveals a common pattern of teacher change, it should be noted that, consistent with Cheng's (2016) study, which found that "The personal transfers of learning were found to be spontaneous, far, diverse, multidirectional, highly individual and, sometimes, quite unexpected" (p.58), the present study also reveals that each teacher has a unique trajectory of change regarding creativity and creative teaching, which needs to be taken into consideration for more sustainable creativity education.


### Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

This work was supported by the Scientific Research Fund of Middle East Technical University Northern Cyprus Campus (Grant number: SOSY-17-D-4).


### Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

### Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

### Ethics Committee Approval Information

This study has been ethically approved by Hacettepe University Ethics Committee on 16/11/2016 with document number 76942594-900/3988.

**Note:** A part of this paper was presented at the 2nd Annual Creativity Conference organized at Southern Oregon University, Oregon, USA on the 11-14th of July, 2019.

## REFERENCES


Akcanca, N., & Cerrah-Ozsevgec (2016). The creativity thoughts of preservice teachers studying at science teaching. *Bayburt Egitim Fakultesi Dergisi, 11*(2), 391-413.

Aktamis, H., & Ergin, O. (2008). The effect of scientific process skills education on students' scientific creativity, science attitudes and academic achievements. *Asia-Pacific Forum on Science Learning and Teaching, 9*(1), 1–21.

Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology, 45*(2), 357-376. https://doi.org/10.1037/0022-3514.45.2.357

Amabile, T. (2011). *Componential theory of creativity* (pp. 538-559). Boston, MA: Harvard Business School.

Ayas, M. B., & Sak, U. (2014). Objective measure of scientific creativity: Psychometric validity of the Creative Scientific Ability Test. *Thinking Skills and Creativity*, *13*, 195-205. https://doi.org/10.1016/j.tsc.2014.06.001

Batey, M., & Furnham, A. (2006). Creativity, intelligence, and personality: A critical review of the scattered literature. *Genetic, Social, and General Psychology Monographs*, *132*(4), 355-429. https://doi.org/10.3200/MONO.132.4.355-430

Beghetto, R. A., & Kaufman, J. C. (2007). Toward a broader conception of creativity: A case for mini-c creativity. *Psychology of Aesthetics, Creativity, and the Arts*, *1*(2), 73–79. https://doi.org/10.1037/1931-3896.1.2.73

Boden, M. A. (2009). Creativity: How does it work? In M. Krausz, D. Dutton, & K. Bardsley (Eds.), *The idea of creativity* (pp. 237–250). Brill.

Bolden, D., Harries, T., & Newton, D. (2010). Pre-service primary teachers' conceptions of creativity in mathematics. *Educational Studies in Mathematics*, 73, 143–157. https://10.1007/s10649-009-9207-z

Bore, A. (2007) Bottom–up for creativity in science?: A collaborative model for curriculum and professional development. *Journal of Education for Teaching, 32*(4), 413-422, https://doi.org/10.1080/02607470600982019

Cheng, V. M. Y. (2016). Understanding and enhancing personal transfer of creative learning. *Thinking Skills and Creativity,* 22, 58–73. https://doi.org/10.1016/j.tsc.2016.09.001

Clarke, D. J. & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*(8), 947–67. https://doi.org/10.1016/S0742-051X(02)00053-7

Cobb, P., Wood, T., & Yackel, E. (1990). Classrooms as learning environments for teachers and researchers. In R.B. Davis, C.A. Maher, & N. Noddings (Eds.), *Constructivist views on the teaching and learning of mathematics* (pp. 125-146). National Council of Teachers of Mathematics.

Colangelo, N. & Davis, G.A. (2003). *Handbook of gifted education* (3rd ed.). Boston: Pearson.

Craft, A. (1999). Creative development in the early years: Some implications of policy for practice. *The Curriculum Journal*, *10*(1), 135-150. https://doi.org/10.1080/0958517990100110

Craft, A. (2001). An analysis of research and literature on creativity in education. *Qualifications and Curriculum Authority*, *51*(2), 1-37.

Creswell J. W. ( 2011). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Upper Saddle River, NJ : Pearson Education.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Thousand Oaks, CA: Sage.

Davis, G. A. (2003). Identifying creative students, teaching for creative growth. In N. Colangelo & G.A. Davis (Eds.), *Handbook of gifted education* (3rd ed., pp. 311–324). Pearson.

Davis, G. A., Rimm, S. B., & Siegle, D. (2014). Education of the Gifted and Talented (6th ed.). Essex, UK: Pearson Education.

de Souza Fleith, D. (2000). Teacher and student perceptions of creativity in the classroom environment. *Roeper Review: A Journal on Gifted Education, 22*(3), 148–153. https://doi.org/10.1080/02783190009554022

Feist, G. J. (1998). A meta-analysis of personality in scientific and artistic creativity. *Personality and Social Psychology Review*, *2*(4), 290-309. https://doi.org/10.1207/s15327957pspr0204_5

Gajda, A. (2016). The relationship between school achievement and creativity at different educational stages. *Thinking Skills and Creativity*, 19, 246–259. https://doi.org/10.1016/j.tsc.2015.12.004

Gelmez-Burakgazi, S. & Can, I. (2020). Examining the relation between secondary teachers' beliefs about their own learning and their instructional practices. *Trakya Journal of Education, 10*(3), 647-667.

Guilford, J. P. (1956). The structure of intellect. *Psychological Bulletin*, *53*(4), 267-293. https://doi.org/10.1037/h0040755

Guskey, T. R. (1986). Staff development and the process of teacher change. *Educational researcher*, *15*(5), 5-12. https://doi.org/10.3102/0013189X015005005

Harris, A.M., & de Bruin, L. (2019). Creative ecologies and education futures. In C. Mullen (Eds.), *Creativity under duress in education? Creativity Theory and Action in Education* (vol 3., pp. 99-115). Springer. https://doi.org/10.1007/978-3-319-90272-2_6

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, *24*(4), 389-403. https://doi.org/10.1080/09500690110098912

Kind, P. M., & Kind, V. (2007). Creativity in science education: Perspectives and challenges for developing school science. *Studies in Science Education, 43*(1), 1-37. https://doi.org/10.1080/03057260708560225

Liu, S. C., & Lin, H. S. (2014). Primary teachers' beliefs about scientific creativity in the classroom context. *International Journal of Science Education*, *36*(10), 1551-1567. https://doi.org/10.1080/09500693.2013.868619

Meyer, A. A., & Lederman, N. G. (2013). Inventing creativity: An exploration of the pedagogy of ingenuity in science classrooms. *School Science and Mathematics*, *113*(8), 400–409. https://doi.org/10.1111/ssm.12039

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage.

Mukhopadhyay, R., & Sen, M. K. (2013). Scientific creativity-A new emerging field of research: Some considerations. *International Journal of Education and Psychological Research*, *2*(1), 1-9.

O'Connor, D. (2012). Creativity in childhood: The role of education [Paper presentation]. 8th Global Conference: Creative Engagements Thinking with Children. https://researchonline.nd.edu.au/edu_conference/76/

Parkhurst, H. B. (1999). Confusion, lack of consensus and the definition of creativity as a construct. *The Journal of Creative Behavior, 33*(1), 1-21. https://doi.org/10.1002/j.2162-6057.1999.tb01035.x

Prentice, R. (2000). Creativity: a reaffirmation of its place in early childhood education. *The Curriculum Journal*, *11*(2), 145-158. https://doi.org/10.1080/09585170050045173

Runco, M. A. (2004). Creativity. *Annual Review of Psychology, 55*, 657–687. https://doi.org/10.1146/annurev.psych.55.090902.141502

Sawyer, R. K., John-Steiner, V., Moran, S., Sternberg, R. J., Feldman, D. H., Nakamura, J., & Csikszentmihalyi, M. (2003). *Creativity and development.* Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195149005.001.0001

Sahin, I., & Yildirim, A. (2005). Transforming professional learning into practice. *ELT Journal, 70*(3), 241-252. https://doi.org/10.1093/elt/ccv070

Sternberg, R. J. (2006). The nature of creativity. *Creativity Research Journal*, *18*(1), 87-98.

Sternberg, R. J. (2018). The triangle of creativity. In R. J. Sternberg & J. C. Kaufman (Eds.), *The nature of human creativity* (pp. 318–334). Cambridge University Press. https://doi.org/10.1017/9781108185936.023

Torrance, E. P. (1965). Scientific views of creativity and factors affecting its growth. *Daedalus*, *94*(3), 663-681. http://www.jstor.org/stable/20026936

Trnova, E., & Trna, J. (2014). Implementation of creativity in science teacher training. *International Journal on New Trends in Education and Their Implications*, *5*(3), 54-63.

Waters, A. (2006). Facilitating follow-up in ELT INSET. *Language Teaching Research, 10*(1), 32–52. https://doi.org/10.1191/1362168806lr183oa

Wei, R. C., L. Darling-Hammond, A. Andree, N. Richardson, & S. Orphanos. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad*. Dallas, TX: National Staff Development Council.

Yang, K. K., Lin, S. F., Hong, Z. R., & Lin, H. S. (2016). Exploring the assessment of and relationship between elementary students' scientific creativity and science inquiry. *Creativity Research Journal*, *28*(1), 16-23. https://doi.org/10.1080/10400419.2016.1125270

Yates, E., & Twigg, E. (2017). Developing creativity in early childhood studies students. *Thinking Skills and Creativity*, *23*, 42-57. https://doi.org/10.1016/j.tsc.2016.11.001

Yoon, H., Woo, A.J., Treagust, D.F., & Chandrasegaran, A.L. (2015). Second-year college students' scientific attitudes and creative thinking ability: Influence of a problem-based learning (PBL) chemistry laboratory course. In M. Kahveci & M. Orgill (Eds.), *Affective dimensions in chemistry education* (pp. 217–233). Heidelberg. https://doi.org/10.1007/978-3-662-45085-7_11