Creative Education, 2022, 13, 1421-1438
https://www.scirp.org/journal/ce
ISSN Online: 2151-4771
ISSN Print: 2151-4755

Creativity in German Science Education in Elementary Schools: Preservice Teachers' Perspective on Whether It Is Essential, Possible or Completely Unnecessary

Marisa Alena Holzapfel[1], Ann-Kathrin Jaggy[2], Maja Brückmann[1]

[1]Department of Pedagogy, Carl von Ossietzky University of Oldenburg, Oldenburg, Germany
[2]Hector Research Institute of Education Sciences and Psychology, Tübingen, Germany
Email: marisa.alena.holzapfel@uni-oldenburg.de

How to cite this paper: Holzapfel, M. A., Jaggy, A.-K., & Brückmann, M. (2022). Creativity in German Science Education in Elementary Schools: Preservice Teachers' Perspective on Whether It Is Essential, Possible or Completely Unnecessary. *Creative Education, 13,* 1421-1438.
https://doi.org/10.4236/ce.2022.134087

Received: February 21, 2022
Accepted: April 24, 2022
Published: April 27, 2022

Abstract

Creativity is one of the key qualifications of the 21st century. Despite this importance, the topic plays a subordinate role in school and teacher training. The article will explore the question of what understanding and values prospective teachers have of creativity in science education. After the relevance of creativity for science education in elementary school is presented, possible definitions of creativity and divergent thinking are shown in the theoretical framework. Based on this, creativity in education and especially in science education in elementary school will be presented. This leads to the following questions: ***RQ1***: *What do preservice teachers of science education in elementary school understand by creativity*? ***RQ2***: *How much relevance do preservice teachers of science education in elementary school attach to creativity for science education in elementary school*? ***RQ3***: *What are preservice teachers' views on the influence of different factors on the development of creativity and on the promotion of creativity in science education in elementary school*? Preservice teachers of science education in elementary school ($N = 131$) from the states of Lower Saxony and North Rhine-Westphalia in Germany were surveyed. The respondents consider creativity to be important for learning in science education at elementary school. They also view creativity important not only for learning in a school context, as well as its high value in professional life in the future. Overall, the findings show that professional experience has no influence on opinions about creativity in science teaching in elementary school. Preservice teachers from the state of Lower Saxony have a somewhat more positive attitude towards the topic of creativity in science education in elementary school, although it must be said that the respondents

from North Rhine-Westphalia also attach great relevance to the topic.

Keywords

Elementary School, Science Education, Preservice Teachers, Creativity

1. Introduction

Creativity is considered an essential 21st-century skill to meet the demands of the present and future (digital) world (Nakano & Wechsler, 2018), and thus is also seen as something important to foster from early on in education. However, although it is currently a hot topic in educational discourse and its importance is emphasized for many different learning fields and abilities like science education, social competence, or identity formation (e.g., Barbot & Heuser, 2017; Beghetto, 2010; Spencer & Lucas, 2018), it has not yet been implemented as standard in educational practice (Ahmadi et al., 2019; Kim & Chae, 2019). The question thus arises of *why not*. A starting point for clarifying why creativity has not yet been implemented in teachers' school practice is to ask how important teachers consider creativity to be, which in turn affects their behaviour (Ajzen, 1991). It has been shown that teachers' attitudes and beliefs towards different topics play a significant role in shaping their classroom practices (Bolhuis & Voeten, 2004). Teachers' attitudes towards inclusion, for example, influence their inclusive teaching behavior (Yang & Yu, 2021). It is therefore important to investigate teachers' attitudes towards creativity, which if necessary, could then be modified in a second step (Koballa, 1988), to introduce more creativity into their educational practice.

Before investigating teachers' attitudes towards creativity, however, it is also important to clarify what is understood by creativity, and what makes a creative person. This question is not as easy to answer as it first appears. There are a number of very different definitions of creativity. Most of them deal with creativity as divergent thinking, i.e., the ability to generate different ideas (Runco, 2004). However, divergent thinking is only one facet of creativity and does not cover creative thinking in a holistic way. During the creative thinking process, it is also important to decide which of the different ideas one generates is the most valuable. Creative thinking therefore also includes convergent thinking processes (Guilford, 1967).

To clarify why creativity has not yet been implemented in classrooms, the current study aims to investigate the attitudes of preservice teachers towards creativity and its role in education, and potential obstacles to implementing it in educational practice. We therefore investigated the views of preservice science education teachers on creativity and its importance in science education, whether and where creativity can be usefully integrated into science education, and how creativity can be promoted in science education in elementary school.

The reason why preservice teachers' view of these issues is so important is that teachers are the ones for incorporating creativity into the classroom. Only when their perspective is clear can interventions or other measures be taken to bring creativity into the classroom. In particular, preservice teachers could be made aware of the importance of creativity in the classroom during their training, as they are much easier to reach than teachers already in service.

2. Theoretical Framework

Defining creativity (in the context of science education in elementary school)

Among the multitude of possible definitions, four seem particularly appropriate to the field of science education and pedagogy as they all indicate the ability to solve a problem or to create a product that is new or innovative in some way. At the same time, each definition highlights different aspects of creativity. The first defines creativity as "the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)" (Sternberg & Lubart, 1998: p. 3). This highlights that a creative person must think as innovatively as possible, but also that the innovation must be useful: the focus is on the product. Another possible definition is that of Barron & Harrington (1981). In their view, the creative person has broad interests, an affinity for complexity, high energy, independent judgment, autonomy, intuition, self-confidence, and the ability to solve problems. Here the focus is especially on the personality traits that favor a person's creativity, so it is not about an innovative and useful product, as in the first definition, but rather about the creative person and his or her characteristics. A third definition sees creativity as a response or idea that is new, or rare in the statistical sense, that can be realized in whole or in part. It must serve to improve a condition or complete an existing goal (Mackinnon, 1962). This definition emphasizes the rarity or exceptionality of a creative idea. However, unlike the previous definitions, it allows that the idea need not be fully realized. Bliersbach & Reiners (2017: p. 324) found the following definition of creativity in the context of chemistry education:

> Creativity describes the potential inherent in every human being to create something new and relevant for his or her environment with the help of various metacognitive strategies, breaking out of known structures and the recombination of knowledge, to create something new and relevant for their respective environment.

Since this definition includes the four components *creative person*, *creative process*, *creative product*, and *creative environment*, it seems to be suitable for elementary school. The current study therefore uses it as a working definition. For the field of pedagogy, all four categories seem to be interesting, although the authors have pointed out that the view of a creative environment is often necessary (Bliersbach & Reiners, 2017). The content of this definition coincides with the definitions of creativity in chemistry teaching selected by Semmler & Pietz-

ner (2018). The four sub-areas also play a role in their selected definitions.

In this context, a question often discussed in creativity research is the relationship between *divergent thinking* and *creative thinking*. In the meantime, we might consider that divergent thinking is an indispensable part of creative thinking, but not equate it with creative thinking. For example, Runco (2006: p. 250) has stated: "One commonality among the diverse articles is the idea that divergent thinking is not synonymous with creativity. It is, instead, a predictor of it". However, the large-scale PISA study (Prenzel & Deutsches PISA-Konsortium, 2004) seems to see this differently and equates the two—probably not least because divergent thinking can be measured relatively easily by numerous existing instruments (e.g., Brophy, 2006; Cropley, 2006; Garaigordobil, 2006). The measurement of creativity, on the other hand, is much more difficult.

Creativity in Education

As already mentioned, all four categories (creative person, creative process, creative product, and creative environment) are interesting in the context of education (Bliersbach & Reiners, 2017). The categories can be linked to the school and to lessons in a very concrete way.

A **creative person** can be a creative student as well as a creative teacher. The creative person must have the intellectual capacity to see problems in new ways. He or she needs prior content knowledge. In addition, other personality traits, such as self-efficacy, willingness to take risks, tolerance of ambiguity, and motivation are important (Beghetto & Karwowski, 2018). Some of these traits are easy to train, others less so, because as personality traits they are difficult to influence. In order to promote students' creative abilities, it is important for teachers to be open to creativity and thus to their students' creative approaches. Ideally, they attach great importance to this and create opportunities for creativity to be acted upon. This includes, for example, setting creative tasks (**creative process**) and being open to creative work results, i.e., **creative products** (Runco, 2004). Of course, it is ideal if the teachers themselves have a certain degree of creativity. A creative process can be an innovative learning process that also allows for unusual methods or goals. This in turn can lead to a creative product. Alternatively, a task may be formulated that aims directly at the production of a creative product, for example a comic or cartoon with subject content (Holzapfel, 2018).

Finally, there is the **creative environment**. There is usually great emphasis on the creative environment in class. It can be specifically designed to set creative processes in motion and to promote the students' creative potential (e.g., Sternberg & Lubart, 1998).

It is already clear from the above that the four categories should not be considered in isolation, but are interconnected and interdependent.

These factors thus should be implemented within education. The STEAM movement is a large-scale initiative currently trying to make the role of creativity in education more visible and to bring creativity into teaching (Liao, 2016). STEAM education combines the areas of Science, Technology, Engineering, *Arts*,

and Mathematics. Consequently, including the arts, i.e. creativity, into STEM education will transform STEM into STEAM (Liao, 2016). The idea is that through adding the arts, students learn more holisticly in the areas of inquiry and critical thinking, for example. One subject that seems ideal for integrating creativity in STEM education and moreover in elementary school is science education, as it is interdisciplinary in nature and just the element of creativity has to be added to become a STEAM subject.

Creativity in Science Education ("Sachunterricht") in German elementary schools

Science education in German elementary schools is called *Sachunterricht* and encompasses all natural and social sciences. It therefore combines biology, chemistry, physics, technology, geography, history and politics (Niedersächsisches Kultusministerium, 2017). These subject areas are divided into social science, natural science, geographical, historical and technological perspectives (see **Figure 1**). In addition, there are the cross-cutting topics of mobility, sustainable development, health promotion and prevention and media.

Teaching science is issue-related and multi-perspective. The lessons are based on a principal theme, which is then analyzed from many different disciplinary perspectives.

All in all, the aim of the subject science education is to look at phenomena and contexts of the living environment, to impart competences to acquire knowledge independently and reflexively, and to open up the world and thus to act responsibly and in solidarity in the natural, cultural, social and technological environment (Gesellschaft für Didaktik des Sachunterrichts, 2013; Niedersächsisches Kultusministerium, 2017). This subject therefore seems ideal for requiring and

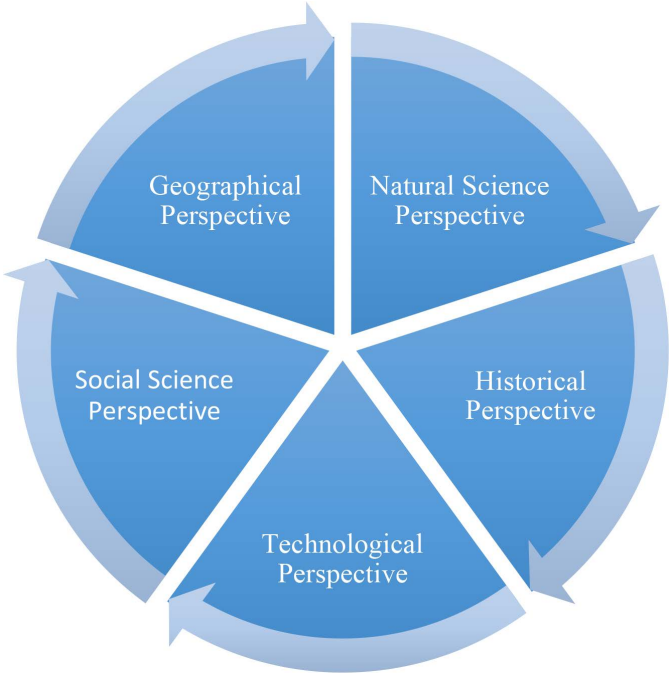

Figure 1. Model of a multi-perspective science education ("Sachunterricht").

promoting creativity.

However, there is ample evidence that people do not attach importance to creativity in science education (Bliersbach & Reiners, 2017; Hadzigeorgiou et al., 2012; Schmidt, 2011). It is often assumed that science teaching is logical and stringent and so excludes creative, innovative approaches. In reality, there is also empirical evidence that leaders of the future should use creativity as one important cognitive ability (Gardner, 2008). Furthermore, Glăveanu (2018) adds evidence that creativity is about agency, flexibility, openness, and emergence. Since capable leaders are needed in companies, the question arises as to whether and how these opposites can be united.

Hadzigeorgiou et al. (2012) discuss numerous interesting approaches for including creativity in science education. First of all, they show that this is by no means a contradiction, but that there must be something like "scientific creativity" in order to generate new ideas and thus discover new things. They pointed out that there can never be one way to solve a problem but that every scientist has individual, creative approaches.

Taken together there are some voices that describe creativity as a characteristic of scientists and future leaders. However, this characteristic is not (always) innate and must therefore be trained. School seems to be a suitable place for this, since in most countries schooling is compulsory. The current study focuses on science education because of its diverse potential. The topic-oriented and multi-perspective approach to a wide variety of topics from the above-mentioned perspectives provides diverse opportunities to try out new, innovative methods and also to find "unconventional ways to the goal".

Current study

The aims of the current study were therefore 1) to identify how preservice science teachers define creativity in the context of science education in elementary school, 2) to identify their views on the importance of creativity in science education, and 3) to identify their perspectives on what influences creativity and how to promote it.

Applying these questions, a first impression of the relevance of the topic of creativity for science education in elementary school in Germany emerges.

3. Method

In order to obtain an empirically grounded answer to these questions, preservice teachers of science education in elementary school were given an online survey which aimed to answer the following research questions:

***RQ*1:** *What do preservice teachers of science education in elementary school understand by creativity*?

***RQ*2:** *How much relevance do preservice teachers of science education in elementary school attach to creativity for science education in elementary school*?

***RQ*3:** *What are preservice teachers' views on the influence of different fac-*

tors on the development of creativity and on the promotion of creativity in science education in elementary school?

4. Sample

A total of $N = 131$ preservice teachers of science education in elementary school from the states of Lower Saxony (48 students) and North Rhine-Westphalia (82 students) in Germany were surveyed (Ø age 22.78; ♀ 87%). The age of the respondents ranged from 19 to 48 years. The sex and age distribution is usual for science education at elementary school level. 95.4% of the respondents were in semester one to three at the time of the survey, the remaining 4.6% were in a higher semester. We can therefore say that a large proportion of the respondents were at the beginning of their studies. 40.5% ($n = 53$) of them indicated that they already had teaching experience.

5. Test Instrument

A newly developed questionnaire was used to assess future teachers' opinions on creativity in science education in elementary school. It consisted of three parts: *definition of creativity*, *creativity in education and science education*, *creative methods in science education*. The questionnaire consisted of open as well as closed items.

For answering the first research question, participants were asked to select the best-fitting definition for science education of creativity from the four theories presented in the theoretical framework. In addition, they were asked whether in their opinion divergent thinking is the same as creative thinking. Both items are single-select items from the section *definition of creativity*.

To answer the second research question, a scale was formed over four closed items on the topic of *relevance of creativity to school* (see **Table A1** in **Appendix**). The respondents were given the opportunity to express their opinion on a four-point Likert scale, from *agree* (4) to *disagree* (1). The scale showed an acceptable internal consistency (Cronbach's $\alpha = .74$). In addition, mean values of two closed items regarding the importance of creativity for learning in science education and the importance of promoting creativity in science education, two half-open items (see **Table 1** and **Table 2**) and the item *Creativity is especially important for learning in the technological perspective*, and 4 other items for the other perspectives, were calculated (see **Table 3**). This was repeated with the item *The creativity of the students can be promoted especially in the technological perspective* and the other perspectives (see **Table 4**). For these items of the mean comparisons, the participants were also asked to express their opinion on a four-point Likert scale from *agree* (4) to *disagree* (1). All items are from the section *creativity in education and science education.*

For the third research question, we report the means of 14 closed items, formulated on the basis of the points named by Hadzigeorgiou et al. (2012) probing the design of creative environments and activities (see **Table 5**).

Additionally, comparisons were made by teaching experience, gender, state and age to find out if these variables lead to different views on creativity in

science education in elementary school.

6. Results

Defining creativity from the perspective of preservice teachers of science education in elementary school

The four possible definitions of creativity presented in the theory were evaluated by the participants according to which one they thought was the most appropriate for science education in elementary school. The definition given by Bliersbach & Reiners (2017) was ranked as by far the most appropriate (63.5%).

The participants were also asked whether divergent thinking is the same as creative thinking. Fifty-one percent stated that creative thinking should be equated with divergent thinking, 45% stated that it is not the same, and the rest did not answer. This shows that there is no clear trend among the respondents surveyed.

Preservice teachers' perspective on the importance of creativity for (science) education in elementary school

Preservice teachers were asked to rate the general relevance of creativity to education on a scale consisting of four items. The mean value (M = 3.53, SD = .44) of the overall sample shows that the respondents attribute a high relevance of creativity to education.

Regarding the relationship between science education and creativity, the future teachers rated creativity as moderately important for learning in science education (M = 2.98, SD = .70), but attached a high importance to the promotion of creativity in this subject (M = 3.56, SD = .56).

Preservice teachers were also asked to rate the selected professions for which creativity is particularly important. Ninety-nine percent rated creativity as particularly important for artistic professions. In addition, 97.9% of the test persons think that creativity is particularly important for the teaching profession. Bringing up the rear here are the managerial professions, with 61.1% (see Table 1).

Table 1. Creativity and profession.

Creativity is important in the following professions…	percent
Artistic professions	99.2%
Teaching	**97.7%**
Advertising industry	96.2%
Crafts	90.8%
Marketing	89.3%
Management	61.1%

At this point, we should also ask whether creativity should already be examined at elementary school age (six to ten years). The results show that the participants think creativity should in fact be reviewed earlier, at the latest in kindergarten (19.8% younger than three years, 45% aged 3 - 5 years). Twen-

ty-nine percent of the test persons think that creativity should be examined at the latest in elementary school and only 6.2% are of the opinion that this should only be started later.

So now that it has been clarified that the participants felt the creativity of even very young children should already be investigated, it is equally reasonable to look at the school subjects in which creativity is particularly important from their perspective (see Table 2). In their opinion, creativity is especially important for the subject of art. Immediately after this, music and science follow with 92.4%. Creativity appears to be considered least important for Mathematics (41.2%) and English (39.7%).

Table 2. Creativity and subjects.

Creativity is important in the following subjects in elementary school…	percent
Arts	100%
Music	92.4%
Science	**92.4%**
Sports	71%
German	58.8%
Religion	47.3%
Mathematics	41.2%
English	39.7%

For science education in elementary schools in Germany, it is particularly interesting to see whether there are differences in the individual subject perspectives. As Table 3 shows, the respondents see creativity as especially important for learning in the technological perspective and consider it least important for the historical perspective. A comparison of the mean values shows that the respondents assign significantly more relevance to creativity to the technological perspective than the historical ($t(131) = 4.253$, $p = .000$), geographical ($t(131) = 3.218$, $p = .002$), or social science perspectives ($t(131) = 2.516$, $p = .013$). All differences have a small effect size.

Table 3. Importance of creativity for different perspectives of science education in elementary school.

Creativity is especially important for learning in the…perspective.	*M*	*SD*
social science	2.83	.703
natural science	2.90	.666
historical	2.70	.741
geographical	2.79	.702
technological	3.01	.739

M = mean, *SD* = standard deviation, green = high mean

Complementary to the perspective in which children are expected to be particularly creative, there is of course also the question of the perspective in which creativity can be particularly promoted (Table 4). Here, too, the respondents are of the opinion that the technological perspective is particularly suitable for promoting creativity of students. The advantage is shown over the significance for historical (t (131) = 4.303, p = .000), geographical (t (131) = 2.622, p = .010) and social science perspectives (t (131) = 2.276, p = .019) with small effects.

Table 4. Promotion of creativity in different perspectives of science education in elementary school.

The creativity of the students can be promoted especially in the...perspective.	*M*	*SD*
social science	2.80	.706
natural science	2.90	.711
historical	2.66	.762
geographical	2.82	.677
technological	**2.98**	.718

M = mean, *SD* = standard deviation, **green** = high mean

Preservice teachers' perspective on the influence of different factors on the development of creativity and promotion of creativity in science education in elementary school

The mean values of individual items were also calculated (see Table 5). The main aim was to find out what the preservice teachers thought 1. *Has an influence on the development of creativity*, and 2. *Which measures to promote creativity* should be integrated into the classroom. Calculations for the formation of scales all showed that these items should be evaluated individually. A first finding is that both artistic (1) and craft (2) aptitudes are not particularly relevant for the development of creativity from the participants' point of view. If we add the result reported above we can say that, according to the participants, creativity is important for the artistic professions but conversely, artistic talent is not necessarily required for creativity.

In contrast, parents (3), teachers (4), the peer group (5), reading books (8), and playing board games (9) are considered to have a major influence on the development of creativity from the perspective of the respondents. According to them, television (6) has a very small influence.

In order to promote creativity in science education in elementary school, it is particularly important to allow the children to bring individual approaches (12) and to let them work as freely and without pressure as possible (13).

Table 5. Influence on creativity and creativity and promotion of creativity.

Number	Item text	*M*	*SD*
1. *Influence on creativity*			
1	Artistic talent is important for the development of creativity.	2.11	.82
2	Craftsmanship is important for the development of creativity.	2.11	.79
3	Parents have a great influence on the development of creativity.	3.25	.71
4	The teacher has a great influence on the development of creativity.	3.12	.69
5	The peer group has a great influence on the development of creativity.	3.11	.76
6	Television has a positive influence on the development of creativity.	2.11	.69
7	The Internet has a positive influence on the development of creativity.	2.40	.72
8	Reading has a positive influence on the development of creativity.	3.53	.52
9	Playing board games has a positive influence on creativity.	3.20	.67
2. *Promotion of creativity*			
10	In order to promote the creativity of students in science education in elementary school, the lessons must be opened up in terms of time.	2.95	.74
11	In order to promote creativity in science education in elementary school, the results of the students' work must be open.	2.95	.74
12	In order to promote creativity in science education in elementary school, individual approaches by the students must be possible.	3.74	.46
13	To promote creativity in science education in elementary school, students must be able to work freely and without pressure.	3.56	.58
14	In order to creative problem solving in science education in elementary school, a certain amount of subject knowledge must be available.	2.86	.81

M = mean, *SD* = standard deviation, green = high mean, red = low mean

Differences in teaching experience, state, gender and age

To analyze differences due to individual demographic variables, mean comparisons were calculated with grouping variables. Grouping was by teaching experience (yes $n = 53$, no $n = 78$), gender (male $n = 16$, female $n = 114$, diverse $n = 1$), state (Lower Saxony $n = 49$, North Rhine-Westphalia $n = 82$) and age (20 and younger $n = 59$, 21 and older $n = 72$). It should be noted that the group size varies.

Teaching experience

In particular, the view of possible teaching experience was meaningful here, as it can be assumed that students who already have teaching experience assess the benefits and promotion of creativity in the science education lessons differently from those without such experience. The grouping was done on the basis of the question of whether the students had already worked at a school. Contrary to expectations, no differences could be measured here.

Gender

The situation is different when it comes to gender differences. Here, differen-

tiation was made according to male and female, as the "diverse" group consisted of only one person.

A significant difference was found in opinions on when creativity should be examined (t (130) = −2.692, p = .008). The male respondents tended on average towards the end of kindergarten and the beginning of elementary school age (M = 2.75, SD = .931) and the female respondents were on average of the opinion that testing could begin at kindergarten age (M = 2.15, SD = .823). For better interpretation, here is the classification of the scale: 1 = younger than 3 years (before kindergarten), 2 = 3 - 5 years (kindergarten), 3 = 6 - 10 years (elementary school), 4 = 11 - 16 years (lower secondary school), 5 = 17 - 19 years (higher secondary school), 6 = older than 19 years (after school).

Furthermore, there was a significant difference in the estimated influence of parents on the development of creativity (t (130) = −2.741, p = .007). Here, the male students (M = 3.69, SD = .602) are more strongly of the opinion that parents have an influence on the development of creativity than the female students (M = 3.18, SD = .698).

Moreover, men (M = 3.25, SD = .775) are more likely than women (M = 2.81, SD = .808) to think that expertise is needed to solve problems creatively. This difference is also significant (t (130) = −2.064, p = .041).

State

Since students from two states (Lower Saxony and North Rhine-Westphalia) were surveyed, differences were also looked for here.

There are some differences. For example, respondents from Lower Saxony (M = 3.41, SD = .574) are more likely to think that playing board games has a positive influence on the development of creativity (t (131) = 2.831, p = .005) than those from North Rhine-Westphalia (M = 3.07, SD = .699). Conversely, respondents from North Rhine-Westphalia (M = 3.60, SD = .493) are more likely than those from Lower Saxony (M = 3.41, SD = .537) to think that reading has a positive influence on the development of creativity (t (131) = −2.057, p = .042).

Although all respondents are of the opinion that creativity should be encouraged in the science education lessons, the respondents from Lower Saxony (M = 3.71, SD = .456) are more strongly of this opinion than the respondents from North Rhine-Westphalia (M = 3.48, SD = .593), a difference which is also significant (t (131) = 2.421, p = .017). There are also differences within the perspectives. Respondents from Lower Saxony are more likely to think that creativity is important in the natural science (M = 3.08, SD = .672) and social science perspectives (M = 3.04, SD = .644) than respondents from North Rhine-Westphalia (natural science perspective M = 2.79, SD = .643, social science perspective: M = 2.71, SD = .711), which is also statistically significant (natural science perspective: (t (131) = 2.447, p = .016), social science perspective: (t (131) = 2.688, p = .008).

A similar picture emerges when we ask about perspectives in which creativity can be promoted. Respondents from Lower Saxony are more likely to think that creativity can be promoted in the natural science perspective (M = 3.14, SD = .677) and in the social science perspective (M = 2.96, SD = .676) than respondents from

North Rhine-Westphalia (natural science perspective: $M = 2.76$, $SD = .695$, social science perspective: $M = 2.71$, $SD = .711$), which is also statistically significant (natural science perspective: ($t(131) = 3.112$, $p = .002$), social science perspective: ($t(131) = 1.998$, $p = .048$).

Age

Overall, there was only one difference that can be attributed to age. The older participants ($M = 3.15$, $SD = .620$) on the whole are more likely than the younger ones ($M = 2.69$, $SD = .793$) to think that the outcome of the work needs to be open in order to encourage creativity ($t(131) = -3.707$, $p = .000$).

7. Discussion

The current study aimed to identify future science education teachers' views on the definition and importance of creativity for science education in elementary school and their opinions on the use, the benefits, and the promotion of creativity in science education in elementary school.

All in all, regarding the **first research question** the results show that preservice teachers preferred the definition by Bliersbach & Reiners (2017). In terms of content, then, it seems important to them that creativity encompass the four components *creative person*, *creative process*, *creative product*, and *creative environment*. This coincides with the theory and thus also with the findings of Bliersbach & Reiners (2017). However, it can be stated that the probands do not have a clear opinion on whether creativity is the same as divergent thinking. It can be concluded that this result is due to teachers perceiving students who have other ways and other approaches to thinking, and thus who ultimately think divergently, as being creative.

In answer to the **second research question**, the preservice teachers attach great importance to creativity for teaching and school education in general, but especially for the teaching of science in elementary school. A very interesting result is that 97.9% of the respondents think that creativity is particularly important for the teaching profession. They think that children's creativity should be studied at a very early age. In addition, they see the possibility of promoting the creativity of elementary school children especially in the subjects of art, music and science. In particular, they believe that learning content from the technological and natural science perspectives requires a great deal of creativity, and that content from these two perspectives is particularly suitable for promoting creativity. A very surprising finding is that from the point of view of the respondents, neither artistic nor craft aptitudes are rated as particularly relevant for the development of creativity. In contrast, all other possible factors influencing the development of creativity listed in the questionnaire were emphasized. In addition, in their opinion, television has only a very small influence (**research question three**).

In summary, it can be said that the preservice teachers surveyed consider creativity to be important for learning in science at elementary school. They also

see that creativity is important not only for learning at school, but has a high value in later professional life.

Overall, the findings show that professional experience has no influence on opinions about creativity in science teaching in elementary school, which seems unexpected. Possibly teachers who have already completed their studies and have several years of professional experience would arrive at different answers, as their expertise and experience are then more clearly differentiated from those of the preservice teachers.

Larger differences are shown by gender. Overall, the male respondents are somewhat more doubtful and tend to see external influences as having more impact on the development of children's creativity.

The differences that result from the affiliation to the state are interesting. Students from the state of Lower Saxony have a somewhat more positive attitude towards the topic of creativity in science education in elementary school, although it must be said that students from North Rhine-Westphalia also attach great relevance to the topic. It is possible that the students from Lower Saxony are already familiar with the topic of creativity in education. There are two other working groups at their university that are researching or have researched the topic (chemistry didactics and empirical teaching and learning research).

The age of the respondents clarifies little difference overall and therefore seems to play only a subordinate role.

The theoretical framework and the data indicate that creativity is not only a personality trait, but from the perspective of pedagogy should rather be seen as a competence and therefore also relevant to the factual instruction of the elementary school. Two perspectives should be opened up here: the creative competence of the students, and the competence of teachers to promote creativity and also to be creative themselves. With regard to the four components of creativity identified in the theoretical framework (Bliersbach & Reiners, 2017; Semmler & Pietzner, 2018), teachers must be able to design creative environments, initiate creative processes, and be open to and provide space for creative products. The teachers' own competence must therefore also be considered. So teachers should be able to open their classroom for creative processes, for example, design them stimulating and inspiring, they should be accessible and open to their students' unconventional approaches as long as they lead to the desired result, and they should give them space to do so, in time and place wherever possible.

With all the things mentioned, the next question to be answered would be the question of how children's creativity could be influenced. What skills and professional competences do teachers need to foster creative processes or environments? Can these skills be trained? How would an environment look that promotes creativity or is even creative itself? Above all, and most important for implementing creativity in the classroom: what are teachers' attitudes to creativity?

To move forward and investigate creativity in the educational context, a valid test instrument is needed for measuring the creative competence of elementary

school students in a holistic way, including divergent and convergent thinking. There are some tools that could serve as a basis, for example the Torrance Test of Creative Thinking (TTCT), which could be adapted (Torrance, 1966). In addition, a test instrument could be developed to measure creative self-concept or expectation of self-efficacy in creativity. Previous studies have found that some of these personality traits can be considered predictors of creativity (e.g., Barron & Harrington, 1981). When these test instruments have been developed, methods to promote the creativity of elementary school students can be generated. Here, the wider scope offered by informal learning is particularly important, picking up the findings of Semmler & Pietzner (2018) whose study found that chemistry teachers particularly use creativity in settings outside the regular classroom. As mentioned, the student teachers in our study see possibilities to promote creativity as well as the necessity to be open to creative approaches, especially in the technological and natural science perspectives. Therefore, the focus should be particularly on these two perspectives in the future. It would of course also be interesting to get to the bottom of why preservice teachers consider these two perspectives in particular to be more suitable than others.

In the survey, the future teachers already showed a high degree of willingness to incorporate creativity into their teaching. Furthermore, in their questionnaire responses they themselves highlighted that creativity is important for the teaching profession. The question remains of why creativity is not a routine part of teaching. More subjectively, conversations and teaching sessions in university seminars also show that student teachers are open to the topic. A next step would therefore be to see how teachers assess their own creativity and their ability to design creative learning environments and learning arrangements that promote or enable creativity. In their article, Hadzigeorgiou et al. (2012) give six points for what should be considered to promote creativity in the science classroom, which could be taught to teachers to include creativity in science education:

(1) Fostering creativity requires a strong conceptual framework.
(2) Creativity in science education is about divergent/imaginative thinking.
(3) Images and visualization should have a central role in science curricula and in the classroom.
(4) The idea of "aesthetic experience" should be given special consideration.
(5) Thinking about future and distant events, possibilities and people is something that can be incorporated into classroom.
(6) The social nature of science indicates activities that provide students with opportunities to interact in social surroundings while thinking divergently and in a visionary way.

As a complement to these points, these authors note that the best thing a science teacher can do is to create an environment that increases the opportunities for creativity to flourish. This, in turn, supports the view already presented here, that the creative environment can be created by teachers. For practical im-

plementation it is advised that opportunities for imaginative/divergent thinking and that lead to aesthetic experiences in science class. The authors make concrete suggestions, such as creative problem solving or creative writing, which can be integrated into the science classroom. It should also be noted here that a certain amount of content knowledge is necessary for creative approaches (Boden, 2001). Following the view of the probands, interventions could be designed for natural science or technological perspective, for example, which take up and implement precisely this.

Based on this, concepts for promoting precisely this professional competence for teachers can be developed and should be evaluated in future studies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Ahmadi, N., Peter, L., Lubart, T., & Besançon, M. (2019). School Environments: Friend or Foe for Creativity Education and Research? In C. A. Mullen (Ed.), *Creativity under Duress in Education? Resistive Theories, Practices, and Actions* (pp. 255-266). Springer International Publishing. https://doi.org/10.1007/978-3-319-90272-2_14

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes, 50,* 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Barbot, B., & Heuser, B. (2017). Creativity and Identity Formation in Adolescence: A Developmental Perspective. In M. Karwowski, & J. C. Kaufman (Eds.), *The Creative Self* (pp. 87-98). Academic Press. https://doi.org/10.1016/B978-0-12-809790-8.00005-4

Barron, F., & Harrington, D. M. (1981). Creativity, Intelligence, and Personality. *Annual Review of Psychology, 32,* 439-476. https://doi.org/10.1146/annurev.ps.32.020181.002255

Beghetto, R. A. (2010). Creativity in the Classroom. In J. C. Kaufman, & R. J. Sternberg (Eds.), *The Cambridge Handbook of Creativity* (pp. 447-464). Cambridge University Press. https://doi.org/10.1017/CBO9780511763205.027

Beghetto, R. A., & Karwowski, M. (2018). Educational Consequences of Creativity: A Creative Learning Perspective. *Creativity. Theories, Research, Applications, 5,* 146-154. https://doi.org/10.1515/ctra-2018-0011

Bliersbach, M., & Reiners, C. S. (2017). Kreativität und Chemie? *Chemie in unserer Zeit, 51,* 324-331. https://doi.org/10.1515/ctra-2018-0011https://doi.org/10.1515/ctra-2018-0011https://doi.org/10.1515/ctra-2018-0011https://doi.org/10.1515/ctra-2018-0011v

Boden, M. A. (2001). Creativity and Knowledge. In A. Craft, B. Jeffrey, & M. Leibling (Eds.), *Creativity in Education* (pp. 95-102). Continuum.

Bolhuis, S., & Voeten, M. J. M. (2004). Teachers' Conceptions of Student Learning and Own Learning. *Teachers and Teaching, 10,* 77-98. https://doi.org/10.1080/1354060032000017093 6

Brophy, D. R. (2006). A Comparison of Individual and Group Efforts to Creatively Solve Contrasting Types of Problems. *Creativity Research Journal, 18,* 293-315. https://doi.org/10.1207/s15326934crj1803_6

Cropley, A. (2006). In Praise of Convergent Thinking. *Creativity Research Journal, 18,* 391-404. https://doi.org/10.1207/s15326934crj1803_13

Garaigordobil, M. (2006). Intervention in Creativity with Children Aged 10 and 11 Years: Impact of a Play Program on Verbal and Graphic-Figural Creativity. *Creativity Research Journal, 18,* 329-345. https://doi.org/10.1207/s15326934crj1803_8

Gardner, H. (2008). *Five Minds for the Future*. Harvard Business School Press. https://doi.org/10.1086/591814

Gesellschaft für Didaktik des Sachunterrichts (2013). *Perspektivrahmen Sachunterricht (Vollständig überarb. und erw. Ausg)*. Klinkhardt.

Glăveanu, V. P. (2018). Creativity in and for Society. *Creativity. Theories, Research, Applications, 5,* 155-158. https://doi.org/10.1515/ctra-2018-0012

Guilford, J. P. (1967). Creativity: Yesterday, Today, and Tomorrow. *The Journal of Creative Behavior, 1,* 3-14. https://doi.org/10.1002/j.2162-6057.1967.tb00002.x

Hadzigeorgiou, Y., Fokialis, P., & Kabouropoulou, M. (2012). Thinking about Creativity in Science Education. *Creative Education, 3,* 603-611. https://doi.org/10.4236/ce.2012.35089

Holzapfel, M. A. (2018). *Fachspezifischer Humor als Methode in der Gesundheitsbildung im Übergang von der Primarstufe zur Sekundarstufe I*. Logos Verlag.

Kim, K. H., & Chae, N. (2019). Recapturing American Innovation through Education: The Creativity Challenge for Schools. In C. A. Mullen (Ed.), *Creativity under Duress in Education? Resistive Theories, Practices, and Actions* (pp. 215-233). Springer International Publishing. https://doi.org/10.1007/978-3-319-90272-2_12

Koballa, T. R. (1988). Attitude and Related Concepts in Science Education. *Science Education, 72,* 115-126. https://doi.org/10.1002/sce.3730720202

Liao, C. (2016). From Interdisciplinary to Transdisciplinary: An Arts-Integrated Approach to STEAM Education. *Art Education, 69,* 44-49. https://doi.org/10.1080/00043125.2016.1224873

Mackinnon, D. W. (1962). The Nature and Nurture of Creative Talent. *American Psychologist, 17,* 484-495. https://doi.org/10.1037/h0046541

Nakano, T. de C., & Wechsler, S. M. (2018). Creativity and Innovation: Skills for the 21st Century. *Estudos de Psicologia, 35,* 237-246. https://doi.org/10.1590/1982-02752018000300002

Niedersächsisches Kultusministerium (2017). *Kerncurriculum für die Grundschule Schuljahrgänge 1-4 Sachunterricht*. https://docplayer.org/52628076-Kerncurriculum-fuer-die-grundschule-schuljahrgaenge-1-4-sachunterricht.html

Prenzel, M., & Deutsches PISA-Konsortium (2004). *PISA 2003: Der Bildungsstand der Jugendlichen in Deutschland: Ergebnisse des zweiten internationalen Vergleichs.* Waxmann.

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

Runco, M. A. (2006). Introduction to the Special Issue: Divergent Thinking. *Creativity Research Journal, 18,* 249-250. https://doi.org/10.1207/s15326934crj1803_1

Schmidt, A. L. (2011). Creativity in Science: Tensions between Perception and Practice. *Creative Education, 2,* 435-445. https://doi.org/10.4236/ce.2011.25063

Semmler, L., & Pietzner, V. (2018). Auffassungen von Chemielehrkräften zur Kreativität im Chemieunterricht. In C. Maurer (Ed.), *Qualitätsvoller Chemie-und Physikunterr-*

icht-normative und empirische Dimensionen (Bd. 37, pp. 404-407). Gesellschaft für Didaktik der Chemie und Physik.

Spencer, E., & Lucas, B. (2018). *Understanding the Role of Creative Self-Efficacy in Youth Social Action: A Literature Review.*

Sternberg, R. J., & Lubart, T. I. (1998). The Concept of Creativity: Prospects and Paradigms. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 3-15). Cambridge University Press. https://doi.org/10.1017/CBO9780511807916.003

Torrance, E. P. (1966). *Torrance Tests of Creative Thinking: Norms-Technical Manual: Verbal Tests, Forms A and B: Figural Tests, Forms A and B* (Research Edition). Personal Press, Inc.

Yang, M., & Yu, C. (2021). A Review of Teachers' Sentiments and Attitudes in Inclusive Education in China. *Frontiers in Psychology, 12,* Article ID: 760115. https://doi.org/10.3389/fpsyg.2021.760115

Appendix

Table A1. Items of the scale: relevance of creativity to school.

Number	Item text
1	Creativity is important for a successful school career.
2	Creativity is important for a successful career.
3	School should contribute to the promotion of creativity.
4	In the (regular) school there should be enough space/freedom/openness for creativity.