Chapter 5
Creativity and Motivation in Early Years Science as it Relates to Cognitive Styles

Nina Skorsetz

5.1 Introduction

In the science education research community in Germany, there is little discussion about the connection between creativity and science in kindergarten-age children, even though fostering science at early ages has been a national goal for roughly 10 years. Their government and education foundations encourage early science education in kindergartens and primary schools. In Germany, children attend kindergarten from the ages of three to six before they go to primary school (year one). The idea is that fostering the motivation to do science at an early age establishes a foundation that will be expanded upon in school and result in interest in working in that career field. Science education research in Germany has mostly focused on teacher professionalism and their self-efficacy as well as students' motivation and learning inquiry (e.g. Kunter et al., 2013).

Baron-Cohen's (2009) Empathising-Systemising (E-S) theory for capturing individual cognitive styles is relatively new to research on motivation in science education. The theory has its origins in autism research and describes two dimensions, the Empathising and Systemising Quotient (EQ and SQ) values which, can be scored using a standardised questionnaire (Billington et al., 2007). People with high SQ scores are 'systemisers' and tend to look for the systems behind things. 'Empathisers' instead orientate themselves to other people's feelings. The theory has been used in other empirical studies in the field of science education. However, Zeyer et al. (2012) distance themselves from the question of the neurological causes that were criticised in Baron-Cohen's (2009) theory. They use the ratio of EQ and SQ (the so-called 'brain type') to explain children's motivation in scientific contexts and

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found that adult systemisers are more motivated to do science than stronger empathisers (Zeyer et al., 2013). Similar results have been shown for young children (Skorsetz & Welzel-Breuer, 2018; Skorsetz, 2019). The motivation of five and six-year-old preschool children was tested in two different pedagogical science learning contexts: structured-instructional and play-based. Children with a high systematic cognitive style were found to be motivated to do science independent of the type of learning setting. Connections between children's motivation and the possibility of being creative in scientific learning settings have not been found, although theories often describe motivation as a condition for creativity (e.g. Steele et al., 2017).

In order to close that gap, this chapter first examines scholarship on the relationship between motivation and creativity in the field of early year's science, specifically focused on scientific learning settings in day-care centres. Next, it describes the reanalysis of our initial data; we categorise the children's actions and statements in order to identify whether the design of the learning environments influences the amount and kind of creative actions. Data were correlated with each other to draw conclusions about the connection between the children's motivation and their "brain type". Finally, we interpret the results and discuss the outlook for further studies.

5.2 Creativity and the Motivation to Do Science

5.2.1 Creativity and Motivation in Science Learning Settings

Motivation is a complex concept of several constructs (intrinsic and extrinsic motivation, goal orientation, self-determination, self-efficacy and fearfulness). According to Glynn and Koballa Jr. (2006), motivation is an internal state that evokes, guides and sustains behaviour such that it cannot be observed directly but only via behaviour (Barth, 2010).

Scientific literature describes children as innately motivated learners. They are curious and discover their environment through inquiry (Lück, 2012; Patrick & Mantzicopoulos, 2015; Oppermann et al., 2017). According to Kahlert (2016), these assumptions describe children as basically willing to learn, but the motivation can differ from one domain to another. According to Patrick and Mantzicopoulos (2015), it seems fundamentally important for motivation in elementary science that the children experience various natural phenomena, scientific ways of thinking and working in the form of productive and systematic learning situations.

In German day-care centres, science education is often provided in the form of scientific learning settings (Kauertz & Gierl, 2014). These settings are structured similarly in terms of time and space, in which preschool teachers guide the children towards a specific learning goal (Einsiedler, 2009; Vosniadou et al., 2001). Settings often start with the collective observation of a natural phenomenon (Wagenschein et al., 1997).

Independent exploration in unstructured settings is seen as important for children's learning processes (Vosniadou et al., 2001). Hammond et al. (2013, p. 294) confirm these assumptions in an international study: "play-based programs tend to more effectively promote creativity and academic achievement than direct instruction programs".

On the contrary, Windt (2011) shows that openly structured learning arrangements promote less learning growth than guided experimentation situations. Her openly structured learning situation seems more like a materials offer than a learning environment, as the researchers failed to detect whether the children were aware of the learning goal.

Different German educational perspectives inform the designs of learning environments. In one, the child is seen as a competent individual who deals with their environment socially and constructively. The learning process is organised in a series of structured experiments systematically built on one another (Fthenakis, 2009; Lück, 2012). The other is based on a 'self-education approach'. Pedagogical specialists in kindergartens are seen as competent partners, who support the child's needs in their individual learning processes, in which the child is also an active participant. Early scientific education has great potential for self-education, if it is designed to mimic everyday life, so that children explore the direct environment in a play-based setting (Schäfer, 2009; Welzel, 2006).

The German-Swiss research project "Professionalisation of pedagogical specialists in kindergartens" (PRIMEL) examines the influence that the day-care centre as well as the room and material equipment have on scientific learning processes (Kauertz & Gierl, 2014). They identify two forms of learning environments in Germany—either an experiment is carried out closely or the children philosophise about the causes, followed by an instructional guided experiment. They mention a different approach in Swiss kindergartens, which the authors call 'experience-oriented' (ibid., p. 178). This often includes stories, role playing or figurines, such as hand puppets. But this project does not record the effects on motivational processes or the influence of learning environments on children's motivation or creativity.

Steffensky et al. (2012) compare these approaches to identify differences in the knowledge gain. In a pre-post design, 245 children in their final year of kindergarten took part in various learning environments. The first learning environment included experiments on the characteristics of water, which were discussed with the children before and after the experiment. The second type of learning environment simulated an everyday situation that was introduced by a framework story and then encouraged the children to playfully use their imaginations. The children's observations and ideas were discussed during the conversation. Finally, in the third type of setting, the two procedures were combined by discussing an everyday situation and then carrying out an experiment on a similar phenomenon. Results showed that only the third type of learning environment increased the children's knowledge. The study did not identify the setting in which children are most motivated nor how the results relate to the design of the learning arrangement and the possibility of being creative in it.

Creativity is often defined as the production of novel and useful ideas (Steele et al., 2017). In school science class, students learn knowledge and comprehend processes that are new to them, but not new for science and society (Newton & Newton, 2010, p. 112). Scientific learning settings in kindergartens proceed similarly in a specific social setting, where the children often 're-experience' an existing research process. If, in this process, the children understand a phenomenon, produce a plan of action, generate alternative interpretation ideas or solve problems that are new to them, it belongs to the creative process frequently referred to as "divergent thinking" (Steele et al., 2017).

Therefore, an expanded definition of creativity in science education is necessary. Newton and Newton (2010) interviewed 16 pre-service teachers in order to capture their definition of creativity in elementary science. In their statements, the researchers identify five categories, each with varying amounts of sub-categories. Four of these categories describe students' creativity-related actions and statements during science lessons. The fifth category is about creative teaching strategies.

Category 1a is defined as "students construct tentative descriptions". Here, creativity is defined as the *"making of predictions"* (ibid., p. 115). Category 1b is "students experience the world and generate explanations". Here, creativity is described as "*construction of a plausible explanation*". The second category is about using scientific information for imagination. The third category is divided into three sub-categories "generate tests/design process/generate possible solutions to a problem". Here, creativity is described as "*generate a test of their predictions and explanations to solve a problem*". The fourth category is non-cognitive—"students develop positive feelings about science during lessons: the wow-factor". Here, creativity is more about *"atmosphere and engagement"*.

The last category shows that creativity is about more than cognitive processes and actions in scientific settings. In scientific processes, the affective part of creativity, such as emotions and motivation, are also important. From their results Newton and Newton (2010, p. 119) conclude that some teachers have a very narrow definition of children doing science, e.g. making models according to instructions. A useful and wider definition of creativity in early year's science could be: "the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context" (Hammond et al., 2013, p. 292).

In conclusion, the question arises how motivation and creativity are related in early year's science education. Interest is one of the most important aspects of intrinsic learning motivation and shown in the time that pupils spend on a task (Artelt, 2005, p. 233). Creativity on the other hand seems to be "preceded by profound interest in an engagement with a task" (Steele et al., 2017, p. 100). Thus, engaged children have the possibility to act creatively in the way defined above within a science learning setting.

5.2.2 *Creativity, Motivation and the Empathising-Systemising Theory*

One critically discussed way to measure children's motivation to do science is to capture their cognitive style. Beginning in 1999, the British psychologist Simon Baron-Cohen developed his E-S theory while searching for an explanation for the development of autism. The theory assumes that children who are prenatally exposed to increased levels of testosterone tend to be more interested in systems and structures than in people and their feelings. Baron-Cohen (2009) concludes that people's brains can be assigned to two dimensions, the EQ and SQ values, which can be scored using a standardised questionnaire. People with high SQ scores are called 'systemisers' and tend to look for the systems behind things. Systemisers like factual texts as well as collecting and sorting things. They prefer group activities over close friendships and often create order through tables or (ranking) lists. On the other hand 'empathisers' orientate themselves to other's feelings and like fictional stories, two-way relationships and animals, and they are often helpful. For a more detailed overview of the typical characteristics, see Skorsetz (2019). Baron-Cohen's research group also finds that the proportions of a person's EQ-SQ dimensions are more predictive than their gender of whether they choose to study science or the humanities (Billington et al., 2007).

Further empirical studies distance themselves from the prenatal testosterone exposure hypothesis and instead use the described characteristics in people's behaviour for research on the individual motivation to do science. For example, adolescent systemisers prefer to study science rather than those with high empathiser scores (Zeyer et al., 2012). Unlike adolescents, young children do not have to decide between science and the humanities. Therefore, our previous study examines the motivation with which children study natural phenomena. Confirming E-S theory, which describes the dimension composition as innate (Baron-Cohen, 2009), results show that even young children demonstrate individual EQ and SQ values (Skorsetz & Welzel-Breuer, 2018; Skorsetz, 2019). According to Zeyer et al. (2013), who conclude that empathisers may need different approaches to scientific learning, the results were correlated with data on the children's motivation in two different learning environments for the same natural phenomenon (here 'absorbency'). In a design-based research approach (The Design Based Research Collective, 2003) the first rather *structured-instructional* learning environment was designed according to Lück's (2012) instructional approach, which assumes that the child co-constructs new knowledge with others, e.g. in an experiment structured by instructions with subsequent interpretation. In this learning approach the children compare the water absorbency features of cotton, aluminium foil and superabsorbent crystals (from a baby diaper). After the experimental phase, an interpretation phase is intended in order to find explanations and to increase the knowledge.

To motivate empathising children for science, Zeyer et al. (2013) suggest re-organising the lessons or learning environments to include first-person perspectives and context-based approaches. So, the second environment was structured to be more *play-based* (Schäfer, 2009). In this learning environment, the materials are available for free exploration and a hand puppet verbalises the problem to solve in a framed story (the floor of his cave is wet). The preschool teacher still structures the setting, however. Additional materials, such as kitchen paper, cotton and fleece socks as well as dishcloths, are provided and can also be tested for their absorbency.

The study tested 99 children in two cohorts. They attended one of the two learning environments described above within small groups and were videotaped. The recordings from both environments were analysed for activities that indicate their motivation as "time on task" (Artelt, 2005) in the form of the duration and frequency of their viewing focus (Skorsetz & Welzel-Breuer, 2018; Skorsetz, 2019).

According to E-S theory, correlated data shows that a high SQ value means that these children are motivated regardless of the design of the learning environment. Surprisingly, children with a high EQ score look at material not currently being used in the exploratory, play-based learning environment for significantly longer and seem distracted although this setting was expected to maintain the 'empathisers' motivation by the fictional story.

In comparing the two environments, the motivation-related activities of all children were examined independent of the EQ and SQ values. All children were more distracted in the instructional learning environment than in the more play-based environment, as well as more focused and in contact with the materials in the latter environment. This could be interpreted as all children are less motivated in more structured environments (Skorsetz & Welzel-Breuer, 2018; Skorsetz, 2019). If motivation enhances creativity (e.g. Steele et al., 2017), the question arises as to whether the children in the more open and play-based settings are also more creative and whether there are correlations with their brain type.

5.3 The Study

5.3.1 Goal and Research Question

E-S theory does not explicitly describe the relationship between creativity and motivation, but it may provide an explanation if we look at the creative possibilities in the inquiry process in the different learning environments and find coherences between cognitive style (or 'brain type') and the amount or kind of creative actions shown by the children.

Hence, we pose the following research question:

> To what extent are creative actions and statements related to preschool children's EQ and SQ scores in slightly different structured learning environments for early science education?

5.4 Method

To answer the research question, we reanalysed the *descriptions of action* for every setting with a transcript of the children's verbal and nonverbal (inter)actions (Skorsetz & Welzel-Breuer, 2018; Skorsetz, 2019). In the original study 29 science learning settings with 99 different five to six-year old children were recorded.

We created a category system based on the definitions of creativity that Newton and Newton (2010) compiled in their interviews with early education teachers. Following the qualitative content analysis according to Mayring (2015), two independent coders categorised every action or statement, because as external agents, we are unable to decide whether one child's action or statement is new for that child.

In the first instructional learning environment, they analysed the interpretation phase that followed the exploration phase and that was introduced by the preschool teacher asking the question "Which object do you think will best soak up the water?" In the second learning environment, they analysed the exploration phase that started after the story and lasted until the end because there is no specified interpretation phase.

When children's actions were coded differently, the coders discussed their coding in an argument-based validation process (Bortz & Döring, 2006) until they reached a consensus. During that process codes were expanded inductively (Table 5.1) so that the following broad categories emerged. No example of the second category "use of scientific information for imagination" from Newton and Newton (2010) was found in the data.

Finally, the codes were grouped according to category, child and setting. We used two-sample t-tests in order to identify significant differences between values.

Table 5.1 Categories of children's creativity in scientific learning settings

I.		**Examples**
1. Predictions	1. Spontaneously, verbally, but also using onomatopoeic expressions	"The water won't go in there."
	2. Using technical terms	"That probably sucks the best."
2. Explanations	1. Spontaneous, verbal, also (short) answers	"That does too."
	2. Using technical terms	"Sucks in!"
	3. Nonverbal	Nodding
	4. Onomatopoeic	Slurping sound
II.		
1. Planning statements	1. On the experimentation process in general	"Then I'll just take the socks, if only those left."
	2. On the experimental process related to the phenomenon of absorbency	"I try that …because it works for babies."
III.		
1. Judging/emotional statements	1. Positive	"Wow, amazing…"
	2. Negative	"Yuck, smells like..."

Finally, we correlated the questionnaire results, i.e. the children's EQ and SQ values, with the video analysis (Spearman, two-tailed) in order to identify possible correlations.

5.5 Results

In the descriptions of actions of the two learning environments, different numbers of codes could be assigned for positions in which the children were creative. In the first, more structured learning environment, a total of 639 codes were assigned to 51 children, resulting in an average of 12.43 creative actions per child. Two children showed no creative behaviour in this learning environment.

In the second, more play-based learning environment, every child showed at least one creative act. A total of 741 codes were assigned to 47 children, resulting in a mean of 15.77. The subsequent t-test with independent samples showed that the two mean values (all creativity categories cumulated) do not differ significantly. Some mean values of the individual categories reveal significant differences in some cases as shown in Table 5.2.

In the instructive learning environment significantly more statements use technical terms (I.2.2), but more spontaneous assumptions were found in the play-based learning environment (I.1.1), where significantly more planning statements (II.1.2) and positive emotions (III.1.1) were expressed as well.

In the next step we correlated creative actions and the EQ and SQ values of the children to determine the degree to which they are related. There was no significant correlation based on all codes cumulated between creativity and EQ/SQ values—neither with regard to the separate learning environments nor overall. The results also show no connection between the children's gender and their creative actions.

Significant correlations (see Table 5.3) between the individual categories and the EQ or SQ values for the first, more instructive learning environment reveal that the higher a child's EQ score, the more non-verbal explanatory statements they made. This connection is not evident for the more play-based learning environment. However, another significant correlation was found for this environment: The higher a child's SQ score, the more explanatory statements they used.

Table 5.2 Significant categories t-test (mean values)

	Structured-instructional setting	Play-based setting
I.1.1 Predictions	0.94	2.40
I.2.2 Explanations	1.31	0.49
II.1.2 Planning statements	0.37	1.43
III.1.1 Judging/emotional statements	0.55	1.21

Note: Two-sample *t*-test; *p < .0.05

Table 5.3 Significant correlations

	Structured-instructional setting	Play-based setting
Code	I.2.3 Explanations	I.2.1 Explanations
EQ	0.034*	0.021
SQ	0.184	0.041*

Note: p > .05* (Spearman-Rho, two-tailed)

5.6 Discussion and Conclusion

Re-analysing the data served to find coherences between the children's cognitive style and their creative actions in different organised settings. Results from the previous study show that according to Billington et al. (2007) and Zeyer et al. (2013) children with a high SQ score demonstrated their motivation to deal with natural phenomenon in both learning environments, i.e. regardless of the didactic-methodical arrangement. No such relationship was found for children with a high EQ score.

In order to answer the research question, the new results concerning creative actions and statements revealed that systemisers manage to proceed more reasonably and use technical terms in the more play-based learning environment. On the other hand, children with a high EQ score, i.e. empathisers, are able to express themselves creatively in the more instructive structured learning environment, but only in actions such as pointing to materials and answering questions non-verbally.

Following the idea that motivation enhances creativity (Steele et al., 2017), results from the previous study on children's motivation in the two learning environments show that *every* child was more motivated in the more play-based structured learning environment than in the instructive environment (Skorsetz, 2019). Re-analysing the data with a focus on creative statements and actions, we preliminarily conclude that both learning environments enable roughly the same amount of creativity, since the mean values of codes do not differ significantly. Nevertheless, the individual categories show that a different didactic-methodical structure promotes different creativity dimensions. The rather instructive learning environment leads the children to use more technical terms. In the more play-based learning environment, the children express themselves more spontaneously and emotionally.

These results confirm Patrick and Mantzicopoulos' (2015) idea that, for motivation, children should experience various natural phenomena in productive and systematic learning situations, in addition to Hammond's (2013) notion that play-based programmes foster creativity.

Based on these results, we tentatively conclude that a motivating and creativity-promoting scientific setting should contain a real problem and inquiry possibilities with the phenomenon or the materials followed by an organised and structured interpretation phase where the preschool teacher and the children work together to explain or describe the phenomenon. Our study indeed has some limitations: in retrospect, the learning settings did not differ significantly rather than being truly contrasting, and only a small portion of the settings were analysed; the determination of the brain type could be inaccurate because parents filled out the questionnaires for their children.

Therefore, the connection between motivation and creativity in learning environments in early science education should be examined further, since the didactic and methodical designs likely influence the development of possible creative actions—more cognitive or more emotional, spontaneous actions. The references to connections between the cognitive style ('brain type') and the use of creative possibilities in learning environments on natural phenomena should be further explored, as it will likely yield further fruitful indications for a motivated and creative learning process.

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