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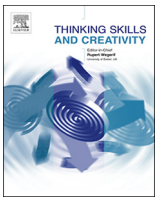

# Creativity in interaction: the dynamics of teacher-student interactions during a musical composition task

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ABSTRACT

In music and arts education, a central question is how teachers can best facilitate the creativity of their students, Most research on primary school students' creativity, however, focuses on creativity at the level of the person or product rather than at the level of the creative process. Precisely this knowledge on how creativity emerges in interaction between teacher and student (s) is needed to answer this question. Therefore, we combined detailed quantitative and qualitative analyses of teacher and student actions and reactions to understand emergent creativity during a musical composition task. Five music teacher – student dyads participated in this study. Student turns were coded in terms of levels of novelty and appropriateness while teacher turns were labeled as convergent (aimed at instructing, providing information and evaluation) divergent (aimed at idea generation) or neutral. We found that the levels of novelty and appropriateness of student turns had highly skewed distributions, with high levels of novelty and low levels of appropriateness being especially rare. With sequential analyses, we found for all five dyads that convergent turns often lead immediately to student turns with no novelty and rarely to highly novel turns. However, we saw no immediate relationship between divergent turns and student levels of novelty. In qualitative analyses of longer interactional patterns, we saw how novel ideas can emerge from interactions where the teacher alternates between convergent and divergent behavior, but also how a teacher and student can become 'stuck' in exchanges with no novelty and repeated convergent turns.

## 1. Introduction

How can teachers facilitate the creativity of their students? Researchers have adopted either one of two approaches to answer this question. One could say that the first approach is summative and looks at creativity as *an outcome* of education, the second is formative and aims at understanding creativity *as part of* education. In line with the first approach, one could implement a classroom intervention which is based on theoretical principles of creativity, and administer pre- and post-tests on well-known measures of creativity, such as divergent thinking tasks. The results are analyzed statistically to see whether there is a significant increase of average creativity scores over time. Preferably, this increase is compared to a change scores in a control group (e.g. Cheng, Wang, Liu, & Chen, 2010; Ju Lee, Bain, & McCallum, 2007). In the second approach, creativity is often analyzed qualitatively as it occurs through social interactions in educational settings where students and teachers work (together) on creative tasks, such as in intra- or extracurricular arts, dance or STEM classes. (e.g. Burnard & Younker, 2008; Griffiths & Woolf, 2009; Vass, Littleton, Miell, & Jones,

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2008). Behind these two approaches lie two sets of assumptions about what creativity *is.* Within the first approach, creativity is seen as a latent, individual trait that can be 'captured' with creative thinking tasks and that can be either positively or negatively influenced by the environment. Within the second approach, creativity is seen as embedded in, and emergent from interactions between student(s) and teacher (Kupers, Lehmann-Wermser, McPherson, & van Geert, 2019; Glaveanu et al., 2019).

Both approaches have advantages and disadvantages. The advantage of quantifying creativity as an outcome measure is that one can get a general idea of whether an intervention meets its goals of improving students' general creative thinking skills. When comparable outcome measures are being used, this also facilitates comparison between different educational interventions. A disadvantage of this type of research, however, is that although we get an idea of whether an intervention works, we do not get any inside into *how* it works. What happens in the classroom, in interaction between student and environment, remains elusive.

The advantage of a qualitative, more process-oriented approach is that rich, thick data is gathered that gives us a thorough understanding of how creativity emerges through interactions between teacher, student, and the creative tasks that are specific for a particular context. Based on these qualitative analyses, sometimes general rules are deduced, such as general teacher strategies that are important when teaching for creativity. However, most qualitative findings remain, to an extent, context-dependent.

In a recent systematic review on empirical studies of children's creativity (Kupers et al., 2019), it was found that the vast majority of research on children's creativity (80 %) conceptualizes creativity a latent characteristic of a person or product.. For instance, scores on a creativity test are related statistically to other traits such as IQ (Jaarsveld, Lachmann, Hamel, & Leeuwen, 2010; Kao, 2016; Markovits & Brunet, 2012) or gender (Cheung & Lau, 2010; Ju, Duan, & You, 2014; Oral, Kaufman, & Agars, 2007). Only 20 % of the literature looks at creativity on the micro level, that is, creativity on the level of the creative process (e.g. (Burnard & Younker, 2008; Gajda, Beghetto, & Karwowski, 2017).

The aim of the current study is to address this gap in the literature and combine quantitative and qualitative analyses of micro-level teacher-student interactions to enhance our understanding of creativity as inherently social, and in the context of education, as embodied and embedded within teacher-student interactions. The current study is the first to use our previously developed Microdevelopmental Creativity Measure (Kupers et al., 2018) which can be used to quantify interactional data, and apply it to empirical cases.

### *1.1. A sociocultural approach to creativity*

What does it mean when we say that creativity is inherently social? Although there is an abundance of research looking at the relation between individual creativity and environmental variables (such as socio-economic status etc.), the environment is often seen as an outside force impacting individual creativity. The well-known systems model of creativity (Csikszentmihalyi, 1999, 1988) instead describes the environment as *an intrinsic part of* the creative process. Creativity emerges in reciprocal interaction between the person and the (proximal and distal) environment. On the one hand, the person shapes the direct environment (the field in the case of professional creativity) by contributing creative (sub)products. The field also acts as a gatekeeper, selecting creative ideas or (sub) products that are 'kept' on the long term. The field in its turn is nested within the culture. The sociocultural approach has gained momentum in the field of creativity research (Glăveanu, 2010; Glaveanu et al., 2019; Sawyer, 2012). Next to the social environment, theoretical models in this tradition have also included the material environment (in education: the task on which children work or the material with which they work). Tasks or materials provide certain affordances or 'action possibilities' (Gibson, 1977) that are to a greater or lesser extent suitable for creative action. (Glăveanu, 2013; Kupers et al., 2019). Creativity is not an intrinsic property of the individual, nor of the (material or physical) environment; instead, it emerges in the interaction between these elements. In education, creativity can therefore be said to emerge in interaction between the student, the teacher (or peers), and the task.

### *1.2. Creativity in teacher-student interactions in the context of music education*

When it comes to studying creativity in education, it makes sense to start in arts education. Creativity is said to be an intrinsic value in arts education (Winner, Goldstein, & Vincent-Lancrin, 2013). Webster (2002) states specifically that creative thinking, the capability to imagine different combinations of sounds, is at the core of musicianship, equally at an amateur and at a professional level. However, longitudinal research has shown that a substantial proportion of music students actually gets *less* able to improvise music as they receive longer periods of music education (McPherson, 2005). Therefore, it is of paramount importance that we study closely what happens in teacher-student interactions in music education, because only in this way we get insight in what teachers say and do to foster or hinder student creativity from moment to moment.

A common misconception is that stimulating creativity in education means as little teacher interference as possible, so that students can freely explore and work independently on their own ideas (NACCCE, 1999). In reality, teaching with the creative development of students in mind requires a skillful balance between interference and letting go – or between improvisation and structure (NACCCE, 1999, 2017; Sawyer, 2011). On the one hand, creativity is not possible without children acquiring skills and knowledge relating to the domain they are practicing, because the child is embedded in a 'field' and in a culture (Baer, 1998; Sawyer et al., 2003). This can occur through more formal, traditional ways of teaching. On the other hand, creativity requires freedom to explore ideas, to question assumptions and to experiment. Providing freedom and openness to exploration can be linked to what creativity scholars refer to as stimulating 'divergent thinking'; the capability to come up with as many possible solutions to a problem if possible (Runco, 2008, 1992). Providing structure can be seen as stimulating convergent thinking: the capacity to narrow down a great number of ideas to find the best possible solution to a given or defined problem. Divergent and convergent thinking are deeply intertwined and both necessary for creativity to occur (Cropley, 2006; Simonton, 2015). Approaches of teachers to stimulate their

students' creativity are summarized under the term 'teaching for creativity' (Jeffrey & Craft, 2004; Sternberg, 2015). Teaching for creativity is a relevant, yet somewhat elusive concept. The question remains what teachers actually *do* when engaging students in creative tasks in the classroom. In a review of teachers' practices in art and design studio classes, Sawyer (2017) defined themes that came up in these practices. Teaching for creativity turns out to be flexible, open-ended and improvised: instructors use a constructivist, learned-centered approach rather than a teacher-centered approach. Students are provided with choices and the teacher adapts to what the student needs. In addition, teachers provide sufficient structure. They model certain techniques, or more in general, a style of working as a professional artist. In these descriptions of teacher behavior, we see again a balance between fostering divergent thinking by encouraging exploration and offering space on the one hand, and fostering convergent thinking by providing structure on the other hand. Previous research on creativity in music education has focused on creative interactions in the context of musical improvisation and composition of a musical piece. Composition is a part of the music education curriculum in many countries (Viig, 2015). With regard to composition, researchers have found different types of strategies which students employ. One type could be qualified as 'vertical' or linear: students work consecutively on small segments of the composition, finishing each one before moving on to the next (Mellor, 2008). The other type of creative processes are 'horizontal': dynamic and non-linear, with frequent shifts between convergent and divergent thinking, as well as shifts between different phases of the creative process (Burnard & Younker, 2004, 2008). Focusing on creativity in interactions research on detailed peer interactions during a musical composition task found that *transactive* turns (turns in which previous ideas are further elaborated) are important in interactions resulting in a high-quality result (Macdonald, Miell, & Mitchell, 2002). The role of the teacher in composing assignments is somewhat ambiguous. On the one hand, the teacher can guide the student to make more sophisticated and complex choices and reflect more in depth on what they are doing, compared to a student working with another peer (Major, 2007). On the other hand, the intentions of the teacher can overshadow the creative ideations of the pupil and their sense of ownership (Ruthmann, 2008). Furthermore, especially non-specialist teachers can feel ill-equiped to teach music composition, leaving it out of the curriculum altogether (Viig, 2015). Therefore, the literature on teacher-student interactions in the context of music compositions could benefit from a detailed and systematic analysis of how and when teachers provide structure (related to convergent thinking) and when they provide freedom and encourage student divergent thinking. How does these teacher behaviors foster or hinder creative ideation within the social creative process?

### *1.3. Measuring creative actions from moment to moment*

Most research on students' creativity is quantitative and summative in the sense that it assesses outcomes of the creative process (on the product or person level) rather than the process itself. Studies on the creative moment-to-moment processes are almost always qualitative, but they do not need to be. Combining qualitative analyses with quantitative sequential analyses of the creative process can deepen our understanding of what patterns occur in socially situated creative interaction, and why. For this purpose, we developed the Microdevelopmental Creativity Measure (Kupers, van Dijk, & Lehmann-Wermser, 2018). Two key aspects in the definition of creativity are novelty and appropriateness (Amabile, 1983; Baas, De Dreu, & Nijstad, 2008). With this measure, we systematically assign levels of novelty and appropriateness to each (verbal or non-verbal action). Furthermore, teacher actions can be systematically categorized based on the core aspects of teaching for creativity: actions either pertaining to providing structure ('convergent teaching') or actions aimed at providing space and encouraging ideation ('divergent teaching') (Kupers, van Dijk, & Lehmann-Wermser, 2018).

### *1.4. Research questions*

In the recent literature, children's creativity has predominantly been defined and measured as an individual trait. More knowledge on how convergent and divergent thinking unfold in interaction between teacher and student results in much-needed insight in what children's creativity in the context of (music) education is, and how student creativity can best be stimulated. In the current study, we aim to analyze how creativity, in the sense of novelty and appropriateness, emerge in interaction between teacher and student in the context of a musical composition task.

1 How are students' creative actions and verbalizations distributed with regards to their levels of novelty and appropriateness?
2 Is there a relation between teacher strategies (divergent versus convergent versus doing nothing) and the immediate consequent level of novelty of the student?
3 What is the relation between teacher strategies (divergent versus convergent versus doing nothing) and the immediate consequent level of appropriateness of the student?
Based on the literature on teaching for creativity (Jeffrey & Craft, 2004; Sawyer, 2017), we expect for research question 2 and 3 that divergent teacher strategies and doing nothing relate to high levels of novelty for the student and that convergent teacher strategies relate to high levels of appropriateness for the student. In conclusion, we focused on longer interaction sequences in depth and qualitatively to understand better how creative ideas emerge in teacher-student interactions
4 How do highly novel and less novel ideas emerge in teacher-student interactions?

**Table 1**
Overview of teacher-student dyads and gender.

| Dyad | Teacher | Student |
|---|---|---|
| 1 | Female | Male |
| 2 | Female | Male |
| 3 | Male | Male |
| 4 | Male | Female |
| 5 | Female | Female |

## 2. Method

### 2.1. Participants

Five primary school students (age between 9;8 and 11;2 years old) and three novice music teachers participated in the study, forming 5 teacher-student dyads. Two students and two teachers were female (see Table 1 for an overview of the dyads). These five dyads were selected from a larger subsample of seven dyads. This selection was solely based on which parents gave informed consent to use video data of their children for further research. The novice teachers (from now on referred to as 'teachers') were undergraduate students in the Music Education bachelor program at a conservatorium in the Netherlands. The teachers were asked to participate voluntarily following a guest lecture on creativity at the conservatorium by the first author. The student participants came from a convenience sample: the music teachers did their internships at three different local primary schools, and the regular (non-music) teachers of the students selected students to participate in the project. The parents of the students informed via a letter gave informed consent before the study took place. The design and procedure of the study were approved by the Ethical Committee of Pedagogy and Education at the University of Groningen (d.d. November 6th 2014).

### 2.2. Material

The musical composition task that the teacher-student dyads worked on was an assignment to compose a short piece of music that accompanied a scene from a story (the students could decide themselves what kind of story, for instance a fairy tale, a scene from a book or from a movie). This assignment was left open-ended on purpose; there are many ways to complete the assignment and many different outcomes possible. Each dyad was provided with a laptop and speakers, on which Magix Music Maker (Magix Software GmbH, 2014) was installed. The program works with a library of many different musical 'loops' i.e. short musical motives of 1–2 bars of different instruments. These loops can be assembled (consecutively but also parallel) to create a musical piece. Additionally, there are options for changing the pace of the loops, the volume and dynamics, etcetera.

#### 2.2.1. Student creativity

Student creativity was assessed on two scales capturing the relevant dimensions of student creativity: novelty and appropriateness with the Microdevelopmental Creativity Measure (MCM, Kupers, van Dijk, & Lehmann-Wermser, 2018). The first step in coding was determining the unit of analysis, from now on called 'turns'. A turn could be either verbal, non-verbal or a combination of both, because the task entails constructing something (a product) but also reflecting on actions and thinking out loud. For verbal units, each time the student made a remark, answered a question, etcetera, this was defined as a turn. Non-verbal turns were defined as 'meaningful actions', in the sense that they were part of the creative process, compared to merely procedural ones (e.g. saving the document, restarting the program after an error). Examples of meaningful non-verbal turns were playing and selecting a loop, adjusting the volume or length of loops already in the composition, deleting parts of the composition, and listening back an already composed piece of music. If a meaningful action was accompanied by a verbal turn (e.g. saying 'I'll put this at the beginning' while dragging a loop to the beginning of the piece), they were coded together as one turn because the action and verbal turn together make up one meaningful unit. If the student voiced a new general idea that took multiple actions to execute, these 'minor actions' were coded as one turn (e.g. saying 'I'll make all of these very loud' and then adjusting the volume of multiple loops). Verbal turns and actions that only referred to technical errors of the software or that were strictly procedural (e.g. 'You should press Save', or: 'Why doesn't this work?') were excluded from the analysis. As a first step,20 % of the data were segmented into turns indepedently by the two authors, and these segmentations were discussed. The rest of the data was segmented into turns by the first author.

Next, all turns were coded on a 4-point ordinal scale for novelty and a 4-point scale for appropriateness (Kupers, van Dijk, & Lehmann-Wermser, 2018). On the novelty scale, we assessed to what extent the turn was new, compared to previous turns. An idea can be either completely new, it can be an elaboration (small or more substantial) upon what has been previously said or done, or it can contain no novelty (for instance saying 'I don't know' or repeating a previous action). On the appropriateness scale, we assessed to what extent each turn fitted the task. After several training rounds, the two authors independently coded 11 % of the data. Interobserver agreement was 82 % (k = .75) on the Novelty scale and 94 % on the Appropriateness scale (k = .48).

#### 2.2.2. Teacher strategies

Teacher strategies were assessed with the newly developed Teacher Strategy scale of the Microdevelopmental Creativity Measure. Similar to the student scale, teacher behavior was first segmented into turns. Each turn was divided into either one of three

categories: divergent strategies (e.g. prompting the student to come up with more ideas, encouraging, asking the student questions related to idea generation), convergent strategies (aimed at evaluation of ideas, providing additional examples, giving information about the assignment) and other teacher behavior. Interobserver reliability on the Teacher strategy codes was 87 % (k = .81).

### 2.3. Procedure

At each school, the first author gave a short introductory lesson about musical composition. The lesson focused on how composed music can be used to accompany a story line (using scenes from a Harry Potter movie as examples) and how music can underline turns of events relating to the story (for instance a build-up of excitement followed by relief). Also, the use of musical composition software was explained. After this introduction, the teacher-student dyads worked on a musical composition task in a separate room outside of the classroom. The dyads were told in advance that they had 30 min to complete this task, after which the researcher left the room. Five minutes before the end of the task, the dyads were reminded that they had 5 min left.

The room in which the dyads worked was further equipped with two video cameras, one aimed at the screen of the laptop and one opposite aimed at the faces of the participants. Afterwards, the video files were coded in detail using MediaCoder (Bos & Steenbeek, 2009; 2017).

### 2.4. Data analysis

In order to answer the quantitative research questions, we constructed transition matrices for each of the five teacher-student dyads (see Menninga, van Dijk, Steenbeek, and van Geert (2017)) for an application of this technique for analyzing teacher-student interactions). A transition matrix consists of all conditional probabilities of one state (in this case, a teacher or student category) being followed by another. In order to construct these matrices, we collapsed the codes of the teacher and student into one sequence over time per dyad in Microsoft Excel. Next, we calculated a frequency matrix which displays how often specific combinations of codes occur (for instance, a divergent teacher turn followed by a student turn with the highest level of novelty). On the basis of this frequency matrix, we calculated a matrix with the relative probabilities of all combinations of codes. We repeated this procedure for each of the five dyads and consequently displayed the results in a transition graph for all five cases together. Next, we tested our hypotheses statistically with a Monte Carlo permutation test, which we used to calculate the probability that our observed transition probabilities occur on the basis of chance alone. This was achieved by shuffling the order of the data and then calculate the frequency and probability matrices as described above. This procedure was repeated 1.000 times, which resulted in an average matrix where the order of teacher and student events was completely random. The probabilities of the transition matrix based on our empirical data were then compared to this matrix. Because the research questions only deal with how student novelty and appropriateness result from teacher behavior, we only tested the cells representing these transition probabilities.

In order to capture not just the structure, but also the content of the interactions, we concluded with a content analysis of the data. Because our research question aims at understanding how high and low levels of novelty emerge in interactions, we selected two fragments with mostly higher, and two fragments with mostly lower levels of novelty, combined with varying teacher strategies. In this way we can deepen our understanding of ‘what works when’ for teacher behavior.

## 3. Results

### 3.1. Descriptive analyses: distribution of students’ and teachers’ behaviors

In Fig. 1, the level of novelty of student turns described and it can be seen that these are not distributed normally. Instead, the distribution is heavily skewed: most ideas have a low level of novelty (0 or 1; respectively 46 and 30 % of utterances fall in these categories) while real novel ideas (level 3) are quite rare (8 % of all utterances).

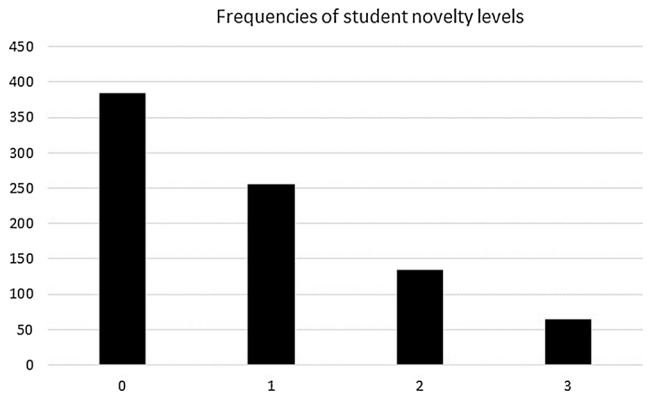


**Fig. 1.** Frequencies of student novelty levels.

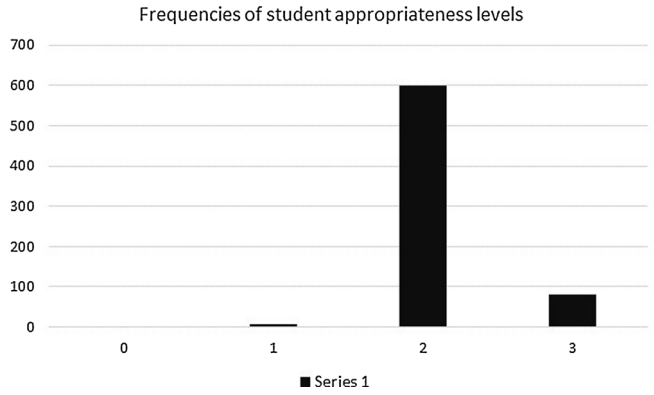


**Fig. 2.** Frequencies of student appropriateness levels.

Compared to student levels of novelty, levels of appropriateness are less varied. Level 2 is by far the most common (87 % of all utterances), level 1 and 3 are scarce (1 and 12 %) and level 0 is non-existent Fig. 2.

Interestingly enough, the teacher strategies also have a non-normal distribution (Fig. 3). While there are marked differences between teachers a consistent pattern is that divergent teacher turns are scarce (8% of all utterances) compared to convergent (47 %) and neutral turns (45 %). Because student appropriateness levels show so little variation, further sequential analyses could not be executed. Therefore, we only looked at the relation between teacher behaviors and student novelty levels.

### *3.2. Relation between teacher behaviors and student novelty levels*

In order to test sequential relationships between teacher behaviors and student novelty levels, we first displayed all possible transitions as arrows from one behavior category to another in Fig. 4. Table 2 displays all relative transition rates between teacher behaviors and student novelty levels. Overall, we see that the following transitions occur most often. A convergent teacher behavior [c] is followed relatively often by a student turn with the lowest level of novelty [0]. Divergent teacher behaviors are always followed by student turns, never by another teacher turn. Interestingly however, divergent turns are not uniformly associated with high levels of student novelty [3]; instead, they can also lead to a low level [0] or intermediate level [1] of novelty. Also, student elaborations/ turns with intermediate levels of novelty often lead to another elaboration [1]. Neutral turns are relatively often followed by a 0, and preceded by a 3. Looking at the lowest transition rates, we see that convergent teacher turns almost never lead to highly novel student turns, or divergent or neutral teacher turns. Also, student elaborations [1] are least likely to be followed by student turns with a high level of novelty, or by a divergent teacher turn. The largest and smallest transition rates described here are displayed visually in the format of the arrows in Fig. 4: the five bold lines represent the largest conditional transition probabilities (sequences that occur relatively often), while the five dotted lines represent the smallest conditional probabilities (sequences that are relative rare).

Because our hypotheses are about how teacher behavior relates to student levels of novelty, we only tested these relations. Table 3 summarizes the test results for all five cases. In 5 out of 5 cases, the chance of a convergent teacher turn leading to a *low* level of student novelty is significantly higher than based on chance ($p < .01$). Also, in three out of five cases, there is a negative relation between a convergent turn and a *high* student level of novelty ($p < .01$).

[Table 3: Number of significant transition rates per cel ($p < .05$).

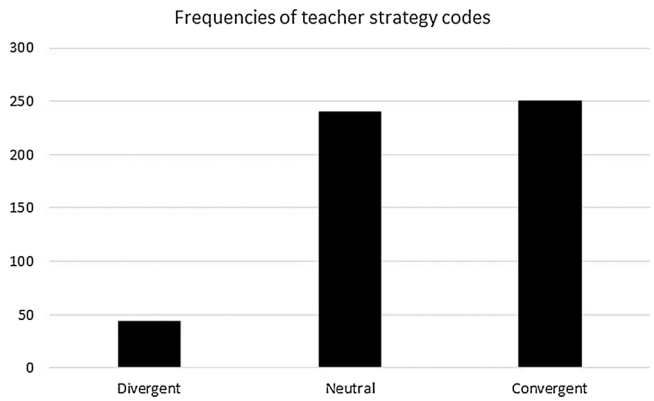


**Fig. 3.** Frequency of teacher strategy codes.

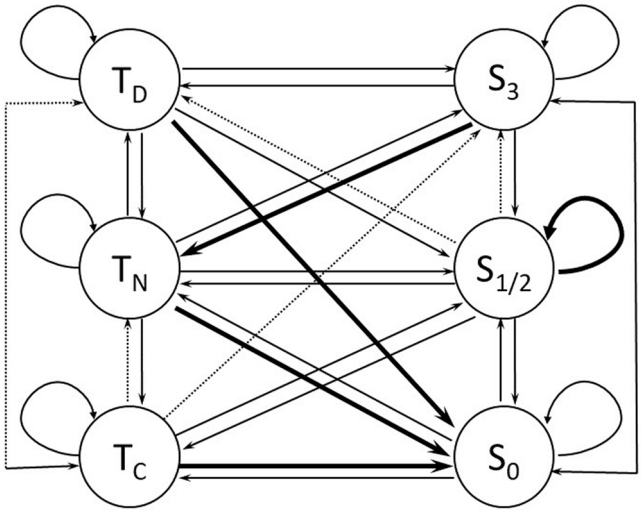


**Fig. 4.** Transition graph depicting transitions between teacher behaviors and student novelty levels. ("T"; subscripts refer to divergent (d), neutral, (n) and convergent (c); "S"; subscripts refer to high (3), intermediate (1/2) and low (0) novelty levels). Bold lines represent the five largest relative transition probabilities; dotted lines represent the five lowest relative transition probabilities.

**Table 2**
Relative transition probabilities between student novelty levels (0–3) and teacher behaviors (divergent, neutral, or convergent) for all five dyads combined.

| | 0 | 1/2 | 3 | Divergent | Neutral | Convergent |
|---|---|---|---|---|---|---|
| 0 | .236 | .135 | .034 | .061 | .297 | .236 |
| 1/2 | .179 | .396 | .022 | .007 | .224 | .172 |
| 3 | .091 | .318 | – | .045 | .364 | .182 |
| Divergent | .375 | .313 | .313 | – | – | – |
| Neutral | .356 | .299 | .08 | .034 | .034 | .195 |
| Convergent | .527 | .264 | .033 | .011 | .022 | .143 |

**Table 3**
Frequency of p-values < .05 for transition rates for all five cases.

| | $S_0$ | $S_{1/2}$ | $S_3$ |
|---|---|---|---|
| Teacher: Divergent | 0/5 | 0/5 | 1/5[a] |
| Teacher: Neutral | 2/5 | 2/5 | 0/5 |
| Teacher: Convergent | 5/5 | 1/5 | 3/5 |

[a] Contrary to expectations: negative relation.

### *3.3. How do highly novel and less novel ideas emerge in teacher-student interactions?*

In the first example (dyad 4), we see that in this dialogue, divergent teacher turns indeed lead to novel ideas of the student. The novelty levels are in brackets in the transcript.

S: I can also do it about my favorite tv show. [3]
T: That is allowed as well
S: That is 'Violetta' but most of the scenes have music. [1]
T: And what kind of music is that?
S: Ehm that depends because sometimes there is really quiet music and sometimes busy music and sometimes they go to concerts. [3]
T: But maybe we can apply this here because like you said, here it is quiet.
S: Hmhm. [0]
T: And then it is busy again.
S: It is again, because that depends, it is very different. [0]
T: Yes.
S: Because when they write songs sometimes it is very quiet and then there are sensitive songs but it's really both when they do the

songs. [1]
T: Maybe we can do a bit of both then. T: But just look around to see what you like.
S: Are these wind instruments? [3]
T: Yes, up there [points to screen].

In this short fragment, the student comes up with three novel ideas: the idea to make a piece of music to go with her favorite tv show, the idea to alternate between quiet and fast/ loud fragments within this piece of music, and the idea to include wind instruments. The first idea emerges without a teacher prompt, after the student first started about another movie. The second novel idea emerges after an open, divergent question of the teacher (What kind of music is that?). In subsequent turns, the teacher subtly refines the initial idea: whereas the student initially only says there are different types of music (as if she has to choose), the teacher elaborates on this by saying she can combine and alternate between different fragments. Lastly, the teacher switches to a divergent turn again, by emphasizing the student can do whatever she wants, to which the student immediately replies with the idea of introducing wind instruments. This first example shows how novel ideas can emerge almost spontaneously after divergent teacher behavior, but also without any teacher prompt at all.

In the second example (dyad 3), divergent turns do not (immediately) lead to novel ideas.

T: Do you have a story in mind already?
S: No. [0]
T: Can you think of something?
S: Ehm… no. [0]
T: Maybe something out of a book you've read. Do you read books sometimes?
S: No. [0]
S: I had this piece of Arjen Robben in the Champions League but that is a piece… I don't know very well how that is. [3]
T: Can you maybe think of a story of Arjen Robben in a game yourself, what happens, what could happen.
S: At the very last… they were competing against a German club and Arjen Robben scores in the last minute of the game. [2]
T: We can use that. S: Yes. [0] T: And was that the winning goal or..?
S: Yes that was the winning goal too. [0]

The first teacher turns are very divergent, but perhaps too open for the student; he cannot immediately come up with something. After a bit of thinking time, however, he comes up with a very original idea; not to take a scene from a book, like the teacher suggested, but instead a defining event during a soccer match. This example shows that divergent turns do not always immediately lead to new ideas – it takes the student quite some effort to come up with a novel idea.

In the third example (dyad 2), we see the student unable to come up with new ideas despite the teacher's efforts to help him.

[student has decided he wants to compose music relating to the scene where the wolf blows away the house of the three piglets in the fairy tale].
T: You are now looking for a theme for the wolf. S: Yes. [0]
T: Ok. Do you like that bass loop? S: Yes. [0] T: Yes? For the wolf? S: Yes. [0] T: Ok. And now suddenly the drums stop here [points].
S: Yes [nods] [0]
T: Do you want that or do you want to continue that? S: I want ehm I think… [0] […] T: The wolf starts blowing.
S: Yes ehm, I'm now searching for a low sound. [0]
T: This is already a pretty low sound right? S: [plays back the already composed part from the start]. Ehm. [turns around, looks at the camera] [0]
T: Difficult, right?
S: Yes. [0]
T: Ok. So he's standing still now because this is finished. This was his theme, right? S: Hmhm. [0]
T: And he starts blowing now. So what are we looking for now?

This third example shows a teacher and a student getting 'stuck' in an interactional loop of ideas with a low level of novelty. The teacher tries to narrow down the assignment by giving more information, evaluating, and by narrowing down the decisions, but this does not lead to new ideas. Rather, the student keeps repeating things he has said before, or stating he does not know.

In the fourth example (dyad 4), we see a teacher-student interaction in which the teacher switches between different approaches.

T: Let's listen to what this sounds like [plays back the already composed piece].
S: [nods] [0]
T: Yes? S: Yes I like it. I like it but one piece goes into another quite rapidly so we can also do that and then continue all the way until here [gestures at extending one loop]. That one but then we have to move it higher. [2]
T: Look what you can do as well is extending this one all the way to the next bar. S [plays back piece until so far]. Which one, that one? [points with the cursor] [0] T: Yes, all of them.
[…] T: Come here, I'll show you what I mean [takes over the cursor]. Look [moves one loop] and if you extend this one [extends loop 1 until it overlaps with loop 2 and adjusts the volume so that loop 1 decreases while loop 2 increases in volume simultaneously]… and then it goes from normal to soft [gestures].
S: [takes back the cursor and plays back a fragment]. Yes I like that, yes. [0]

T: And then you can make the song as long as you wish.
S: And then there is, I thought if you have this [points at previously adjusted loop] T: Yes. S: And that you do again from loud to soft [points next to adjusted part] and then soft and then another part like that but with different instruments. [3]

Rather than having a fixed divergent or convergent 'style', the teacher switches between leading and following student (not only verbally but also non-verbally, by taking the console or by letting the student take it), resulting in a creative process where teacher and student work together almost as peers. The student states she wants to change something: she thinks the loops end too abruptly. She wants to fix this by extending one loop underneath all the other ones, but the teacher has a more sophisticated idea: making all loops overlap a bit and then adjusting the volume so that one loop fades into another one, making the transitions between loops more smooth.

Together, these qualitative illustrations show different ways in which novelty can emerge: as a direct or delayed response on a divergent teacher utterance, but also in an organic way through equal collaboration between teacher and student. Also, the third example shows that teacher-student interactions can also unfold in a suboptimal pattern, showing rigidity and repetition where neither the student or teacher is seemingly able to 'break out of'.

## 4. Conclusion and discussion

Creativity is of paramount importance in music and arts education. Only if we study the interactions between teachers and students more closely both qualitatively and quantitatively, we are able to distil what types of interactions foster or hinder creativity. The aim of this paper was therefore to deepen our understanding of how novelty and appropriateness, two key characteristics of creativity, emerge in teacher-student interactions in a musical composition task. In order to reach this goal, we combined quantitative and qualitative analyses of observed interactions during an open-ended, musical composition task.

First, in our descriptive analyses, we found that the degree of novelty in children's utterances resembles a power law distribution rather than a normal distribution: ideas with a low level of novelty are the most common, while genuine novel ideas are relatively rare. This power law distribution is common for variables relating to creativity, talent and innovation on a professional level (Den Hartigh, Van Dijk, Steenbeek, & Van Geert, 2016; Ghiglino, 2012; Simonton, 2014), which demonstrates the validity of the Microdevelopmental Creativity Measure. At the same time, to our knowledge, this is the first study to have demonstrated such a distribution for the emerging creativity of children. While 'mini-c' creativity might be qualitatively very different from creativity at the professional or genius level (Kaufman, Beghetto, & Watson, 2016), it is interesting to see that this is a fundamental similarity. Regarding the teacher's behavior, we saw that divergent turns are much more rare than convergent and neutral turns. This is striking, as the literature on creativity states that especially divergent strategies (leaving space and providing choice, encouraging the student to come up with many possibilities, asking open-ended questions) are crucial for stimulating creativity. However, this finding also emphasizes that there are two sides to teaching-for-creativity: structuring the assignment, providing additional information and evaluating what has been created so far can be equally important.

Our first research question was to what extent teacher's divergent and convergent behavior was associated to the degree of novelty in the student's behavior. It turned out that especially convergent teacher behavior had an impact on consequent student behavior. Convergent teacher behavior significantly more often led to no student novelty, and very rarely led to high student novelty. Although there is quite some descriptive literature on the danger of a completely 'convergent' teaching style ruling out possibilities for students to be creative (Beghetto, 2010), this is, to our knowledge, the first time that this has been found in micro-level patterns of teacher actions and student reactions.

With divergent teacher behavior, we could not find such an association: sometimes, teacher divergent turns are followed by low novelty, sometimes by intermediate and sometimes by high levels of novelty. The picture that arises from these results is that novelty can easily be constrained by what the teacher does, but that it is more difficult to directly stimulate novel ideas. Although divergent behavior was not significantly related to high levels of novelty, almost all turns with the highest level of novelty were preceded by a divergent turn. This implies that divergent behavior is probably necessary for novel ideas to occur at all.

This finding was explored more in depth in the second research question: how do novel and less novel ideas emerge in teacher-student interactions? Following the results of the first question, we looked in detail at moments where the teacher engaged in different types of convergent or divergent teaching and that were characterized by high, or by low levels of novelty. We found that some students easily come up with novel ideas when the teacher is very open, but that other students might take more time. For these students, divergent teacher behavior might be too 'open' and they need more suggestions to come up with a novel idea, or perhaps simply more time to think. This is in line with lab studies on creativity that find idea generation is improved after 'warm-up' exercises of some sort (Worinkeng, Summers, & Joshi, 2013). These students might benefit more from a social modeling approach, where the teacher first demonstrates creative behavior herself. Such a kind of modeling approach has proven potential when it comes to fostering students' creativity (Soh, 2017). Furthermore, we found that teacher and student can get stuck in a loop of ideas without any novelty, and convergent teacher behavior. In this case, the teacher narrowing down the problem and evaluating only decreased the chance that the student came up with a novel idea, which made the teacher trying to narrow the problem even further, etc. We know from previous, longitudinal research on teacher-student interactions that these kinds of sub-optimal teaching-learning interactions can become rigid attractors, which can be hard to break out of (Kupers, van Dijk, & van Geert, 2017; Steenbeek, Jansen, & Geert, 2012). Last, these in-depth analyses showed that teachers generally tend to shift between convergent and divergent teacher behavior. This echoes the literature on convergent and divergent thinking and their relationship: for real-life creative thinking in schools, both divergent and convergent thinking are necessary and strongly related. This means that, if the teacher is adaptive to the needs of the

student, she should be flexible in applying these strategies, shifting between sometimes a leading and then a following role in the interaction. This conclusion is drawn in previous research that focused not necessarily on creative learning and teaching, but of learning and teaching in all kinds of other educational contexts (Pennings et al., 2018; van de Pol, Volman, & Beishuizen, 2009). We seem to have encountered a fundamental principle of adaptive, student-centered learning, which has been proven to be beneficial for learning all kinds of skills. This makes sense because in essence, all research on learning is dealing essentially with the question how novelty (in the sense of novel insights, novel skills, novel behavior) emerges (Sawyer et al., 2003). Together, these analyses also show the added value of not only investigating immediate transition probabilities, such as in the sequential analyses, but also taking into account longer patterns of creative action.

### *4.1. Strengths and limitations*

Although the literature on children's creativity is blossoming, we clearly see a bias in the empirical literature. On the one hand, the most influential creativity theorists have defined creativity as socially constructed, physically embodied, and dynamic (Csikszentmihalyi, 1988, 1999; Glăveanu, 2015). Recently, a group of 20 notable creativity scholars have taken an explicit position in stating that a sociocultural approach to creativity is the absolutely necessary to move the field of creativity forward (Glaveanu et al., 2019). However, when we look at the actual empirical literature on children's creativity, the vast majority of studies still operationalizes creativity as an internal, psychological trait. This study is an important contribution to our understanding of creativity as embedded in social interactions. Moreover, the combination of qualitative and quantitative analyses of micro-level interactional data provide interesting avenues for future research on this topic.

Both a strength and a limitation of this study is that we collected our data in a relatively controlled setting inside school, but outside of the actual classroom. This controlled setting allowed for two things: one, we could study a long, uninterrupted 'chain' of interactions between one teacher and one student. This would have been impossible in an actual classroom, where a teacher switches between multiple students. However, this is a limitation in the sense of ecological validity: the interactions could have been different in an actual classroom, particularly since students also interact with each other. Therefore, more research on these processes in classroom contexts is necessary. Another thing we controlled for is the task. In order to be able to compare teacher-student interactions across cases, all dyads were given the same assignment. We assume based on theory task aspects can elicit of inhibit novelty and appropriateness (Gibson, 1977; Glăveanu, 2013) although ecological studies that focus explicitly on the role of the task (for instance by comparing different types of tasks) are relatively rare. Therefore, in our opinion the task should most certainly be studied more in future research.

Although the thorough quantitative analyses of interaction sequences is definitely a strength of this study, a limitation of the transition matrices in this study is that only one-lag-sequences were studied. That meant that we could only look at the relation between what the teacher did in terms of convergent or divergent teaching, and the teacher and student behaviors that occurred *immediately thereafter*. Of course, teacher behaviors can both have an immediate consequence but also result in novel ideas only after a while. In future research, statistical analyses can be employed that are designed to look at longer interactional patterns. We suggest combining techniques that are aimed at analyzing the *content* of longer interactional patterns (for instance t-pattern analyses (Magnusson, 2000; Mascareño, Snow, Deunk, & Bosker, 2016) with techniques that provide more insight in the *structure* of creative teacher-student interactions (Gates & Liu, 2016). The latter would allow us to look more in depth at whether interactions are for instance rigid or flexible, and how these relate to other characteristics of the creative process and creative products that are a result of these interactions.

## CRediT authorship contribution statement

**Elisa Kupers:** Conceptualization, Methodology, Investigation, Data curation, Writing - original draft. **Marijn van Dijk:** Conceptualization, Methodology, Writing - review & editing.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.tsc.2020.100648.

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