STEAM (Further) AHEAD: Assessing Levels of Creative Expression in Special Primary Education Students

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Abstract

Within education, creativity is consequently recognized as an essential 21st-century skill that the young generation of students should master, placing the development of creativity prominently in the curriculum. One upcoming and promising way to spur creative development is through STEAM education. Following the complex dynamic systems theory, creativity generally emerges out of communication and interaction between creators. Not much is known about the stimulation of student interaction and communication through STEAM education, especially for students having difficulties with their communication and interaction skills. The purpose of this study, based in the Netherlands, was to explore whether STEAM education would stimulate creative expressions in special primary education students. The following research question was investigated: to what extent does STEAM education, as expressed through using a STEAM toolbox, stimulate student creative expressions? The sample included eleven children with a communicative difficulty and four children without a communicative difficulty, between the ages of 7-10. Results of this study provide initial evidence that no significant difference can be found between children with and without a communicative difficulty in the level of creative expression, which was according to expectation. A preliminary inspection of *within* group and *within* individual creative expression was provided, however, further research is necessary to elaborate on the moment-to-moment interactions so that the development of creativity can be better understood and implemented in practice.

Key words: STEAM, Complex Dynamic Systems, Interaction and Communication, Creativity, Creative Expression

1. Introduction

Current educational curricula strive for students to stimulate their curiosity, to be creative, to be critical and innovative, to recognize problems, and to come up with solutions (Menninga & Van Vondel, 2017). The rapid changes in our 21st-century society make considerable demands on the young generation of students to master these essential skills to navigate successfully in our complex world (Marmon, 2019; De Vugt, 2020; SLO, 2021). In order to meet these requirements, school systems must support, stimulate and challenge the optimal development of every student. Arguably the most important task of the educational system is to foster more inclusive education, i.e., creating optimal learning opportunities for children with and without extra support needs.

One way to optimally increase developmental opportunities for every student is through a meaningful and coherent curriculum. An innovative educational practice that designs the curriculum more meaningful and coherent is STEAM education, a promising and broadly applicable transdisciplinary approach to design, inquiry, and creative learning (Khine & Areepattamannil, 2019; Lathan, 2022). STEAM education could be considered as an approach that integrates the five disciplines that make up the acronym (Science, Technology, Engineering, Arts, Mathematics) for the purpose of enhancing the learning outcomes of the student. The justification for this is that through the implementation of the Arts, and thus the creativity component, a STEAM-based curriculum would provide opportunities for the development of innovative and creative problem solvers (White & Delaney, 2021). Active teaching models are at the center of this approach, i.e., students are learning by doing. Or, students are taught *how* to learn, instead of *what* to learn. Such an approach provides opportunities for students to actively engage in their own learning processes, which in turn increases collaboration, creativity, and scientific inquiry skills (Li et al., 2022). Besides the reasoning that adding the ‘A’ for the Arts in STEAM should spur the much-needed development of creativity (Khine & Areepattamannil, 2019), it also seems to be a more engaging and accessible curriculum for students (Bush & Cook, 2019). The potential of STEAM education has been acknowledged among many scholars and practitioners worldwide (Li et al., 2022), but a gap in the literature exists in exactly *how* STEAM education can be implemented to strengthen student development (White & Delaney, 2021).

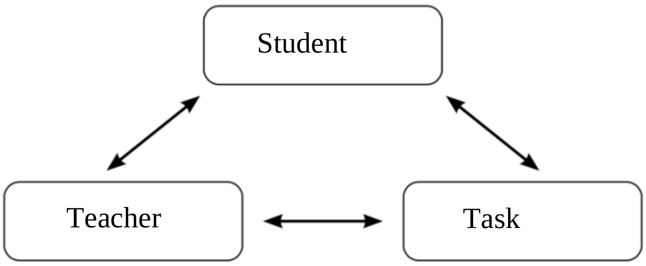
This thesis will contribute to the bigger research project STEAM (Further) AHEAD (Geveke, 2020-2022). A complex dynamic systems approach will be used as a framework for studying creative expressions through STEAM-based education. This study will examine expressions of creativity in the context of STEAM education in special elementary education in the Netherlands, i.e., for 7 to 12-year-old students. The purpose of the present study is first, to assess whether STEAM education will stimulate student interaction and communication, and second, to determine the level of student creative expressions through a STEAM-based activity.

[1.1] Interaction, Communication, and Expression as Determinants of Development

Learning processes are influenced by forms of interaction. Following the complex dynamic systems approach, children's development emerges as a nonlinear process out of continuous real-time interactions between the child and their environment (Steenbeek & van Geert, 2013). Applied to learning environments, interactions between components of the 'talent triangle' *[talentdriehoek]* allow for growth in a child's development (Figure 1; Haakma et al., 2020). Child-environment interactions are thus essential for learning. Patterns of interaction can either help or hinder learning processes. There is a well-established field of research on the perceived value of teacher-student interactions (e.g., Mercer & Sams, 2006; Steenbeek & van Geert, 2013; Van De Pol et al., 2011), peer interaction (e.g., a meta-analysis by Tenenbaum et al., 2020) and task-student interaction (e.g., Glâveanu, 2012). In the objective of creating optimal learning opportunities for all children in the educational sphere, it is essential to understand these patterns of interactions and how to stimulate them.

Figure 1

'Talent triangle' [Talentendriehoek]



Note. Adopted from Haakma et al. (2020), translated to English by the author of this thesis.

In recognizing the importance of child-environment interaction, language is often used as a tool to foster these patterns of interaction. Taking a Vygotskian perspective, language is a crucial factor in psychological and cultural development (Mercer & Sams, 2006). Loosely translated, involvement in social activities promotes individual development and vice versa. Schools are the primary context of learning (Patrick et al., 2012) through social activities, thus able to provide opportunities to enhance student interaction skills.

There can be no interaction without communication. The linguistic component of interaction and communication is particularly essential here, as language is perceived as an important factor to function successfully in our future society (SLO, 2021). There are, however, two means of resources in interaction: verbal language (i.e., spoken turns) and non-verbal means of expression (i.e., actions) (Dagarin, 2004). Using verbal language as a tool for interaction can be difficult, if not stressful, for children with difficulties in their interaction and communication skills. Difficulties can take a range of definitions, but there is considerable consensus that the linguistic difficulties disrupt the child's communication in everyday interaction with others (Singer et al., 2020). Based on this consensus, this study will hereafter refer to children with a communicative difficulty. A communicative difficulty can have a profound impact on the development of a child, and the educational system is the designated space to assist its students in the most optimal, possible way.

There is increasing interest in academic research in finding and evaluating alternatives for assisting children's interaction and communication development. Johnson & LaGasse (2021), for example, studied the development of interaction through music education in children with ASD (Autism Spectrum Disorder) and concluded that peer interaction may be beneficial for children with ASD and typically developing children. Pitt (2020) studied the benefits of musical activities on the development of communication skills, providing evidence that such an approach is beneficial for learning and language development. Differing from the use of music, Ralph & Rochester (2016) designed an intervention to encourage the development of communication and language skills by using LEGO bricks.

These studies represent a small, but promising, scope of studies regarding the stimulation of interaction and communication development in children with and without a communicative difficulty. What seems to be in common here, is that expressive activities involving the arts can be implemented as a tool to stimulate interaction and communication development. Some children with a communicative difficulty do not primarily use verbal language in their interaction with others, but rather prefer non-verbal expressions. Through expressive activities, the arts facilitate the opportunity for communicating feelings and thoughts in a non-linguistic way. Some children need such an approach to augment their verbal language (Ralph & Rochester, 2016), and non-verbality positively affects the development of interaction and communication skills in young children with special needs

(Pitt, 2020). That is, withdrawing the focus from verbal expressions could possibly stimulate verbal expression.

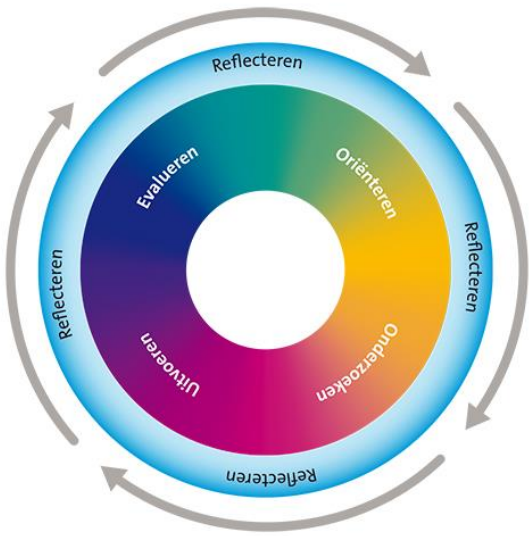
[1.2] The Role of STEAM Education in Developing Children's Creativity

Within education, the importance of creativity is consequently recognized as an essential 21st-century skill, placing the development of creativity prominently in the curriculum (SLO, 2021). It is therefore important for all agents involved in education to be able to understand the processes behind the stimulation of creativity. An elaborate review of creativity as a construct is beyond the scope of this thesis, but this section will shortly touch upon the most important characteristics of creativity in the context of education.

Creative activities, such as in STEAM education, are generally comprised of communication and interaction between creators (Shoda et al., 2016). A literature review by Kupers et al. (2019) revealed that children's creativity is often measured as a static construct, i.e., assessed on the level of the person or the product. Creativity is often seen as either an inherent personal characteristic (someone is born creative or not) or as an outcome (e.g., *de Nachtwacht* by the painter Rembrandt van Rijn is creative, while an imitation of the artwork by an art student is not). The authors acknowledge, however, that an important level of creativity is overlooked in the existing literature – the creative process. Creativity can be viewed from the complex dynamic system perspective: creativity emerges out of interaction with the environment. Classroom contexts matter in the development of creative potential (Beghetto & Kaufman, 2014), with widely recognized roles for the teacher (e.g., Beghetto & Kaufman, 2011) and the task (e.g., Glâveanu, 2013). The environment can provide opportunities for interaction with the task through, for example, using open-ended questions or by provoking motivation and enjoyment through its appearance (Kupers et al., 2019). Following the premises in current Dutch education curricula, the STEAM (Further) AHEAD project takes the creative process as a starting point for the development of student creativity (SLO, 2019). The idea here is that, during a STEAM activity, students collaboratively move through four cyclic phases as part of the creative process (Figure 2).

Figure 2

Creative Cycle



Note. Adapted from SLO (2019).

Note. Phase 1 = orientation [*Oriënteren*], phase 2 = investigating [*Onderzoeken*], phase 3 = executing [*Uitvoeren*], phase 4 = evaluation [*Evaluatie*], Reflecteren = reflection (Terms translated to English by the author of this thesis).

These phases are, according to this model, required to arrive at a novel discovery. As the STEAM (Further) AHEAD project takes a collaborative approach to a STEAM task, the advantage of such a creative cycle is that each individual student can go through the creative process at a different pace or level, depending on their own developmental rate. Reflection is encouraged throughout the entire creative process, a skill that must stimulate students to reflect and provide justifications for their choices. In other words, students are encouraged to communicate their ideas in interaction with their peers, which has the power to stimulating their interaction and communication skills.

If children's creativity is a core developmental skill in current curricula, it must also be understood how creative expressions can be recognized and assessed. There is consensus amongst scholars and practitioners that creativity can be assessed along the characteristics of novelty and appropriateness (Kupers et al., 2018). Something is seen as creative if it fits within a certain frame (i.e., appropriate) and if it adds something new or original (i.e., novel). Viewing creativity as emerging out of interaction and communication, these two characteristics of creativity can be observed and measured on a micro, real-time level (Kupers et al., 2018). That is, creativity can be assessed from moment to moment in the observable behavior of the individual. Communication can be identified through verbal (i.e., spoken turns) and non-verbal (i.e., meaningful actions) cues, and creativity in STEAM activities can take a similar approach. It is important to acknowledge that children's creativity must be understood as 'mini-c' creativity, that is creativity inherent in a learning process (Kaufman & Beghetto, 2009). Understanding children's creativity in this regard, variations in creative expressions that arise from the dynamic interactions are predominantly on a low degree of novelty, while very few ideas have a high degree of novelty (Kupers et al., 2019). Children can thus reach personal creativity through dynamic, interactive processes, with these creations being new and meaningful to themselves.

[1.3] Present Study

Prior research, as shown in the literature review, has argued for the inclusion of the Arts in expressive activities. STEAM education is Creativity emerges from communication and interaction, but the extent to which STEAM education specifically stimulates student interaction, communication, and expression is not yet fully explored, particularly regarding groups of children with a communicative difficulty. The goal of the present study is to evaluate the extent to which STEAM education, as expressed through using a STEAM toolbox, stimulates creative expressions (RQ). To be able to answer this research question, several sub-questions need to be addressed: Does the STEAM toolbox stimulate student interaction and communication (SQ1), and does the STEAM toolbox stimulate creativity expressions (SQ2)? Considering the nature of STEAM education and the perceived benefits for children with and without a communicative difficulty, it is hypothesized that interaction, communication, and creative expressions are stimulated in all children throughout using a STEAM toolbox, expecting no significant difference between both groups.

2. Method

[2.1] Participants

Five groups of students from one special primary education school (*Speciaal Basisonderwijs or SBO in Dutch)* in the North of the Netherlands participated voluntarily in this study. The participating students (*N=15*) were between 7 and 10 years old (*M=8.6,* 53% boys) during the data collection. All students were native speakers of the Dutch language. Before the start of the data collection, teachers (*N=4*) were asked whether students had a communicative difficulty or not. This classification was not based on official diagnoses – it was purely subjective based on the teacher's experience and image of the student (see Table 1). Communicative difficulty was specified as students who – whatever the reason – had difficulty with interaction and communication, that is, engaging and staying in conversation. The included data consisted of 11 students with a communicative difficulty (hereafter Group CD) and 4 students without a communicative difficulty (hereafter Group NCD).

[2.2] Design

The data collection, which took place in the academic year 2021/2022, consisted of video recordings of groups of children executing the musical bottle STEAM task. Due to the timely availability of informed consent, this study was allowed to include recordings of 5 different groups of students (15 students). Teachers and parents of these participating students gave informed consent before the start of this study.

Table 1

Participant's Details

Student group	Student	Grade	Gender	Age	Communicative difficulty (yes/ no)
1	1	SBO 4/5	Female	8	Yes
	2	SBO 4/5	Male	8	Yes
	3	SBO 4/5	Male	8	Yes
2	4	SBO 4/5	Female	8	No
	5	SBO 4/5	Male	8	Yes
	6	SBO 4/5	Male	8	No
	7	SBO 4/5	Female	7	Yes
3	8	SBO 4	Female	10	Yes
	9	SBO 4	Male	9	Yes
	10	SBO 4	Female	9	Yes
4	11	SBO 4	Male	9	Yes
	13	SBO 4	Male	10	Yes
5	14	SBO 4	Female	9	Yes
	15	SBO 4	Female	9	No
	16	SBO 4	Male	9	No

Note. SBO 4/5 = special primary education grade 4/5 (combination class), SBO 4 = special primary education grade 4.

Note. Student group 4 consisted of three students (student 11, 12 and 13), however, student 12 was excluded due to missing background information.

Note. Students without a communicative difficulty (Group NCD) are indicated by a grey background.

Data was collected in a secluded classroom where the groups of students could take part in the activity without external distractors. For each student group, the execution of the STEAM activity was recorded. In these recordings, the teacher first instructed the participating students on how to use the STEAM toolbox and how to execute the task. The teacher in these videos was a female student-intern at the Hanzehogeschool Groningen. After the instruction, the students proceeded with the activity in a collaborative manner, and the instructor was asked to participate only when necessary.

A Brief Description of the Musical Bottle STEAM Activity

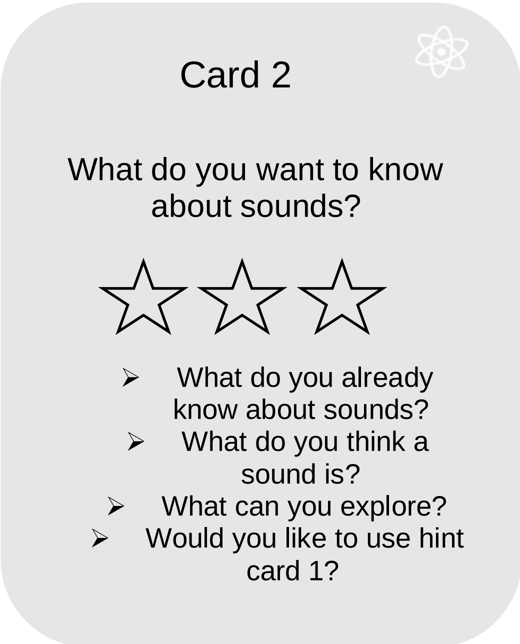
The musical bottle STEAM-activity is a collaborative task, where three or four children work together to construct a song using glass bottles filled with water. Each child has a specific role, and there are three roles to be divided. One is the planner, who organizes the progression of the activity by keeping time, making sure everyone is involved, and checks if the assignments are executed correctly. Another child is the scientist, who attempts to explore with the team the science behind the activity. Lastly, the artist brings creativity to the table through many ideas. The student groups progress through four steps of the creative-based learning cycle together by using conversation cards (Figure 3). For more detailed information regarding this STEAM activity, please be referred to the STEAM (Further) AHEAD project (Geveke & Steenbeek, 2022).

[2.3] Procedure

The data used in this study consists of students' spoken turns and actions throughout the execution of the STEAM activity. The activity had a total duration between 20 and 40 minutes, depending on the group. As children's creativity is understood as a process in which continuous interactions between the child and its (social) environment account for its emergence (Kupers et al., 2018), each moment during the creative process must be assessed. All utterances (both verbal and non-verbal, or spoken turns and actions) that were made during the entire activity are therefore chosen to be selected for analysis. By using the coding software Mediacoder (Bos & Steenbeek, 2017) it was possible to register all student's spoken turns and actions in real-time. These identified utterances were then transcribed in order to re-code these utterances as precisely as possible on the level of creativity.

Figure 3

Illustration of a Conversation Card Used in the STEAM Musical Bottle Task



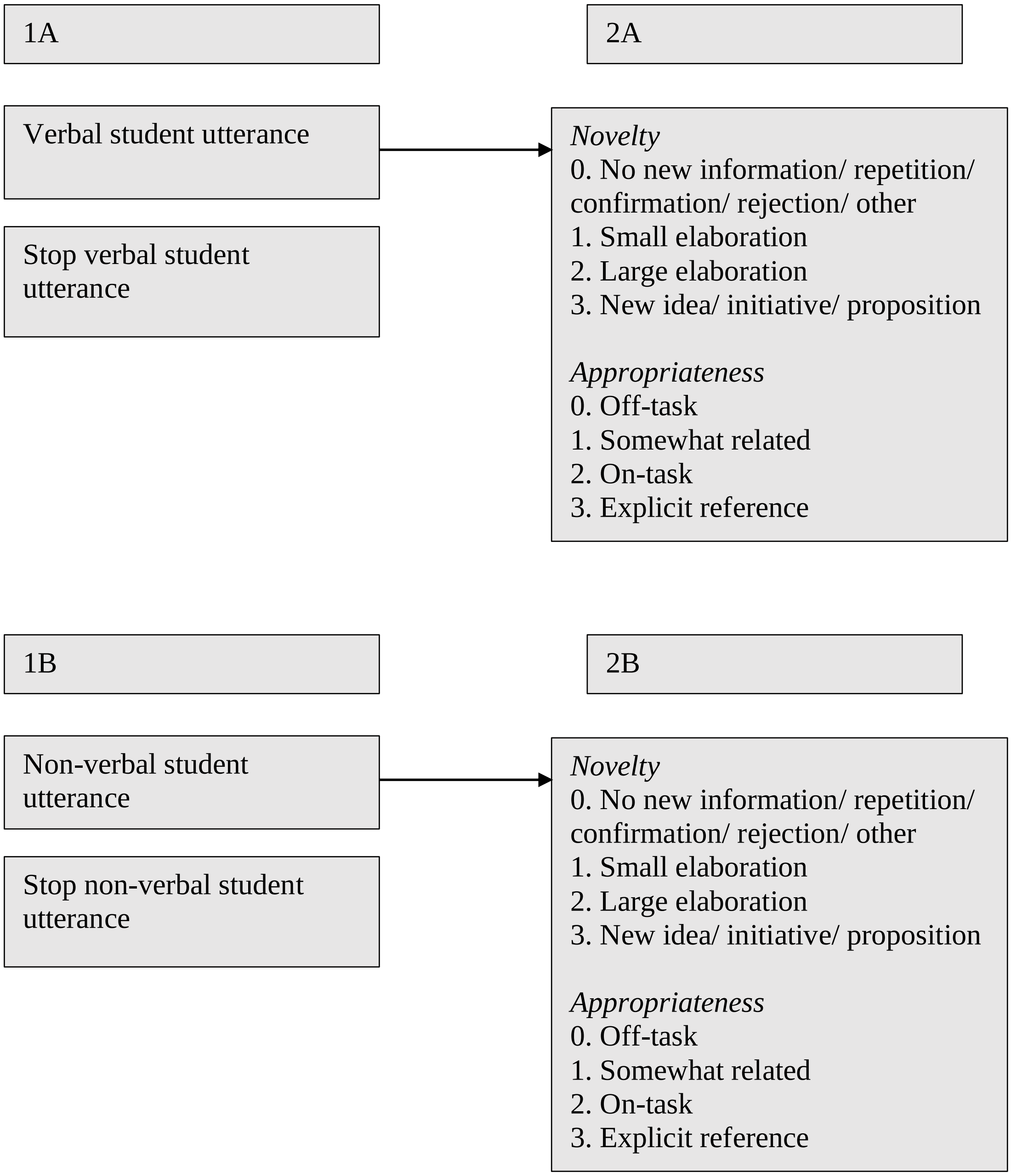
Note. Translated to English by the author of this thesis.

[2.4] Variables and Coding Procedure

Because of the large number of codes, the coding of the variables consisted of a first round for coding the unit of analysis (student utterance) and a second round for the levels of creativity (see Figure 4). This section will cover the main points of the coding procedure; for an elaborate description, including decision rules, please refer to the coding manual in Appendix 1.

Figure 4

Steps in Coding Creativity



Utterances

Student utterances were coded on a basic level. That is, the coder observed if there is an utterance or there is not. Both student spoken turns and actions were coded. Spoken turns are defined as spoken turns, whereas actions are defined as any meaningful actions related to the task (Kupers et al., 2018). To ensure that the starting point for coding would be the same for all recordings, every video recording started coding when the first conversation card was read out loud.

Creativity

The spoken turns and actions were then recoded using a coding scheme based on an existing system for coding creativity (Kupers et al., 2018). The system was adapted for use in the context of creative expression in STEAM education using a STEAM toolbox (see coding manual in Appendix 1). According to this system, creativity can be measured on two dimensions: novelty and appropriateness. Both dimensions were coded on an ordinal 4-point scale at each moment (i.e., utterance) during the creative process. Inaudible or incomplete utterances were excluded in these coding rounds, as these cannot be given a level of creativity.

Coding Reliability

Coding of the spoken turns, i.e., coding 1A, was done by the author of this thesis and a second coder. Both coders collaborated in constructing a manual with information about student utterances (see Appendix 1). To foster alignment between coders, this manual was used to conduct training using video footage of another STEAM task. These coders independently made notes on the observable utterances in this training video. The observers scored these utterances in a test video and changed codes after resolving disagreements. To guarantee the reliability of this manual, both observers independently coded the student utterances in one video included in this study. Inter-rater variability of a maximum of 1 second was considered a mutual agreement. Keeping this into account, substantial inter-rater reliability for the application of the coding scheme was reached, with the inter-observer agreement of 97% (Monte Carlo $p < .01$).

Due to availability and time constraints of other coders, the coding reliability of non-verbal utterances and creative expressions was done through intra-observer agreement. Even though this type of reliability is not particularly common (O'Connor & Joffe, 2020), intracoder reliability might be useful to see if coding is done consistently at different time points. The author of this thesis reviewed the same video twice, with approximately two months in between, to ensure the reliability of the coding scheme. An intra-rater agreement of 88% (MC $p < .01$) was reached for the coding of meaningful actions (i.e., coding 1B). For coding on the novelty dimension, substantial intra-rater reliability was reached, with an agreement of 76% (MC $p < .01$). The coding system of the appropriateness dimension reached significant intra-rater reliability (MC $p < .01$), with an agreement of 88%.

[2.5] Data Analysis

The data analysis of the first and second sub-question was similar, as three steps were taken for answering SQ1 and SQ2. As the aim of this analysis is to determine whether the number of utterances and the level of creativity is similarly stimulated between Group CD students and Group NCD students, both variables will undergo a systematic analysis. The analyses were conducted on two aspects: (1) the mean differences between Group CD and Group NCD throughout the entire STEAM task, and (2) the mean differences between Group CD and Group NCD in the difference between phase 1 and phase 3.

Interaction and Communication

Descriptives. For answering SQ1, the frequencies of the number of utterances throughout the task were compared, giving a first impression of the overall interaction and communication of each student. Both the total number of utterances as well as the number of utterances per research phase were counted. Visual graphs are additionally created to give a first impression of the group averages throughout the STEAM task as calculated and visualized per phase.

Monte Carlo Analysis. To be able to analyze whether the observed mean scores between the two groups of interest were significant, the scores were subjected to a Monte Carlo Analysis. Monte Carlo analyses were used to (a) test the difference for the mean level of expressions between the groups of interest throughout the entire STEAM task, and (b) to test whether there was a difference between Group CD and Group NCD in two task phases. All analyses were performed in Excel in combination with a macro (van Geert, 2023).

For the first Monte Carlo test, the testing criteria were the differences in the mean scores of the frequency of expressions (Group NCD mean minus Group CD mean). The data of the two groups were reshuffled across each other (1.000 times) to create resampled time series. This simulates the results for the null hypothesis that there is no difference between the groups. The scores of both the empirically found data as well as the simulated data were averaged, with these empirically and simulated found mean levels of the number of utterances being subjected to a Monte Carlo analysis to test the significance of the observed differences between Group CD and Group NCD. The result is considered to differ significantly from the null hypothesis if the probability of finding the observed value in the resampling output is below 5%.

For the second Monte Carlo test, the procedure was highly similar to the first. The testing criteria in this case, however, were the differences in mean scores in phase 1 and phase 3 of the STEAM task (Group NCD mean minus Group CD mean).

Timeseries. To give a perception of the fluctuation of interaction and communication throughout the task, all identified utterances were plotted over time in a timeseries graph. By doing so, it gives a first impression of interaction and communication over time within a student group and within individuals. Key characteristics that will be considered are comparisons regarding turn-taking, which allows for an initial inspection of interaction and communication over time. As this research is aimed at observing whether there is a difference between Group CD and Group NCD, one student group in which students with *and* students without a communicative difficulty are collaborating is chosen for further inspection. Student group 5 is the only group with both CD and NCD students executing the entire four phases of the creative cycle, hence this group is chosen for initial inspection.

To summarize the first subquestion, the analyses can be used to accept or reject the hypothesis on a group level. A first observation to which extent there is an observable mean difference between Group CD and Group NCD is provided by the descriptives. The hypothesis can be accepted if the results indicate that there is no significant difference between the average number of expressions between both groups, as analyzed with a Monte Carlo Analysis. Lastly, as the creative process within a small collaborative student group is visualized through the individual timeseries trajectories, it is possible to give an indication whether the group differences are also observable within student groups.

Creative Expression

Descriptives. Similar to answering SQ1, the frequencies and visual graph of the complexity levels on the novelty and appropriateness dimension of creativity were first displayed. This provides an initial assessment of the complexity of each student's creative expressions.

Monte Carlo analysis. To test the significance of the observed differences between CD students and NCD students, the mean level of the complexity level of those expressions of each group was subjected to a Monte Carlo analysis. The procedure was highly similar in comparison with answering SQ1. The testing criteria, however, were (a) the differences in the mean scores of the levels of creativity over the entire task between groups (Group NCD mean minus Group CD mean) and (b) the differences in the mean scores of the levels of creativity between phase 1 and phase 3 (Group NCD mean minus Group CD mean). This procedure was followed for both the novelty and appropriateness dimension separately.

Timeseries. As this research is aimed at observing the difference between students with and without a communicative difficulty, a first inspection of this difference is obtained by plotting the levels of novelty and appropriateness over time in a timeseries graph. One group is again chosen for further analysis on two aspects: (1) a trendline of each individual student, which gives an indication of the overall level of creativity, and (2) a closer inspection of novelty and appropriateness levels between phase 1 and phase 3. Key characteristics that will be taken into account are the highest levels of both dimensions (level 3) as well as the frequency of transitions between the levels of creativity.

The second subquestion can be summarized using the results from these three steps. The descriptives and visuals of the frequencies can give a first inspection whether the groups differ. The results from the Monte Carlo analysis can then be used to accept or reject the hypothesis. Similar to SQ1, it was hypothesized that there are no differences between Group CD and Group NCD. This hypothesis can be accepted if the Monte Carlo analyses show no significant result. The timeseries can subsequently give a useful visual indication on the creative process throughout the STEAM task, as well as the levels of creativity within a smaller collaborative group of students.

[3] Results

[3.1] Interaction and Communication

This section describes the results for the first subquestion: does the STEAM toolbox stimulate student interaction and communication? In line with previous STEAM (Further) AHEAD research, it was expected that both interaction and communication would be stimulated in all children.

Descriptives

The frequencies of the number of utterances of each individual student throughout the STEAM task are shown in Table 2, displayed for the four research phases as well as the total score. This shows the percentage that each student is participating in the STEAM task, giving an indication of overall interaction and communication throughout the task. Looking at these numbers, phase 1 and phase 3 seem to elicit the most utterances among all students, with phase 3 outnumbering phase 1 for all students besides student 1, 2 and 3. Interestingly, these students are all part of the same collaborative student group. When looking more closely at the numbers between phase 1 and phase 3, there are some interesting observations on the distinction between spoken turns and actions. In general, phase 3 appears to initiate more actions and spoken turns in comparison to phase 1. Again, students in group 1 seem to stand out, as there is a decrease in number of spoken turns, but an increase in the number of actions, albeit a smaller difference. Interestingly, the most *and* the least expressions throughout the task are observed for students with a communicative difficulty, student 2 with the most, and student 13 with the least.

Table 2

Frequencies of Utterances Spoken Turns and Actions) per Phase and Over the Entire STEAM Task

	Phase												
	1			2			3			4			Total
Student	V	A	T	V	A	T	V	A	T	V	A	T	
1	25	9	34	12	4	16	20	10	30	8	6	14	94 (30,6%)
2	88	17	95	43	8	51	41	21	62	29	8	37	255 (48,3%)
3	65	19	84	26	9	35	40	23	63	6	5	11	194 (57,6%)
4	10	0	10	x	x	x	36	19	55	7	5	12	114 (57,6%)
5	15	0	15	x	x	x	30	8	38	10	2	12	65 (37,5%)
6	13	3	16	x	x	x	11	16	27	3	3	6	49 (25,1%)
7	6	0	6	x	x	x	11	7	18	0	1	1	44 (19,8%)
8	16	5	21	13	3	16	20	25	45	8	1	9	91 (34,1%)
9	30	11	41	28	8	36	44	20	64	10	4	14	155 (52,2%)
10	7	2	9	10	2	12	11	6	17	3	2	5	43

													(24,6%)
11	28	12	40	x	x	x	35	14	49	10	2	12	101 (47,6%)
13	8	3	11	x	x	x	8	8	16	4	1	5	32 (25,7%)
14	13	7	20	13	0	13	19	19	38	5	5	10	81 (40,3%)
15	35	6	41	20	1	21	29	15	44	14	4	18	124 (44,1%)
16	10	2	12	6	0	6	13	10	23	5	1	6	47 (23,2%)

Note. V = spoken turns, A = action, T = total utterances (V+A) per research phase, Total = total utterances (V+A) throughout the entire task

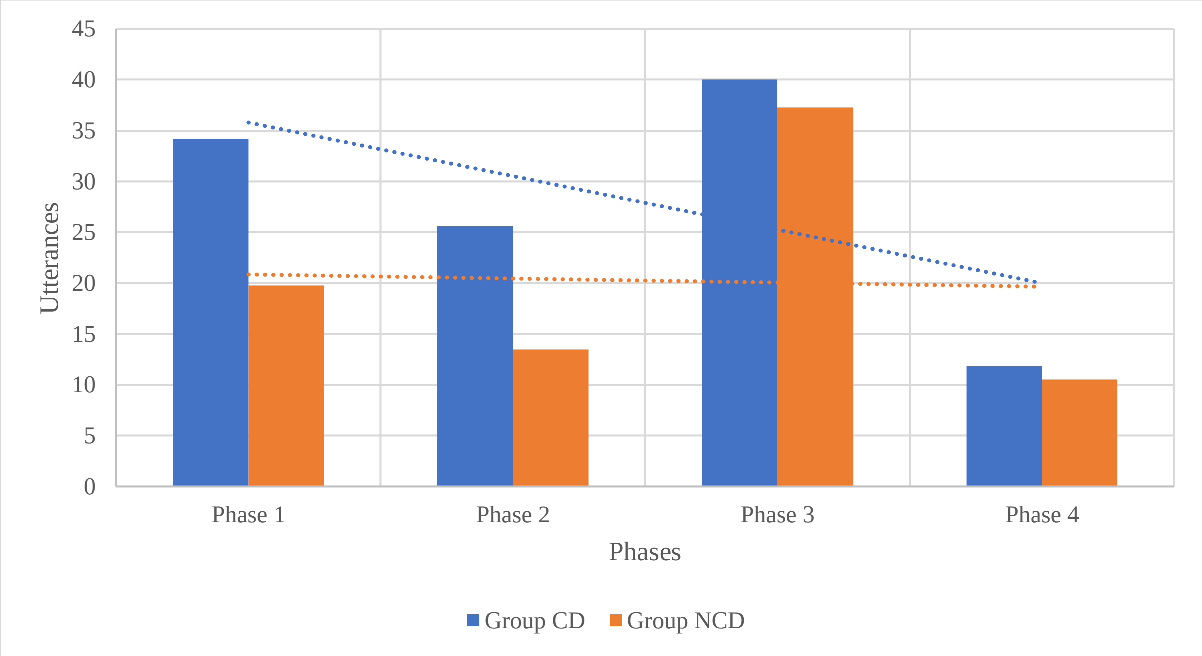
Note. Students without a communicative difficulty (Group NCD) are indicated through a grey background.

Note. Data are missing for student group 2 (i.e., student 4, 5, 6 & 7) and student group 4 (i.e., student 11 & 13), as phase two was skipped during data collection (indicated by ‘x’).

When visually inspecting the trajectories of the number of utterances (Figure 5), it stands out that Group CD seems to express themselves more often than Group NCD. This difference is larger in the first two phases of the STEAM task as compared to the last two phases. Both Group CD and Group NCD show most utterances in phase 3, with a relatively steep increase for both groups. When looking at the trendlines, both groups seem to decrease as time progresses, with Group CD obviously decreasing more steeply than Group NCD.

Figure 5

Average Number of Utterances (Spoken turns and Actions) Throughout the Phases of the STEAM Toolbox



Note. Group CD = students with a communicative difficulty, Group NCD = students without a communicative difficulty

Analysis

The results of the Monte Carlo analysis, as shown in Table 3, revealed that there is no significant difference between the means of Group CD and Group NCD over the entire task (Mdiff = -21.5, p = .677). This means that the observed result is not significantly different from the null hypothesis, meaning that there is likely no difference between the number of utterances throughout the STEAM task between both groups. Regarding the difference in the number of utterances in phase 1 vs. phase 3, there is no significant difference between Group CD and Group NCD according to the Monte Carlo analysis (Mdiff = 11.68, p = .290).

Table 3

Monte Carlo Analyses on Interaction and Communication

	Phase 1	Phase 3	Phase 1-3		Overall		
	M	M	Mdiff	p-value	M	Mdiff	p-value
Group CD	34.18	40	5.82		105		
Group NCD	19.75	37.25	17.5		83.5		
Group CD - Group NCD			11.68	.290		-21.5	.677

Note. Group CD = students with a communicative difficulty, Group NCD = students without a communicative difficulty, Group CD – Group NCD = the difference between both groups

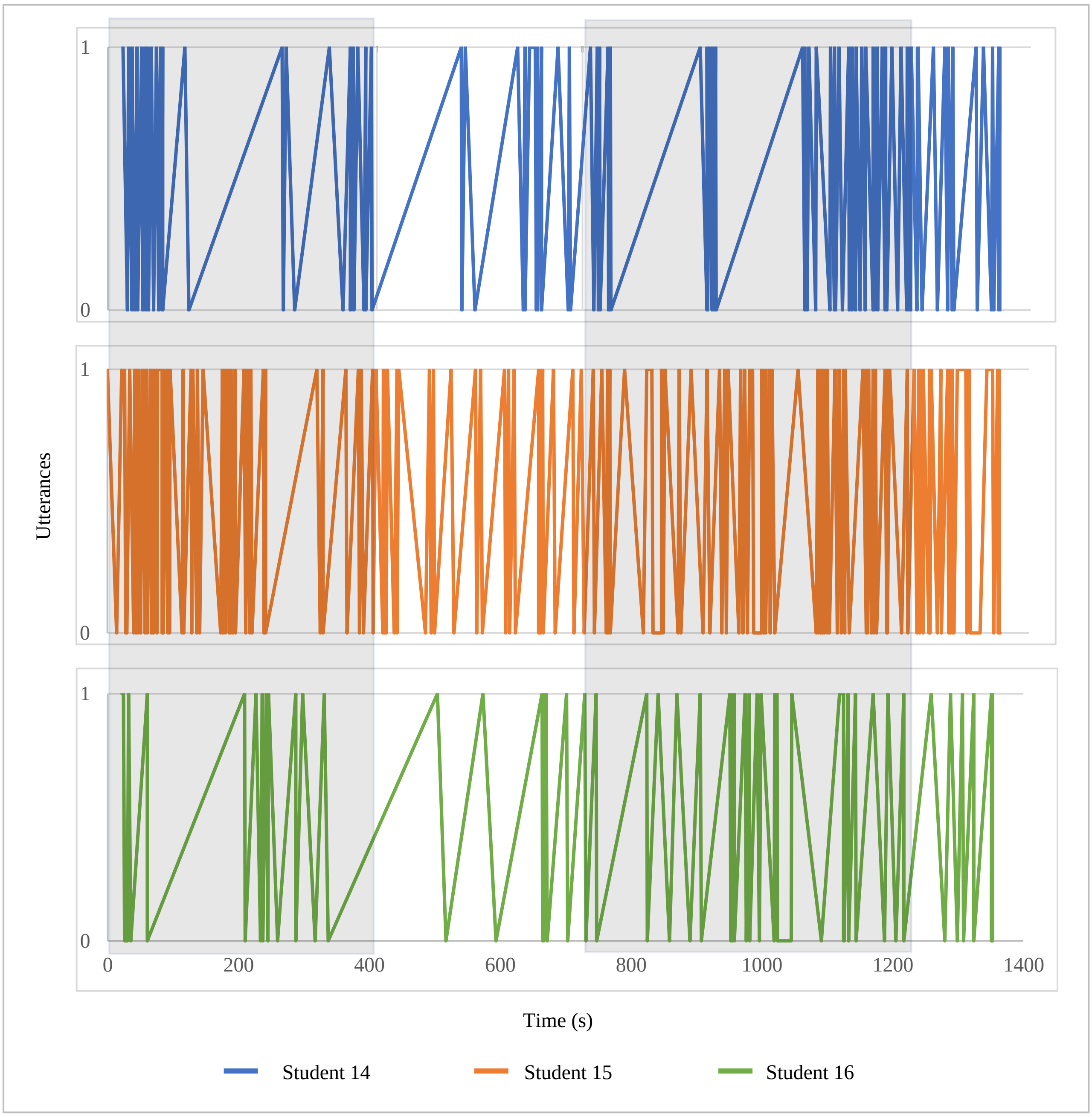
Note. Empty spaces are not computed in this research. For example, the mean differences *within* groups (within Group CD and within Group NCD) are chosen not to be conducted for analysis.

Timeseries

Looking at this graph (Figure 6), it is striking that there are many clusters of utterances where all three students are taking turns. The beginning and end of each research phase are interesting marks, apart from the beginning of phase two. When looking more closely at the individual trajectories, it stands out that student 15 takes turns frequently and consistently throughout the entire task. In contrast, student 14 shows short and less frequent peaks of turn-taking, being most active at the end of each research phase. Student 16 is more active in the last two phases of the task.

Figure 6

Timeseries of the Total Utterances of Student Group 5



Note. The duration of phase 1 and phase 3 are indicated by a grey square.

Note. Utterance level 0 = no utterance, utterance level 1 = utterance

Summarized Results on Utterances

Combined, the results provide support for the hypothesis that interaction and communication, as analyzed through the number of utterances, are stimulated while using the

STEAM toolbox for both CD children and NCD children. The descriptive table and figure give a first impression of the stimulation of interaction and communication and indicates that there is an observable difference between both groups, with Group CD showing higher averages in all four phases. The Monte Carlo analysis, however, does not confirm this difference as significant. Lastly, the timeseries inspection of student group 5 do indicate that there are differences in individual trajectories. Drawing conclusions on group difference from this visualization, however, is not yet feasible.

[3.2] Creative Expression

This section describes the results for the second subquestion: does the STEAM toolbox stimulate student creativity expressions? Comparable to the first subquestion, and considering the nature of STEAM education, it was hypothesized that the task would provoke creative expressions in both Group CD and Group NCD, with no clear observed difference between the two groups. Student's creativity is measured on both the novelty and appropriateness dimension; hence this section will state the results separately for both.

Novelty

Descriptives. The distribution of the event-based codes for the novelty dimension of coding creativity is displayed in Table 4. Throughout the execution of the STEAM task, code 0 is the most frequent, giving the impression that a large percentage of all utterances gave no new information. Code 2 is the least assigned among all students. Interestingly, even though student 10 seems to use utterances to a lesser extent, a considerably large percentage of those utterances are scored on the highest novelty level.

Table 4

Frequencies of Novelty levels for Each Individual Student

	Frequencies of Novelty Levels				
Student	0	1	2	3	Total
1	69 (77,53%)	8 (8,99%)	6 (6,74%)	6 (6,74%)	89 (100%)
2	143 (59,58%)	40 (16,67%)	13 (5,42%)	44 (18,33%)	240 (100%)
3	111 (60,33%)	36 (19,67%)	12 (6,56%)	25 (13,66%)	184 (100%)
4	49 (65,33%)	11 (14,67%)	4 (5,33%)	11 (14,67%)	75 (100%)
5	49 (76,56%)	4 (6,25%)	1 (1,56%)	10 (15,63%)	64 (100%)
6	30 (62,50%)	4 (8,33%)	5 (10,42%)	9 (18,75%)	48 (100%)
7	15 (62,50%)	5 (20,83%)	1 (4,17%)	3 (12,50%)	24 (100%)
8	60 (65,93%)	12 (13,19%)	4 (4,40%)	15 (16,48%)	91 (100%)
9	93 (62,84%)	23 (15,54%)	6 (4,05%)	26 (17,57%)	148 (100%)
10	28 (65,12%)	3 (6,98%)	0 (0%)	12 (27,91%)	43 (100%)
11	60 (63,83%)	16 (17,02%)	5 (5,32%)	13 (13,83%)	94 (100%)
13	20 (74,07%)	5 (18,52%)	1 (3,70%)	1 (3,70%)	27 (100%)
14	40 (66,67%)	8 (13,33%)	4 (6,67%)	8 (13,33%)	60 (100%)
15	87 (70,16%)	11 (8,87%)	5 (4,03%)	21 (16,94%)	124 (100%)
16	34 (73,91%)	7 (15,22%)	1 (2,17%)	4 (8,70%)	46 (100%)

Note. 0 = novelty code 0, 1 = novelty code 1, 2 = novelty code 2, 3 = novelty code 3, total = total count of novelty codes.

Note. Inaudible or incomplete utterances were excluded in this analysis.

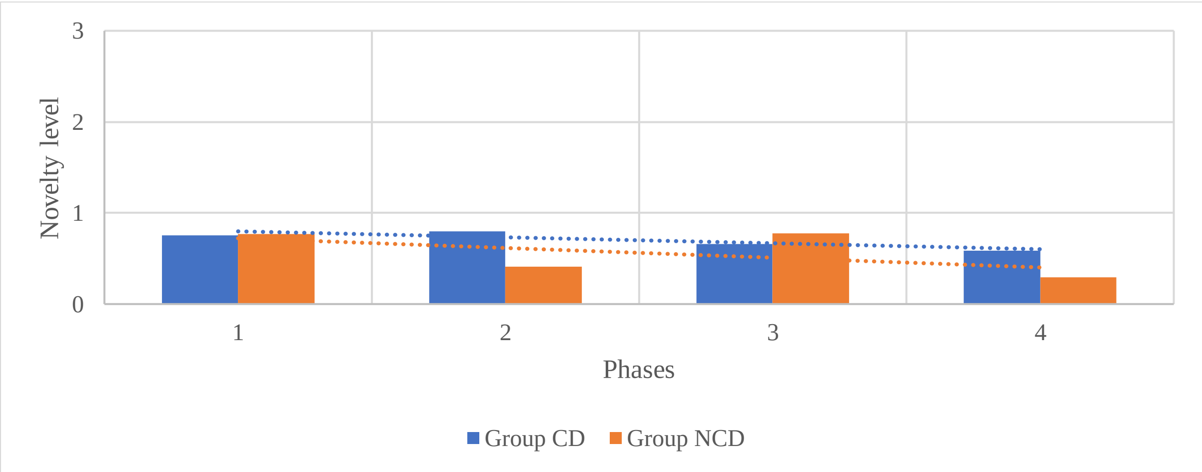
Note. Students without a communicative difficulty (Group NCD) are indicated through a grey background.

Note. Different student groups are separated through the black lines.

Visual inspection of the data of the Novelty dimension suggests that there is very little difference between groups throughout the entire STEAM task (Figure 7). The difference in group average in phase 1 and phase 3 seem to be smaller than in phase 2 and phase 4. This is interesting, as the nature of phase 1 and phase 3 differ more, although it might be argued that the mean difference is still very small. A reason for the larger mean difference in phase 2 and phase 4 might be explained by the missing data. From the four students out of Group NCD, two of them skipped phase 2. The average score of Group NCD is hence based on two students, with student 16 not participating as much.

Figure 7

Average Number of Novelty Levels per STEAM Task Phase

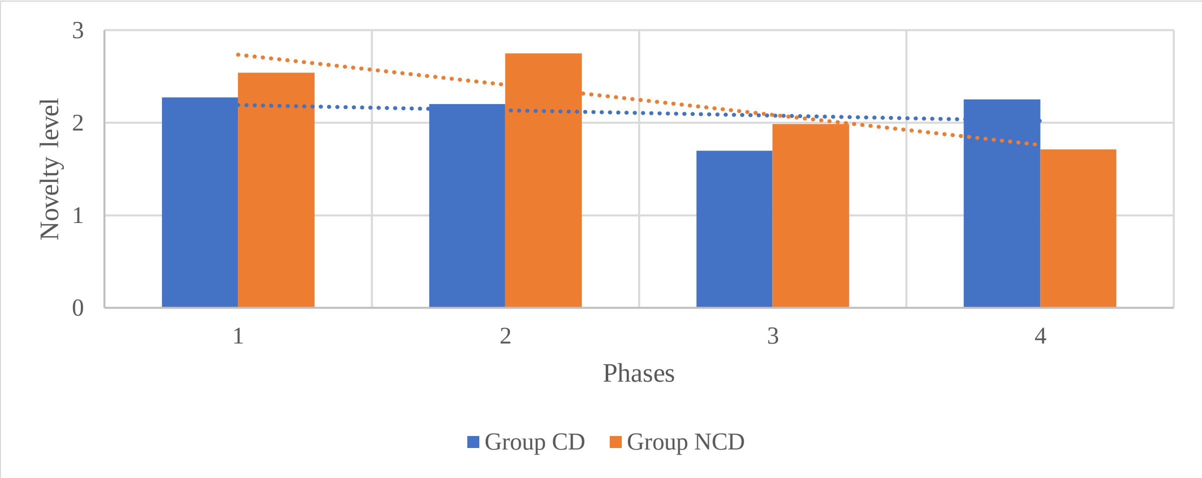


Note. Group CD = students with a communicative difficulty, Group NCD = students without a communicative difficulty

As the initial descriptives of the novelty levels indicated an overarching presence of level 0, the mean novelty level of both groups is below 1 the entire task. Creativity, however, is measured by coding on either level 1, 2 or 3. Figure 8 represents the group mean of novelty levels omitting level 0. Compared to Figure 7, larger mean differences can be observed. Group NCD appears to be more novel in comparison with Group CD, except in phase 4.

Figure 8

Average Number of Creativity (i.e., Novelty Code 1, 2 or 3) Throughout the Task



Note. Group CD = students with a communicative difficulty, Group NCD = students without a communicative difficulty

Analysis. Overall, the Monte Carlo analysis (Table 5) showed that there was no significant difference in the novelty dimension between the two groups throughout the entire task (Mdiff = .12, p = .152). Similar results were found when the mean differences were compared in the difference between phase 1 and phase 3 (Mdiff = .02, p = .482). Although the Monte Carto analyses showed no significant mean differences, these results did adhere to the expectations, and thus shows support for the hypothesis that participation in the STEAM task stimulates creativity in all children.

Table 5.

Monte Carlo Analyses on the Novelty Dimension

	Phase 1	Phase 3	Phase 1-3		Overall		
	M	M	Mdiff	p-value	M	Mdiff	p-value
Group CD	2.27	1.70	-.57		2.01		
Group NCD	2.54	1.98	-.56		2.13		
Group CD – Group NCD			.02	.482		.12	.152

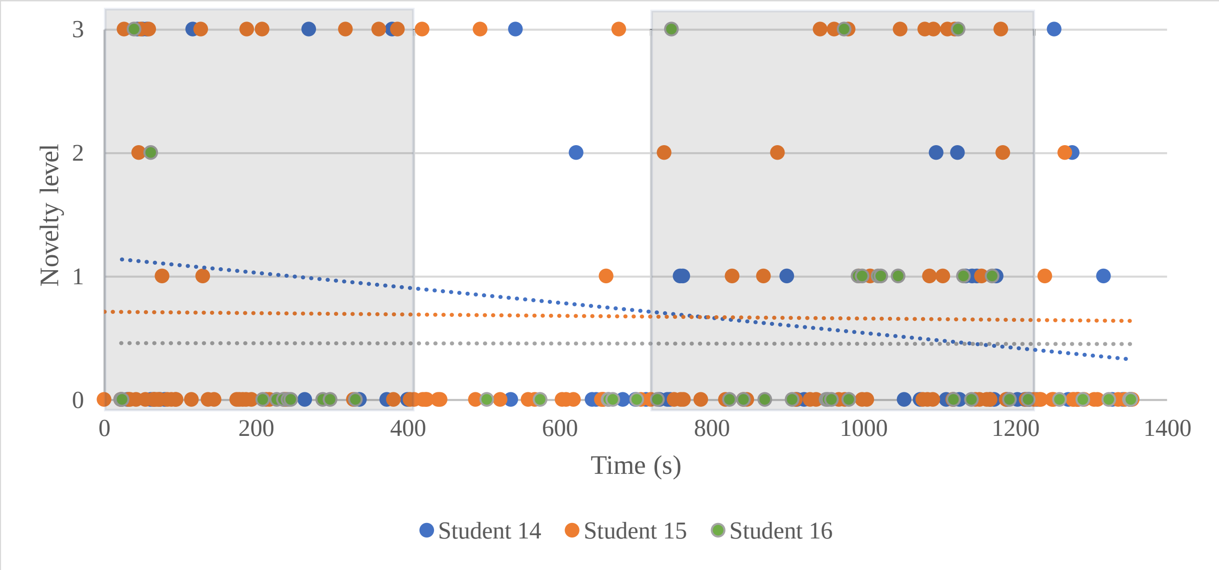
Note. Group CD = students with a communicative difficulty, Group NCD = students without a communicative difficulty, Group CD – Group NCD = the difference between both groups

Note. Empty spaces in this Table are not selected for analysis. For example, the mean differences *within* groups (within Group CD and within Group NCD) are chosen not to be conducted for analysis.

Timeseries. The novelty level representation of group 5 is presented in Figure 9. Looking at the novelty levels throughout the task, it stands out that students 15 and 16 do not seem to increase nor decrease over time. In contrast, student 14 shows a decrease over time, with a higher starting point than the other two students but a lower ending point. This indicates that students without a communicative difficulty, in this group student 15 and student 16, are equally novel throughout a STEAM task. Student 15 is noticeably more active in terms of coming up with variations or new ideas. High levels of novelty (level 3) occur throughout the task, but phase three is clearly inviting for more frequent switches between different novelty levels compared to phase 1, as there are more dots on level 1 and level 2.

Figure 9

Timeseries for Novelty levels of Student Group 5



Note. The duration of phase 1 and phase 3 are indicated by a grey square.

Appropriateness

Descriptives. The frequencies of the codes assigned to the appropriateness dimension is displayed in Table 6. The first observation is that all students are primarily task-appropriate, with a high majority of the turns coded on level 2. Remarkably, level 3 was barely present in all students, indicating that there were overall very little references to the actual making of a musical bottle organ.

Table 6

Frequencies of Appropriateness Levels Throughout the Entire Task

	Frequencies of Appropriateness levels				
Student	0	1	2	3	Total
1	2 (2,25%)	9 (10,11%)	77 (86,52%)	1 (1,12%)	89 (100%)
2	17 (7,08%)	60 (25,00%)	160 (66,67%)	3 (1,25%)	240 (100%)
3	15 (8,15%)	64 (34,78%)	105 (57,07%)	0 (0%)	184 (100%)
4	5 (6,67%)	26 (34,67%)	42 (56,00%)	2 (2,67%)	75 (100%)
5	9 (14,06%)	11 (17,19%)	42 (65,63%)	2 (3,13%)	64 (100%)
6	9 (18,75%)	3 (6,25%)	36 (75,00%)	0 (0%)	48 (100%)
7	3 (12,50%)	2 (8,33%)	17 (70,83%)	2 (8,33%)	24 (100%)
8	4 (4,40%)	11 (12,09%)	75 (82,42%)	1 (1,10%)	91 (100%)
9	14 (9,46%)	25 (16,89%)	107 (72,30%)	2 (1,35%)	148 (100%)
10	2 (4,65%)	5 (11,63%)	36 (83,72%)	0 (0%)	43 (100%)
11	4 (4,26%)	19 (20,21%)	71 (75,53%)	0 (0%)	94 (100%)
13	0 (0%)	3 (11,11%)	24 (88,89%)	0 (0%)	27 (100%)
14	3 (5,00%)	9 (15,00%)	48 (80,00%)	0 (0%)	60 (100%)
15	10 (8,06%)	32 (25,81%)	82 (66,13%)	0 (0%)	124 (100%)
16	1 (2,17%)	5 (10,87%)	40 (86,96%)	0 (0%)	46 (100%)

Note. 0 = appropriateness code 0, 1 = appropriateness code 1, 2 = appropriateness code 2, 3 = appropriateness code 3, total = total count of appropriateness codes.

Note. Inaudible utterances were excluded in this analysis.

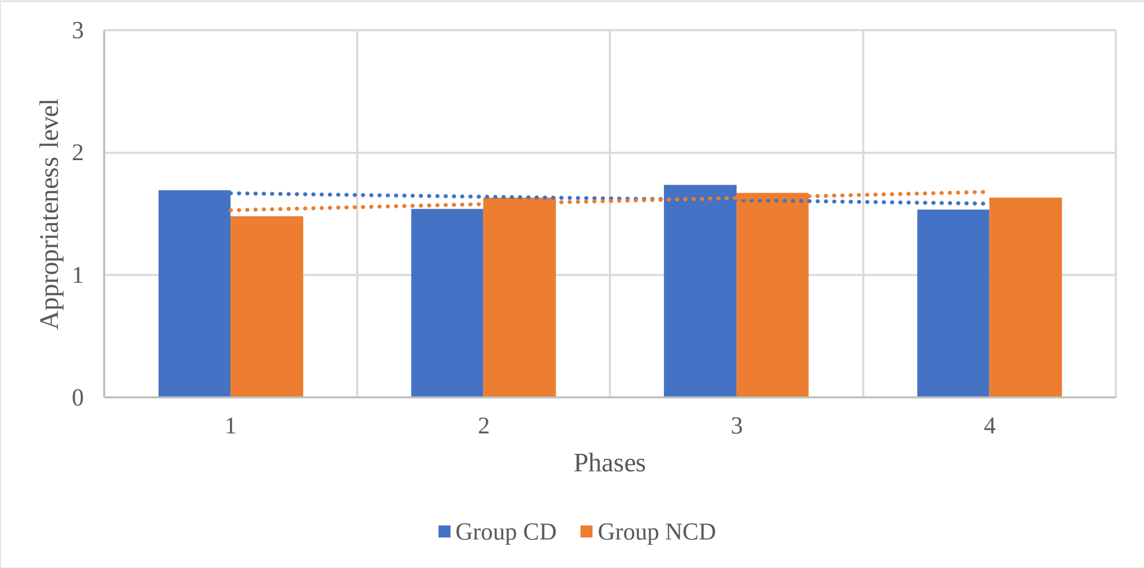
Note. Students without a communicative difficulty (Group NCD) are indicated through a grey background.

Note. Different student groups are separated through the black lines.

According to the visual inspection of the appropriateness dimension (Figure 10), both groups appear to average between level 1 and level 2. Both groups are thus task-appropriate throughout the entire task, but a considerate number of utterances are not specifically related to the content of the task (level 1). Following the trendline, Group CD seems to slightly decrease in appropriate level over time, whereas Group NCD seems to slightly increase.

Figure 10

Average Number of Appropriateness Levels per STEAM Task Phase



Analysis. The results of the Monte Carlo analysis (Table 7) did not confirm the difference between the groups (Mdiff = -.06, p = .935). The calculated means show a small difference in overall appropriateness level, which does not reach significance. Zooming in on the phase difference however, the Monte Carlo analysis show a larger difference in appropriateness level, almost reaching significance (Mdiff = .15, p = .072).

Table 7

Monte Carlo Analyses of the Appropriateness Dimension

	Phase 1	Phase 3	Phase 1-3		Overall		
	M	M	Mdiff	p-value	M	Mdiff	p-value
Group CD	1.69	1.74	.04		1.67		
Group NCD	1.48	1.67	.19		1.61		
Group CD – Group NCD			.15	.072		-.06	.935

Note. Group CD = students with a communicative difficulty, Group NCD = students without a communicative difficulty, Group CD – Group NCD = the difference between both groups

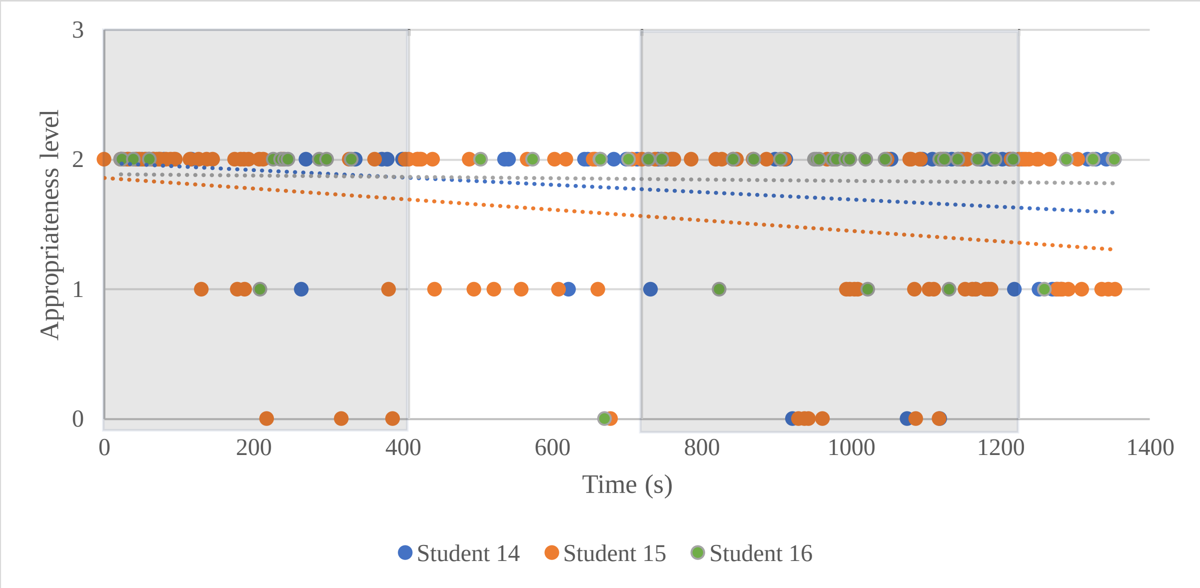
Note. Empty spaces in this Table are not selected for analysis. For example, the mean differences *within* groups (within Group CD and within Group NCD) are chosen not to be conducted for analysis.

Timeseries. Looking at the appropriateness levels of student group 5 throughout the task, as displayed in Figure 11, student 14 and student 15 seem to decrease in their level of appropriateness, as indicated by the trendlines. Accordingly, student 15 switches more frequently to lower levels of appropriateness, i.e., level 0 and level 1.

In accordance with the observed frequencies, high levels of appropriateness (level 2) occur throughout the session. There are no codes on level 3, which means that this group of students did not actually make explicit references to constructing a bottle organ. When comparing phase 1 with phase 3, phase 3 seems to be giving more space for lower levels of appropriateness, albeit student 15 with the majority of the codes.

Figure 11

Timeseries for Appropriate Levels of Student Group 5



Note. The duration of phase 1 and phase 3 are indicated by a grey square.

Summarized Results on Expression

Together, these results show support for the hypothesis that both students with as students without a communicative difficulty show creativity. The descriptive visuals already indicate that there are small mean differences between Group CD and Group NCD on both the novelty as the appropriateness dimension, indicating that this difference is too small. This observation is supported by the Monte Carlo analysis, as no significant result was found for both the overall analysis as the analysis between phase 1 and phase 3. Similar to subquestion 1, there are noticeably individual differences as visualized in the timeseries, however, conclusions about group differences cannot be drawn from this additional descriptive.

[4] Conclusion & Discussion

The main research question in this thesis was whether STEAM education, as expressed through using a STEAM toolbox, stimulates creativity expressions. To answer this research question, this study first analyzed whether the toolbox stimulated interaction and communication. It was expected that through participation in a collaborative STEAM task, both students with and without a communicative difficulty would show signs of interaction and communication. In other words, no significant difference was expected. Even though there seemed to be an observable mean difference, the statistical results showed no significant differences, in line with the expectation.

The second part of this study aimed to answer the question “does the STEAM toolbox stimulate creativity expressions?”. Creativity expressions were measured on two dimensions: novelty and appropriateness. For both aspects of creativity, no significant results were found, meaning that there is likely no clear difference between the groups. Similar to the first subquestion, these results are in line with the expectation that creative expressions in both students with and students without a communicative difficulty are stimulated.

The conclusion that can be drawn from this study is that STEAM education stimulates creativity in all children. The fact that the results did not show a significant effect was in line with our reasoning, as the hypothesis predicted that the stimulation of interaction, communication and expression was similar for all students while executing a collaborative STEAM task. In other words, no significant difference was expected. These results give an indication that engagement in a STEAM task would benefit not only regular students, but also students with a communicative difficulty. This might be a useful finding for practical implication, as teachers in special primary education perceive this type of education often as too difficult for their students (Geveke, 2021).

[4.1] Limitations and Directions for Future Research

Apart from the considerations described above, there are several limitations to acknowledge when interpreting the results.

A first limitation concerning the data is that the data is not entirely homogenous. That is, the content of the used video data in this study varies greatly on a number of criteria that must be mentioned. To begin with, not all student groups are of similar size, as some student groups consist of three students, while others have four. Group size, however, is a key aspect in the context of dynamic interactions and may influence the quality and intensity of group interactions (Tenenbaum et al., 2019). It might be easier for students to exert less effort than optimal in larger groups, while it is more difficult not to engage in smaller groups (Topping et al., 2017). This might also have been the case in this study, as there is always one student with considerably less utterances than the other two or three. To add to that, the STEAM task consists of four phases, but due to time restrictions during data collection, two collaborative student groups skipped a phase. This resulted in the fact that there was considerable difference in the time spent on the task. Groups that had longer automatically had more time to express themselves, which might have resulted in an uneven distribution and therefore different results in creativity.

Additionally, the small sample size is a limitation that must be mentioned. This study aimed at analyzing the stimulation of creativity throughout a STEAM task for two groups: students with and students without a communicative difficulty. The sample sizes, however, are not equal as Group CD is almost three times as large as Group NCD. Adding to that, this research has included a preliminary inspection of differences in levels of creativity within groups and within individuals by constructing timeseries. An interesting point for further research is to explore these dynamic patterns over time in more depth, as it gives the possibility for an analysis of individual creativity processes. Monte Carlo analyses can be used to give more information about individual trajectories, for example on the degree of creative variability (Lowie et al., 2017). The creation of State Space Grids (Hollenstein, 2007) might be a valuable addition, as it can explore the relationship between both dimensions of creativity. This can take research on creativity in STEAM tasks to an even higher level.

Thirdly, this study solely focused on utterances on both individual and group level. It must be recognized, however, that there might be other circumstances influencing the student participation such as the presence of a teacher. Initially, the STEAM toolbox that was used in the data collection was meant for groups of students to work on without teacher assistance. This appeared to be difficult in the groups of students who attended special education schools, i.e., the participants included in this study. As this research was aimed at analyzing creative expressions in each student, the influence of the teacher was omitted. Teachers, however, have an immensely important role in supporting student learning, and the presence of a teacher assistant might have influenced the number of utterances in students. There is increasing interest in the continuous interactions between teacher and student, hence a point of interest for future research might be to explore the influence of teacher interference on student creativity in a STEAM task.

To add to this, even though the results in this study indicated that there is no significant difference between students with and without a communicative difficulty, all students attended special education. These participants attended special education for (unknown) extra support needs, but not necessarily a communicative difficulty. As there are many forms of support needs (Ralph & Rochester, 2016), generalization to a broader audience should be taken with caution. Future studies could be directed at evaluating whether these STEAM activities would have the same effect for children with other support needs. Another interesting direction for future research is to see whether a difference can be observed between children attending regular education versus special education, as an observation can be made between special needs and typically developing children.

A last limitation regarding this study is that these results must be taken with caution when generalizing to the overarching STEAM approach. The STEAM toolbox used in this study is developed considering the STEAM principles, but that does not mean that it is transferable to STEAM education. These results do indicate that participation in a STEAM activity does stimulate student creativity, but this STEAM activity is not yet integrated in the overarching curriculum. A practical model for classroom implication is still to be developed (White & Delaney, 2021), but these results point towards useful implications of the STEAM principles.

To conclude, this study has primarily focused on the expressions throughout STEAM education as expressed through using a STEAM toolbox, giving an insight on levels of creativity in real time. This research has shown that creativity is stimulated in both students with and without a communicative difficulty throughout STEAM education. STEAM education, however, is a transdisciplinary approach under construction. The set-up of this study was aimed at providing a first inspection of the implementation of the STEAM toolbox for stimulating creativity, hence was chosen to perform simple analyses. More in-depth studies are necessary to further explore the effects of STEAM education. The results in this study can be explored and analyzed more extensively, as the data provides for extracting a richer collection of information than has been done in this study. By doing so, it can take a small step towards the overachieving goal in education: enhancing student participation and equity, so that all children are giving the opportunity to reach their optimal development, no matter their background.

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Appendix 1

Code book

Handleiding Codering

STEAM (Further) AHEAD

Handleiding voor het coderen van…

- Verbale en non-verbale leerlinguitingen
- Verbale en non-verbale creativiteit

… gedurende een STEAM-taak in de bovenbouw van het regulier en speciaal (basis)onderwijs.

Introductie

Deze handleiding heeft als doel richtlijnen te geven voor het coderen van verbale en non-verbale uitingen van leerlingen tijdens het uitvoeren van een STEAM-taak in de bovenbouw van de basisschool. De codering is bedoeld om verdere analyses wat betreft de mate van creativiteit van leerlingen mogelijk te maken. De coderingsschema's voor de focusleerlingen kunnen verderop in dit bestand gevonden worden.

Het coderen gebeurt in mediacoder (Bos & Steenbeek, 2017), een programma om videobestanden te coderen aan de hand van een codeerschema. Indien gewenst kan je een uitlegfilmpje kijken over het gebruik van het programma.

Intrainen

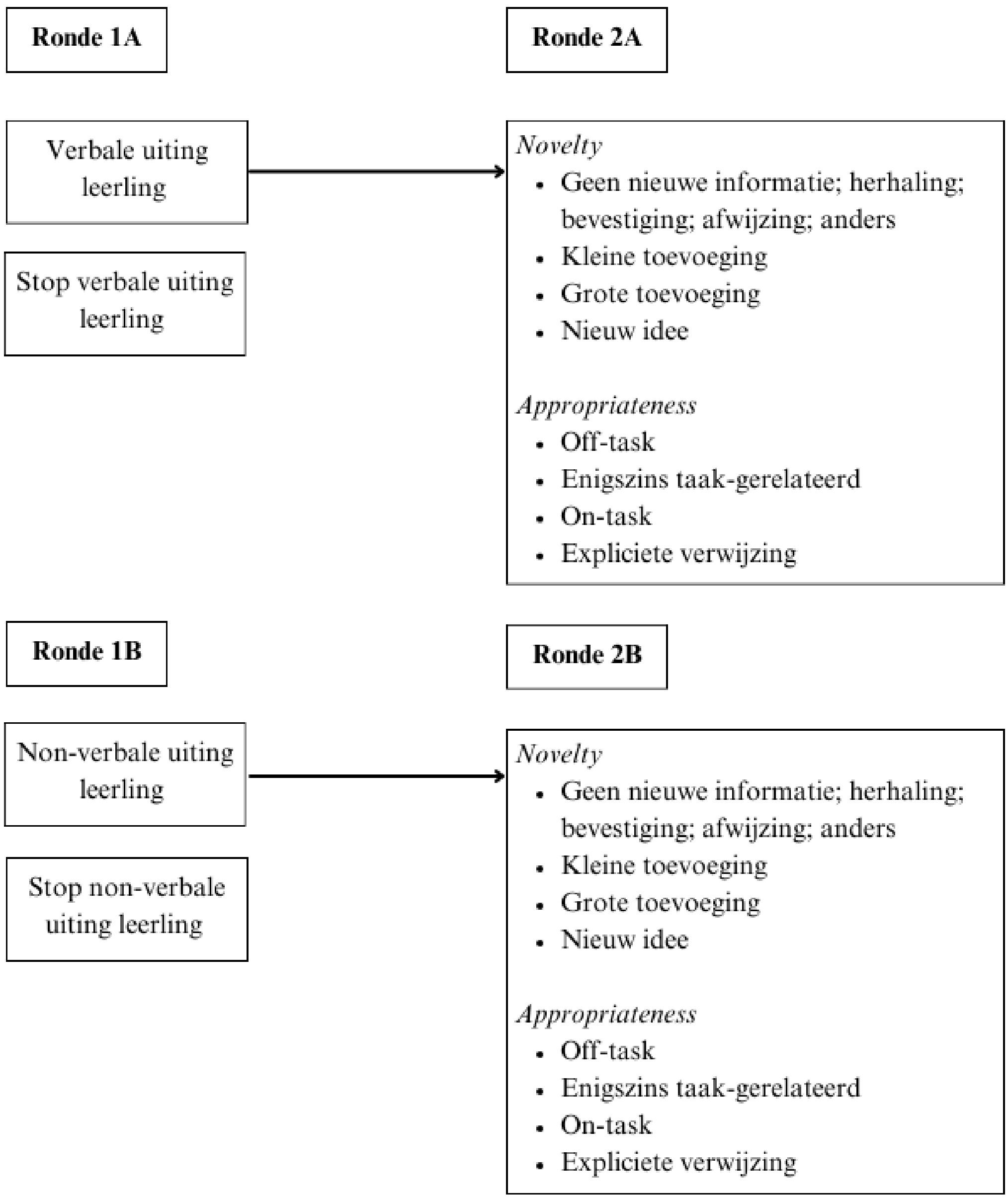
Als je nieuw bent met het coderen, of als je na een lange periode weer begint met coderen, begin dan met het coderen van oefenfragmenten. De bedoeling hiervan is om vertrouwd te raken met zowel het programma mediacoder als de codeerschema's die je gaat gebruiken. Hiervoor kun je bijvoorbeeld video's van youtube voor gebruiken waar het codeerschema van toepassing is.

Algemene aanwijzingen coderen

Voordat je begint met coderen kijk je de te coderen video opname helemaal af. Zo krijg je een goede indruk wat de taak inhoudt, en hoe de leerlingen zich uitten. Maak een logboek waarin je alle algemene indrukken noteert. Voorbeelden hiervan kunnen zijn dat de focusleerling even stil is, voornamelijk reageert op de vragen van de leerkracht, of even uit beeld is. De bedoeling hier is om opvallende afwijkingen te noteren, wat je eventueel in je analyse mee kunt nemen. De opnames verschillen van lengte tussen de +/- 20 minuten en +/- 40 minuten. Per video opname zijn er drie á vier leerlingen betrokken. Je gaat per leerling de uitingen coderen, en je doet dit gedurende de hele video.

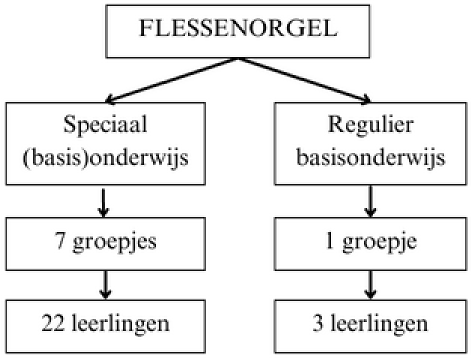
Begin met coderen vanaf de eerste leerlinguiting en eindig wanneer de laatste leerling een uiting toont met betrekking tot het spel. Als de leerkracht voorafgaand de toolbox uitlegt, worden de uitgelokte leerlinguitingen nog niet meegenomen in de codering. De eerste uiting dat uitgelokt is door het spel is vaak wanneer de eerste leerling een gesprekskaartje voorleest.

In de eerste en tweede ronde (ronde 1A en 1B) worden de uitingen op een basaal niveau gecodeerd. Dat wil zeggen, er is een verbale of non-verbale uiting of niet. Bij de derde en vierde ronde (ronde 2A en 2B) worden deze gedragsuitingen gecodeerd op mate van creatieve complexiteit. Hieronder een visualisatie van waar je op gaat letten tijdens het coderen.



Beschrijving beeldmateriaal

Het beeldmateriaal bestaat uit filmopnames van leerlingen die in groepjes van 3 of 4 een STEAM-taak uitvoeren. De inhoud van de STEAM-taak is ontwikkeld gedurende het STEAM (Further) AHEAD-project van de Hanzehogeschool Groningen (2021-2024). Eén van de taken is het maken van een flessenorgel, waarvan tot op heden opnames beschikbaar zijn van 8 groepjes leerlingen.



Naamgeving codeerbestanden

Je kunt voor elke codering dezelfde mediacoder codeset (.json) openen. Het is belangrijk dat je voor iedere focusleerling een eigen bestand met coderingen aanmaakt, en hierbij helpt het dat er een systeem in de naamgeving zit.

Als je (voorlopig) klaar bent met het coderen, gebruik het volgende format om de mediacoder bestanden op te slaan:

Codering_MC_STEAM_[taak]_[videonaam]_[focusleerling]_[onderwijstype]_[variabele]

Bijvoorbeeld

Codering_MC_STEAM_flessenorgel_Thirsa_1-1_SBO_UIT_V
(= filmpje 1 van Thirsa, leerling 1, leerlinguiting, verbaal)

Codering_MC_STEAM_flessenorgel_Thirsa_1-2_SBO_CRE_NV
(= filmpje 1 van Thirsa, leerling 2, creativiteit, non-verbaal)

1. **Coderen van verbale en non-verbale leerlinguitingen tijdens het uitvoeren van een STEAM-taak**

Korte Theoretische Achtergrond

STEAM

STEAM-onderwijs biedt de uitgelezen kans om leerlingen te laten samenwerken. Hiermee wordt er op een natuurlijke manier ruimte geboden voor leerlingen om te kunnen communiceren en interacteren. Communicatief kwetsbare leerlingen (bijvoorbeeld kinderen met een taalontwikkeling stoornis (TOS) of introverte kinderen) kunnen moeite hebben met het talige aspect van communicatie en interactie. Aangezien talige expressie een kernprobleem is bij deze groep leerlingen kunnen kunstzinnige opdrachten de mogelijkheid bieden om zich te uiten op een niet-talige manier. In STEAM-onderwijs worden verschillende disciplines aan elkaar gekoppeld, met de kunst als verbindende factor (Marmon, 2019). Uit onderzoek is gebleken dat kunstzinnige, expressieve activiteiten kunnen bijdragen aan het stimuleren van taal- en communicatievaardigheden bij kinderen die hier moeite mee hebben. Zo beargumenteren Johnson & LaGasse (2021) en Pitt & Welch (2020) dat muziekeducatie kan bijdragen aan de ontwikkeling van communicatie- en interactievaardigheden bij kinderen met een Autisme Spectrum Stoornis (ASS). Ook het gebruik van LEGO-stenen kan de taalontwikkeling stimuleren bij kinderen met een TOS (Ralph & Rochester, 2016).

Tijdens het uitvoeren van een STEAM-taak kunnen de variabelen communicatie, interactie, en expressie dus op zowel verbale als non-verbale uitingen geobserveerd worden. Door de aandacht af te leiden van de talige kant van het onderwijs door middel van een kunstzinnig, expressief element in de taak, zouden communicatie- en interactievaardigheden juist gestimuleerd kunnen worden.

Non-verbale uitingen kunnen herkend worden aan het inzetten van het lichaam van de leerling. Belangrijke indicatoren hierbij zijn gebaren, gezichtsuitdrukking, beweging

Unit of Analysis

In dit onderzoek wordt gedrag gecodeerd uit de uitingen van leerlingen. Voor iedere leerlinguiting wordt een nieuwe code (score) toegekend. De STEAM-taak lokt zowel communicatie en interactie tussen de leerlingen uit, als het creëren van een product (het flessenorgel). In dit onderzoek worden dus zowel verbale, non-verbale en een combinatie van beide uitingen gecodeerd.

De verbale uitingen worden gecodeerd wanneer de focusleerling een talige uiting doet. Dit kan dus een vraag zijn, een opmerking, een idee, ect. Ook een simpele ‘ja’ of ‘nee’ kan gecodeerd worden als verbale uiting.

De non-verbale uitingen worden gecodeerd wanneer dit een ‘betekenisvolle actie’ is ten opzichte van de inhoud van de taak (*meaningful actions*, Kupers et al., 2018). Belangrijke indicatoren zijn hierbij wanneer de leerling het lichaam gebruikt om bezig te zijn met de taak.

In het maken van een eigen flessenorgel kan dit bijvoorbeeld zijn dat de leerling een fles met water vult, met een stokje op de fles tikt, of de flessen op een bepaalde volgorde neer zet.

De combinatie van verbale en non-verbale uiting wordt enkel zo gecodeerd als de betekenisvolle actie wordt gecombineerd met een talige uiting. Een voorbeeld zou kunnen zijn wanneer de leerling zegt “we kunnen zo de sponsen neerleggen” terwijl de sponsen tegelijkertijd op die manier worden neergelegd door dezelfde leerling.

De Unit of Analysis zijn dus verbale, non-verbale, of een combinatie van uitingen die uitgelokt zijn door de taak.

Procedure coderen ronde 1A

1. Het coderen gebeurt per video opname, dus per groepje. Gebruik de codeset ‘Codeset_MC_STEAM(Further)AHEAD_UIT’, open deze in Mediacoder, en open daarnaast de te coderen video opname.
2. Kijk eerst de hele opname. Maak aantekeningen van je algemene indrukken of opvallende afwijkingen. Bijvoorbeeld: *Leerling 1 is t/m minuut 9 stil. Leerling 1 reageert voornamelijk op vragen van de leerkracht.*
3. Start met de eerste ronde codering: de **verbale** leerlinguitingen. In deze ronde codeer je (simpelweg) wie wat zegt en wanneer een uiting stopt.

Je begint met het scoren van de verbale uitingen van leerling 1. Markeer het begin van de verbale uiting met een (U of O) en het einde met een (S). Plaats de U of O precies aan het begin van de uiting van de leerling, en de beurt loopt door tot de uiting stopt. Plaats de S precies bij het eind van de leerlinguiting. Bij korte uitingen (bijvoorbeeld een simpele ‘ja’ of ‘nee’) zal je de stop-knop snel na de de verbale uiting moeten indrukken.
Er kan overlap zijn in de codering van de focusleerlingen. Het kan zijn dat leerlingen door elkaar (of door de leerkracht) heen praten. Zie het kopje ‘beslisregels’ voor verduidelijking.

4. Ga hiermee door tot de focusleerling de laatste uiting doet met betrekking tot de STEAM-taak.
5. Herhaal stap 1 t/m 3, maar dan voor leerling 2, leerling 3, ect.

Procedure coderen ronde 1B

1. Als je alle focusleerlingen op verbale uitingen hebt gecodeerd, start je met ronde 1B: de **non-verbale** leerlinguitingen.
2. Herhaal stap 1 t/m 5 uit ronde 1A, maar richt je dan tot de non-verbale uitingen.

Voor iedere opname codeer je in mediacoder in de eerste ronde **alle** leerling uitingen op basis van onderstaand schema.

Leerling uitingen			
Code	Label	Beschrijving van uiting/ gedrag	Voorbeelden
0	Geen uiting/ stopcode (S)	Leerling stopt de verbale of non-verbale uiting.	

1	Uiting (U), Off-topic (O) of Voorlezen (V)	Verbale of non-verbale uiting door een leerling dat wordt uitgelokt gedurende de STEAM-taak	*Pak een nieuw kaartje!* *Jij bent!*

Wat is een leerling uiting?
Een leerling uiting wordt gedefinieerd als een *on-task verbale of non-verbale uiting* van een leerling. Off-task uitingen scoren we als off-topic (O). Als er niet duidelijk te verstaan is welke leerling aan het praten is, coderen we deze als Anders (A). Soms komt het voor dat de leerling niet in beeld is, maar wel duidelijk te horen is dat deze leerling praat en wat de inhoud van de uiting is. Deze scoren we dan wel als een uiting.
We coderen álle leerlinguitingen die uitgelokt worden gedurende het spel. Dit kunnen dus uitingen zijn als initiatie of reactie op zowel een mede-leerling, de taak zelf (bijvoorbeeld voorlezen), of de leerkracht. Indien er een pauze wordt ingelast in de zin, maar er wordt niet doorheen gepraat, codeer je deze uiting als één uiting. Een leerlinguiting kan soms onderbroken worden als een ander reageert of door de zin heen praat. De uiting wordt gestopt als:

- De leerling zijn/ haar zin afmaakt, ondanks de onderbreking; *Bijvoorbeeld: Als een ander kind een snelle 'nee' of 'ja maar' door de zin gooit*
- De leerling reageert op de onderbreking van een ander. Dit kan betekenen dat de leerling overgaat op een nieuwe uiting, en deze codeer je dus als een nieuwe uiting.

Beslisregels leerlinguitingen

1. Kijk eerst of er sprake is van een on-task verbale of non-verbale uiting. Is de uiting off-topic, codeer dan een O.
2. Als er niet duidelijk te verstaan is welke leerling aan het praten is, codeer je deze als Anders (A). Als je wel weet welke leerling een uiting doet, maar je kan het niet (volledig) verstaan, codeer dan wel als een U.
3. Soms komt het voor dat de leerling niet in beeld is, maar wel duidelijk te horen is dat deze leerling praat en wat de inhoud van de uiting is. Deze scoor je dan als een uiting (U).

2. **Coderen van verbale en non-verbale creativiteit tijdens het uitvoeren van een STEAM-taak**

Korte theoretische achtergrond

Creativiteit op twee dimensies

Wat is creativiteit? Aan de ene kant vindt men iets creatief als het iets onverwachts met zich meebrengt, dat het iets nieuws of origineels meebrengt ten opzichte van wat er al bestond. In de creativiteitsliteratuur wordt dit ook wel het *novelty* aspect genoemd. Creativiteit vereist echter meer dan enkel de toevoeging van iets nieuws: creativiteit moet ook nuttig en bruikbaar zijn. Creativiteit moet dus ergens op slaan, en een passende oplossing bieden voor de taak of het probleem. Dit wordt ook wel het *appropriateness* aspect genoemd. Het concept van creativiteit wordt dus beoordeeld aan de hand van deze twee aspecten.

Creativiteit in basisschool STEAM-onderwijs

De ontwikkeling van creativiteit heeft een prominente plek gekregen in het huidige onderwijssysteem. Creativiteit is nodig om oplossingen te vinden voor de steeds complexere problemen in onze samenleving, waardoor het een essentiële vaardigheid voor onze toekomst is. STEAM-onderwijs biedt de uitgelezen kans om creativiteit van basisschoolleerlingen te stimuleren. Door verschillende vakgebieden te combineren, met de kunst als verbindende factor, worden studenten gestimuleerd om op een kunstzinnige en creatieve manier met die vraagstukken om te gaan.

Wat is dan de ontwikkeling van creativiteit in kinderen? In dit onderzoek is het belangrijk om te beseffen dat de creativiteit van kinderen op een ander level geanalyseerd moet worden dan de creativiteit van een expert. De creatie van Mozart’s muzikale composities is simpelweg niet te vergelijken met een kind die tijdens de muziekles op school een nieuwe melodie probeert te schrijven. Een belangrijk onderscheid dat hier gemaakt wordt is dat de creativiteit van kinderen op een andere orde plaatsvindt dan die van een creatief talent. Kinderen uiten hun creativiteit in hun leerproces tijdens het leren van een nieuw onderwerp (mini-c creativiteit), terwijl een expert (Big-C creativiteit) iets uitzonderlijks creatiefs heeft toegevoegd dat een grotere, maatschappelijke impact heeft (Kaufman & Beghetto, 2009). In een STEAM-taak wordt dit geoperationaliseerd aan de hand van mini-c creativiteit, dat wil zeggen dat de uitingen nieuw/ origineel zijn in referentie naar wat al eerder is voorgekomen tijdens de taak.

Procedure coderen ronde 2A

1. Gebruik de codeset [Codeset_MC_STEAM(Further)AHEAD_CRE], open deze in Mediacoder, en open daarnaast de te coderen video.
2. Voor het coderen van de mate van creativiteit gebruik je de gecodeerde verbale leerlinguitingen die je in ronde 1A hebt aangewezen als een U, O of V.
3. Start met de ronde 2A: het coderen van de verbale mate van creativiteit. Creativiteit wordt op de twee dimensies gecodeerd, namelijk op de mate van *novelty* en *appropriateness*. Begin met leerling 1: geef alle verbale uitingen een code uit het coderingsschema *novelty*.

4. Ga hiermee door tot je alle codes 1 (verbale uiting kind) van de focusleerling één van de codes hebt gegeven uit het *novelty* codeerschema. Herhaal dan stap 1 t/m 3, maar dan voor leerling 2, leerling 3, ect.
5. Wanneer je alle leerlingen hebt gecodeerd volgens het *novelty* coderingsschema, ga dan verder met de tweede dimensie van creativiteit: *appropriateness*.
6. Begin weer met leerling 1: geef alle verbale uitingen uit ronde 1A een code uit het coderingsschema *appropriateness*. Ga hiermee door totdat je alle leerlingen hebt gecodeerd op mate van verbale creativiteit.

Procedure coderen ronde 2B

1. Wanneer je alle focusleerlingen hebt gecodeerd op de verbale mate van creativiteit, begin dan met het coderen van ronde 2B: de mate van non-verbale creativiteit.
2. Herhaal stap 1 t/m 6 uit ronde 2A, maar richt je dan enkel op de non-verbale uitingen. Gebruik hierbij de non-verbale leerlinguitingen die je in ronde 1B hebt aangewezen als een U, O of V.

Coderingsschema voor de *novelty* dimensie			
Code	Label	Beschrijving van uiting/ gedrag	Voorbeeld
0	**Geen nieuwe informatie; Herhaling; Bevestiging; Afwijzing; Vraag; Statement; Reactie; Uitvoering van ‘opdracht’ Anders**	De (verbale of non-verbale) leerlinguiting geeft geen nieuwe informatie; is een herhaling van een vorige beurt; een bevestiging van een vorige beurt; of een afwijzing van een idee zonder een nieuw idee naar voor te brengen	*Wat staat erop dan?*
1	**Kleine toevoeging en/of variatie**	De (verbale of non-verbale) leerlinguiting bevat kleine toevoegingen en/ of variaties ten opzichte van een vorige beurt.	*Wanneer er materiaal wordt gezegd in een andere context, bijv. in 1-3 (+/- 00:20:02)*
2	**Grote toevoeging en/of variatie**	De (verbale of non-verbale) leerlinguiting bevat grotere verschillen ten opzichte van een vorige beurt, of meerdere elementen worden aan de uiting toegevoegd.	
3	**Nieuw idee**	De (verbale of non-verbale) leerlinguiting is een nieuw idee, initiatief, of voorstel. De uiting heeft geen overeenkomsten met een vorige	

		beurt. De leerling verwoord iets wat nog niet eerder is genoemd, gebruikt nieuw materiaal, of gebruikt het bestaande materiaal op een nieuwe manier dat nog niet eerder is gedaan.	

Coderingsschema voor de *appropriateness* dimensie			
Code	Label	Beschrijving van uiting/ gedrag	Voorbeeld
0	Off-task uiting/ gedrag	De leerling is met andere dingen bezig dan de taak.	
1	Enigszins gerelateerd aan de taak	De leerling is met de taak bezig, maar op een manier dat niet duidelijk relateert op de inhoud van de taak.	*Bezig zijn met spelbord bijv., of verzetten van de pion*
2	On-task uiting/ gedrag	De leerling is gefocust & geconcentreerd bezig met de taak.	*Bezig zijn met spelbord bijv., of verzetten van de pion* *Antwoorden op vragen van leerkracht/ gesprekskaart*
3	Expliciete verwijzing naar de taak	De leerling legt een link (verbaal of non-verbaal) via elementen die expliciet verwijzen naar de taak. *Link = expliciete verwijzing naar het maken van een flessenorgel*	*Deze, want die is hoger!* *En dan*

Beslisregels non-verbaal coderen

1. Het voorlezen van een gespreks- of hintkaart coderen we als on-task gedrag op de *appropriateness* dimentie, en wordt altijd als een 2.