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"Doing" mindsets in the classroom: A coding scheme for teacher and student mindset-related verbalizations

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Abstract: There is a growing body of research showing the crucial role that students' *growth* versus *fixed ability-mindsets* have in their school achievement, enjoyment, and resilience. The overwhelming majority of this research adopts a variable-oriented approach. As a result, little is known about how teachers and students co-regulate each other's mindsets within classroom interactions. This manuscript addresses the need for more person-oriented research that examines how teachers and students *do* mindsets in naturalistic settings, i.e., their mindset-related verbalizations. In this manuscript, we provide a coding scheme to study the moment-to-moment dynamics of mindset-related verbalizations of both teachers and students within Science, Technology, Engineering, and Mathematics (STEM) contexts: The STEAM (Student-TEAcher-Mindset) coding scheme. We demonstrate the utility of the coding system through content and ecological validity, inter-rater reliability, and a case study of STEAM-generated time-series data. We show how these data can be used to chart moment-to-moment dynamics that occur between teacher and student. The coding scheme provides teachers and researchers with a practical tool for analyzing how person-specific mindset-related language can wax and wane in the context of peer and teacher interactions within STEM lessons.

Keywords: mindsets of ability, implicit theories, classroom discourse, student-teacher interaction, observational research

Introduction

Teacher: "I don't think you did your best on this task"
Student: "No, I gave up too soon. I'll try it again".

Teachers and students communicate about, and interpret, failures and successes in everyday classroom interactions. In doing so, they enter a dialogue about the nature of "ability": Something that can be trained and improved with effort, or something that 'you just have' and will not easily change. Verbalizations such as those quoted above convey messages about the former, and correspond with an incremental theory of ability, or growth mindset. In contrast, verbalizations that focus on outcomes or stable person characteristics convey messages about the latter, and correspond with an entity theory of ability, or fixed mindset (Dweck, 1986; Dweck, 2010).

Students' mindsets are at the core of successful and enjoyable learning (Blackwell et al., 2007; Boaler, 2013; Dweck & Molden, 2005), as they correspond with different learning goals, and with different responses to setbacks. When children conceive of their attributes as malleable, they are more likely to have learning itself as a goal, which translates into how they deal with challenges. Children with growth mindsets tend to respond to setbacks by facing the challenge head on (Burnette et al., 2013; Dweck & Leggett, 1988; Dweck & Molden, 2005). In contrast, when children conceive of their attributes as more or less immutable, they are more likely to try to demonstrate their ability to themselves and others and to avoid challenges, as setbacks are seen as confirming one's inability (Burnette et al., 2013; Dweck & Leggett, 1988; Dweck & Molden, 2005). Not surprisingly, then, children tend to demonstrate more academic improvement – especially in challenging contexts – when they adopt a growth mindset (Blackwell et al., 2007).

Given the centrality of mindsets in learning, it is vital that we gain a deeper understanding of how these mindsets emerge and further develop. Recent findings suggest that adult language-use is pivotal for the development of children's mindsets (Gunderson et al., 2013; Pomerantz & Kempner, 2013; Rattan et al., 2012). Adults convey messages regarding the malleability of attributes – intentionally or not – in their interactions with children; and the kinds of messages that they convey have an important role in how children come to think about the plasticity of personal attributes (Gunderson et al., 2013; Pomerantz & Kempner, 2013; Rattan et al., 2012).

Prevailing methods used to study mindsets do not lend themselves particularly well to the study of how adult-child interactions socialize mindset development, however. This may be because a variable-oriented approach is most commonly adopted. Specifically, 'mindsets' are measured as (latent) variables, and the group-based relationships with other variables are the focus (Bergman, 2001). To this end, commonly used methods include self-report questionnaires to assess individuals' beliefs about attributes (De Castella & Byrne, 2015; Dweck et al., 1995) and imagined reactions in hypothetical situations (Rattan et al., 2012).

To be sure, the above research methods have been highly valuable in illustrating various kinds of fixed versus growth language (e.g., feedback, comments) that influence children's mindsets, as well as their behavior in learning and performance contexts. At the same time, children not only have mindset 'beliefs' that they can reflect on, but they also 'do' mindsets (Raeff, 2019). Indeed, it is at this level of 'doing' mindsets that children's mindsets are likely socialized, that is, through their mindset-related actions. Through revealing patterns of student-teacher mindsets as they are done in real-life situations, we can truly understand the bi-directional processes of mindset development that is of special interest for mindset research (Haimovitz & Dweck, 2017).

To understand how teachers and students affect each other in how they do mindsets in the classroom, a person-oriented approach is necessary (Bergman, 2001). In such an approach, the dynamics of change for individual students (and their interaction with their teachers and peers) is central, rather than central tendencies of a larger sample (de Ruiter et al., 2019). For such an approach, it is useful to conduct observational research of real-life interactions between teachers and students (Raeff, 2019; Reis, 2012; Schwarz, 2012), where one focuses on moment-to-moment mindset-related actions. Studying mindset-related actions in a systematic and reliable way requires a coding scheme. Currently there is no such coding scheme available to study naturally occurring mindset-related actions for both teachers and children (a scoring form that has previously been used is limited to assessing teachers' fixed and growth feedback; de Kraker-Pauw, van Wesel et al., 2017).

The current article presents a coding scheme, called the STEAM (Student TEAcher Mindset) coding scheme, which researchers can use to acquire detailed qualitative data consisting of mindset-related verbalizations for teachers and students, specifically.

Characteristics of the STEAM Coding Scheme

We outline the main characteristics of the STEAM coding system here. First, the STEAM coding scheme is designed to capture specific types of verbalizations that have been shown or theorized as being important for mindset development. For teachers, these are the verbalizations that influence students' mindsets. For students, these are the verbalizations that reflect their own mindsets. As such, the STEAM coding scheme consolidates available work highlights types of verbalizations as being 'fixed' or 'growth' related. These verbalizations include, but are not limited to just feedback. Our coding scheme thus provides an exhaustive taxonomy of theoretically relevant mindset-related verbalizations for teachers and students.

Second, the STEAM coding scheme is also designed to capture mindset-related verbalizations as they occur in real-life contexts to ensure ecological validity. This is vital, as mindset scholars increasingly acknowledge the need to assess mindset language in real-life contexts (Dweck, 2015; Haimovitz & Dweck, 2017), and test generalizability of findings obtained in controlled or imagined settings (Smith et al., 2018). Adding to its ecological validity, STEAM is also data-driven: it specifies how each type of verbalization can be recognized in the real-life context of a lesson.

Third, the coding scheme is intended for use in the context of STEM (Science, Technology, Engineering, and Mathematics) subjects. STEM subjects are highly relevant for the study of mindset socialization, as they may elicit fixed mindsets across time (Dai & Cromley, 2014; Scott & Ghinea, 2014), which can erode children's achievement levels and interest (Blackwell et al., 2007; Good, Rattan & Dweck, 2012). The coding scheme was developed in the context of math lessons, as a representative STEM context known for communicating the strongest fixed ability communication and thinking (Boaler, 2010), and often involves "right" versus "wrong" solutions that directly provide feedback to students about the successfulness of their performance (Boaler, 2013).

Overview of the Current Article

We begin with an overview of the theoretically relevant types of fixed and growth verbalizations for teachers and students based on extant literature. The overview includes verbalizations that convey mindset-related messages (intentional or unintentional). Next, we describe the process of developing the STEAM coding scheme, and include instructions for implementing the STEAM. Finally, we demonstrate the use of the STEAM coding scheme in a case study involving a primary-school classroom during a math lesson. Our demonstration concerns the moment-to-moment synchrony between teacher and student mindset-related verbalizations.

Overview of the Literature: Communication of Growth and Fixed Mindset in the Classroom

Teachers: Communication of Growth Messages

Teachers who communicate growth messages in class emphasize that intelligence and other characteristics are malleable (Boaler, 2013; de Kraker-Pauw et al., 2017; Sun, 2015). This can be communicated in diverse ways, but research has focused predominantly on how teachers provide feedback to their students, including praise or criticism.

Praise that conveys a growth message is often called "process praise" (Brummelman et al., 2013; Gunderson et al., 2013; Kamins & Dweck, 1999), but has also been referred to as "task-related praise" (Patrick et al., 2001) or "strategy-oriented praise" (Rattan et al., 2012). In providing process praise, teachers focus on the learning process of their students; the effort they made, the strategy they used, and the actions they showed. Thus, they praise for doing (de Kraker-Pauw et al., 2017). Teachers can also criticize the behaviors of students, called "process criticism" (Kamins & Dweck, 1999). Like process praise, process criticism is focused on what students do (de Kraker-Pauw et al., 2017).

Besides the feedback that they provide, teachers can communicate growth messages to students in several other ways. For example, teachers can provide feedback to students with regard to their strategies used while learning, that is, strategy-oriented feedback (Dweck, 2010; Rattan et al., 2012). This kind of feedback does not entail criticism or praise, but focuses on students' attention on their learning process. Also, teachers can react to students' failure in a way that conveys a growth message. A subtle way of doing this is by using the word "yet" in their reactions: "You can't do it yet" (Dweck, 2010; Park et al., 2016), communicating that failure does not indicate an immutable lack of ability. Furthermore, teachers may communicate that failures and mistakes do not need to be avoided, but are essential for learning (Boaler, 2013; Haimovitz & Dweck, 2016; Hooper et al., 2016; Sun, 2015).

Finally, a teacher who communicates a growth message in class teaches for understanding (Hooper et al., 2016; Sun, 2015). This can be done by bringing students' attention to their own thinking processes (Boaler, 2013). A teacher can focus on how outcomes have been achieved or can be improved (de Kraker-Pauw et al., 2017), such as by asking questions about the explanation behind an outcome (Sun, 2015), letting students revise their work (Hooper et al., 2016; Sun, 2015), suggesting alternative strategies (de Kraker-Pauw et al., 2017; Patrick et al., 2001), modeling strategies (Hooper et al., 2016), emphasizing shared accountability for success (Hooper et al., 2016), focusing on the progress that has been made (Dweck, 2010), or offering help to students when they get stuck while doing their work (Patrick et al., 2001). These aspects of communication are not necessarily 'feedback', but more indirect ways of directing students' attention to their learning process rather than the performance outcome.

Teachers: Communication of Fixed Messages

Teachers who communicate fixed messages in class emphasize that intelligence and other characteristics are unchangeable (Rattan et al., 2012). For example, they may communicate that students are either 'smart or not' (Boaler, 2013), and that performance levels tend to be stable (e.g., good performances will predict good performances in the future, and vice versa; Rattan et al., 2012; Sun, 2015). Again, most of the existing literature refers to how teachers praise and criticize their students.

Praise that conveys a fixed message is called "person praise" (Brummelman et al., 2013; Gunderson et al., 2013; Kamins & Dweck, 1999). Teachers who provide person praise do so by focusing on the personal characteristics of a student, such as by praising them for being "smart" or "fast" (Dweck, 2010; de Kraker-Pauw et al., 2017; Sun, 2015).

With regard to criticism, teachers can communicate a fixed message by criticizing the stable characteristics of their students, called "person criticism" (de Kraker-Pauw et al., 2017; Kamins & Dweck, 1999). For example, they may communicate that they are "disappointed" in a student (Kamins & Dweck, 1999). Teachers can also console students for their personal characteristics (e.g., "It's okay, you can't be good at everything you do"; Rattan et al., 2012), or group their students together by ability (Boaler, 2013; Sun, 2015) suggesting that there are "smart" and "less smart" students.

Aside from focusing on students' personal characteristics, teachers can also communicate fixed messages by focusing on students' performance outcomes, while ignoring the learning process that led to these outcomes (de Kraker-Pauw et al., 2017). They may do so by emphasizing students' grades, right answers, and ability (de Kraker-Pauw et al, 2017; Park, et al., 2016), or by communicating that failure leads to poor academic outcomes (Haimovitz & Dweck, 2016), and that mistakes should be avoided (Boaler, 2013).

Students: Communication of Growth Messages

Like teachers, students can also convey growth messages in the classroom, by communicating that traits are malleable, and that intelligence can be developed with effort (Bhattacharya & Mehrotra, 2013; Blackwell et al., 2007; Gunderson, et al., 2013; Haimovitz & Dweck, 2016; Mueller & Dweck, 1998; Rickert et al., 2014; Yeager & Dweck, 2012). They may do so through the attributions they make regarding their "successes" or "failures", and the amount of effort they invested (Gunderson, et al., 2013).

Most literature has focused on the attributions students make after failures or setbacks. This research suggests that students manifest a growth mindset after a setback by acknowledging that the setback is part of the learning process, and necessary for developing their abilities (Hooper et al., 2016). As such, a setback is attributed to something that can be changed, such as insufficient investment of effort (Gunderson, et al., 2013; Yeager and Dweck, 2012).

Through attributing setbacks to factors other than their personal, stable characteristics, students show resilience after failure (Kamins & Dweck, 1999), and are motivated to improve after a setback (Blackwell et al., 2007; Haimovitz et al., 2016). This can be manifested in behaviors such as working harder (Yeager & Dweck, 2012), generating new strategies for improvement (Blackwell, Trzesniewski & Dweck, 2007; Cimpian et al., 2007; Gunderson, et al., 2013; Kamins & Dweck, 1999; Yeager & Dweck, 2012), or persisting after failure (Kamins & Dweck, 1999; Mueller & Dweck, 1998). These behaviors are collectively referred to as mastery-oriented reactions to setbacks (Kamins & Dweck, 1999).

Students can also communicate a growth mindset through enjoying and taking a positive attitude towards challenges (Dweck, 2010) and learning (Mueller & Dweck, 1998; Murphy & Dweck, 2010). This can be observed through students' preference for challenging tasks (Gunderson, et al., 2013; Mueller & Dweck, 1998), working actively on personal growth goals (Bhattacharya & Mehrotra, 2013), and learning goals (Blackwell et al., 2007; Yeager & Dweck, 2012).

Students: Communication of Fixed Messages

Students who communicate a fixed message in class emphasize how traits are stable, and how earlier performances are predictive of later performances (Bhattacharya & Mehrotra, 2013; Kamins & Dweck, 1999; Mueller & Dweck, 1998). They may communicate this through attributing successes to "smartness" and setbacks to "dumbness" (Mueller & Dweck, 1998; Yeager & Dweck, 2012), not only with regard to themselves but also to others (Murphy & Dweck, 2010).

Most research regarding such attributions has investigated how students respond to setbacks. After failure, students who hold a fixed mindset often react with less resilience than students with a growth mindset (Kamins & Dweck, 1999). They do so because they view failure as indicating a lack of ability (Kamins & Dweck, 1999), lack of talent (Yeager & Dweck, 2012), or low intelligence (Cimpian et al., 2007). Students manifest a fixed mindset after failure through the expression of sadness (Cimpian et al., 2007), feeling ashamed (Brummelman et al., 2013; Rickert et al., 2014) or angry (Rickert et al., 2014), or quickly giving up (Yeager & Dweck, 2012). These behaviors are collectively referred to as a helpless reaction to a setback (Kamins & Dweck, 1999).

Where growth messages are communicated through positive responses to learning, fixed messages are communicated through negative responses to challenges while learning (Kamins & Dweck, 1999). This may include showing reduced motivation in the face of challenge (Rattan et al. 2012), preferring easier tasks over more challenging ones (Mueller & Dweck, 1998), avoiding tasks on which they performed badly in the past (Cimpian et al., 2007), putting less time into schoolwork (Rickert et al., 2014), cheating (Yeager & Dweck, 2012), or generally trying to look smart (Yeager & Dweck, 2012).

Development of the STEAM coding scheme

The development of STEAM was aided by the practical guide to the development of coding schemes outlined by Chorney et al. (2015). As we will describe below, steps 1 and 2 involve gathering and organizing relevant theoretical indicators for mindsets, and steps 3 and 4 involve an assessment of how these theoretical indicators can be observed in real-life empirical data. Note that, while we have chosen to describe these as progressive steps, steps 2, 3, and 4 were constantly being revisited based on decisions made at any given step. As Chorney et al. (2015) emphasized, the development of a coding scheme is iterative. Revisiting previous steps is necessary to ensure that the coding scheme sufficiently links theory with observations of real-life interactions.

Step 1: Deriving Global Theoretical Categories for the Communication of Fixed and Growth Mindsets in the Classroom

In Step 1, we organized existing literature into descriptions of fixed-related behavior versus growth-related behavior, and did so for students versus teachers – this was done in accordance with the global categorization of behavior from the overview of the literature above. This first step was vital for providing an initial theory-driven foundation for the coding scheme. The theory that was included in this step is broad by nature, including only a distinction between growth behaviors (i.e., verbalizations that focus on "effort, strategy, actions") and fixed behaviors (i.e., verbalizations that focus on "performance outcome, knowledge, person characteristics"). The literature review of these behaviors was conducted for teachers and students separately. This global distinction forms the first level of the coding scheme (see Table 1 and 2, "Growth" and "Fixed"). For Step 1, we deliberately approached the literature with this general theoretical framework as our aim was to be exhaustive. This broad theoretical distinction was then further specified into more refined sub-categories after examining the empirical data (Step 2).

Step 2: Deriving Sub-categories for the Communication of Fixed and Growth Mindsets in the Classroom

In this step, we organized the global "fixed" and "growth" behaviors from the literature overview into sub-categories (see the column "sub-category" in Table 1 and 2 for the final list of sub-categories). The aim here was to establish types of growth behavior and fixed behavior that have theoretical relevance (Chorney et al., 2015). This was thus done by studying the behaviors from Step 1 as they are described in the literature (and not based on observations of empirical data; revisions were made to the original set of sub-categories in Step 4 after contextualizing the sub-categories in the real-life empirical data).

Step 3: Deriving Initial Behavioral Indicators of Sub-categories for Fixed and Growth Messages in the Classroom

In Step 3, we aimed to ground the sub-categories (developed in Step 2) in naturalistic data using a new sample of data (see the section on Sample and Procedure below). The goal of this step was to assess whether and how observed verbalizations could be related to the theoretical sub-categories developed in Step 2, and to formulate preliminary operational definitions of the theory-based sub-categories (Chorney et al., 2015).

To this end, we methodically analyzed the filmed classroom interactions between teachers and students, and we attempted to assign each observed teacher and student verbalization to a theoretical sub-category, noting when a verbalization was not represented by a theoretical sub-category (which would indicate non-exhaustiveness of the coding scheme; Chorney et al., 2015) and when it was represented by more than one sub-category (which would indicate a lack of specificity; Chorney et al., 2015).

Regarding the former situation (i.e., non-exhaustiveness), when a behavior could not be placed in the original list of sub-categories, it was either listed as a possible "other" behavior (which includes in-class verbalizations that are not mindset related), or a new sub-category was created (for example, the sub-category "Preference for non-challenging learning" (a Fixed sub-category, code V) was added to the list after observing student verbalizations such as "it's too hard, I don't like it", which were mindset related but could not be placed in one of the original sub-categories). Regarding the latter (i.e., lack of specificity), when a behavior could be placed in more than one sub-category, we assessed whether it was theoretically justifiable to collapse the overlapping sub-categories into one sub-category or whether the description of the sub-category could be further clarified so that inclusion and exclusion of specific behaviors could be made clearer. For example, the current sub-category "Mentioning learning behavior" (Growth, code Y) was originally split into categories based on when the verbalization occurred (i.e., "while providing instruction" versus "in reaction to a student's performance"). These two were collapsed when, firstly, the distinction proved to be too subjective, and secondly, both sub-categories referred to the same verbalization content.

Sample and procedure

The two filmed math lessons that we used were observations of two female primary-school teachers, from two different schools in the Netherlands, and their students. Observations were done in the context of a larger research project concerning the dynamics of teacher and student mindset-related verbalizations during math lessons, for which approval was obtained from the Ethical Committee of Psychology at the University of Groningen. The teachers were nominated for participation by the principals of the schools who took part in the study, who thought they would be interested. Teachers then confirmed their interest and participated voluntarily. Both the teachers and the students' parents gave active informed consent to use the film material.

In one lesson (grade 1, or "groep 3" in Dutch), the teacher worked closely with two female students for approximately 30 minutes, after first providing general information in front of the class about the arithmetic task at hand (approximately 10 minutes). In the second lesson (grade 2, or "groep 4" in Dutch), the students all worked independently on their arithmetic task while the teacher walked around checking on students and responding to requests for help (approximately 30 minutes). This also followed a section in which the teacher provided information about the task to the class (approximately 15 minutes).

Both lessons were recorded in their entirety. The class was encouraged to behave as "normally as possible," and no educational situations were created for the study purposes. The teacher was given a microphone that was attached to the shirt, and two video cameras were placed on stands in corners of the classroom so that the interaction between teacher and student could be followed from different angles.

Step 4: Revisiting Theoretical Sub-categories for the Communication of Fixed and Growth Messages in the Classroom

In Step 4, we further developed and re-structured the theoretical categorization of the communication of fixed and growth mindsets based on the results from Step 3. We recursively visited Steps 2, 3, and 4 until theoretical saturation was reached, meaning that no verbalizations emerged that could not be exclusively and exhaustively categorized using the coding scheme.

Note that the constant back-and-forth between theory and observation ensures content validity of the coding scheme, as it involved a close examination of the mindset literature (Chorney et al., 2015; Suen, 2010). To further assess content validity, we also used expert consultation for the final version of the coding scheme (i.e., the third author of the current article and another independent researcher in the mindset field).

Step 5: Refining the Coding Scheme

We gathered information from challenges and disagreements that arose during the cyclical process of steps 3 and 4 to further refine the operational definitions, examples, and instructions to increase the clarity and usability of the coding scheme (Chorney et al., 2015). The resulting coding scheme and instructions can be found below.

The STEAM Coding Scheme

Tables 1 and 2 present the final STEAM coding scheme. The column "sub-category" outlines the different kinds of behaviors that fall within the global "growth" and "fixed" categories. These sub-categories were developed based on the literature, and further revised based on the real-life empirical data (as described in the section on the Development of the STEAM coding scheme above). The sub-categories as showed in Tables 1 and 2 thus describe the various ways that teachers and students can communicate growth and fixed messages in real-life classrooms. In the column "indicators", the final operational definitions for each sub-category are provided. These are accompanied by "examples" from the observational data. The "code" is the character used to indicate each operational definition in the process of coding—using such characters increases the speed of coding (and is necessary when using Mediacoder software for coding).

Table 1.
STEAM coding scheme for coding teachers

Category	Sub-category	Indicator	Example	Code
Growth (G): Statements about **effort, strategy, actions**	**Compliment for** learning behavior	**Positive judgements** about effort/strategy/actions after a task is done	*"Well done, you kept at it"* *"Nice try"* *"That's a good place to start"*	Q
	Criticism of learning behavior	**Negative judgements** about effort/strategy/actions after a task is done	*"You didn't do your best here"* *"No, that's the wrong place to start"* *"Wrong, this is a counting error"*	W
	Console for **mistakes**	Statements about **mistakes** as **good/not bad**	*"It's okay that you made this mistake"* *"You can learn from this mistake"*	E
	Statements about **change**	**Observe** or **predict** improvement or worsening	*"I see you're making improvements"* *"You did better last time"* *"You can't do it yet, but let's try again"*	R
	Attribute perfor-	Link performance outcome	*"This was a hard question"*	T

	mance to **external context**	with the attributes from **task** or **teacher**	*"Sorry, I didn't explain it clearly"*	
	Mention learning behavior **without positive/negative judgement**	**Ask about/suggest/describe/ show** effort/strategy/actions **without judgement**	*"Can you come up with a different approach?"* *"Just count aloud, maybe it helps"* *"I see that you're using a different strategy this time"* *"I will write it down, then you can see how I did it"*	Y
Fixed (F): Statements about **performance outcome, knowledge, person characteristics**	**Compliment for** person/ performance	**Positive judgements** about intelligence/capacity/trait or good performance	*"Clever girl"* *"You're a natural"* *"You're so fast"* *"Yes! That's the right answer"*	Z
	Criticism of person/ performance	**Negative judgements** about intelligence/capacity/trait or bad performance	*"This isn't your strong suit"* *"No, that is the wrong answer"* *"You're too slow"*	X
	Console for **person** characteristics	**Console** for intelligence/capacity/trait	*"It is okay, you're good at other subjects"* *"I am also bad at math, don't worry"*	C
	Statements about **stability**	**Observe** or **predict** stability	*"You got an A! I am sure you'll pass the rest of the course"* *"In the past you weren't so good at this. Maybe you shouldn't choose the difficult task"*	V
	Grouping/ labelling	Based on intelligence/ability/trait	*"Children from Group C, can you stay a little bit longer?"* *"I think Group C is going to find this difficult"* *"Group A can skip to page 8"*	B
	Mention performance outcome/ knowledge **without positive/ negative judgement**	**Ask about/suggest/describe/ show** performance outcome/knowledge **without judgement**	*"Did you get it right?"* *"What is the answer?"* *"The answer is 6"*	N
Other	Statement is **not growth/fixed**	Keeping order, structuring the lesson, small talk, unintelligible	*"Go back to your seats please"* *"You have 3 minutes left before the break"*	O

Table 2.
STEAM coding scheme for coding students

Category	Sub-category	Indicator	Example	Code
Growth (G): Statements about **effort, strategy, actions**	**Attribute positive** outcome to learning process	Link made between **positive outcome** and strategy/effort/action/ external factor	*"I practiced a lot"* *"I used the right tactic"* *"Thanks for your help!"*	Q
	Attribute negative outcome to learning process	Link made between **negative outcome** and strategy/effort/action/ external factor	*"I didn't have enough time"* *"I didn't know where to start for this"* *"I should have concentrated better"*	W
	Statements about **change**	**Observe** or **predict** improvement or worsening	*"I can do this better the next time"* *"I can't do it yet"*	R
	Positive about **challenges** and **learning**	**Positive statements** about mistake, challenge, finishing task	*"Yes! I see where it went wrong, I skipped a step""* *"I want to learn something new"* *"I just want to finish this task, one second"*	T
	Mention learning behavior **without positive/negative judgement**	**Ask about/suggest/describe/ show** effort/strategy/actions **without judgement**	*"Do you know how I should do this?"* *"I'll explain how to do it"* *"I added these two together"*	Y
Fixed (F): Statements about **performance outcome, knowledge, person characteristics**	**Attribute positive** outcome to person characteristics	Link made between **positive outcome** and intelligence/ability/trait	*"I just know this"* *"... because I am good at this"* *"I'm smart"* *"I'm a whizz kid"*	Z
	Attribute negative outcome to personal characteristics	Link made between **negative outcome** and intelligence/ability/trait	*"I'm just not smart enough"* *"I'm always really slow at subtracting"* *"... because I am bad at math"*	X
	Statements about **stability**	**Observe** or **predict** stability of performance	*"I won't be able to do it next time either"* *"I am going to fail the test. I always score low on this subject"*	C

			"I always get high marks"	
	Preference for non-challenging learning	**Negative statements** about mistake, challenge, finishing task; **positive statements** about no mistakes/completing task quickly/easy tasks	*"It's wrong? Oh no..."* *"It's too hard, I don't like it"* *"Do I have to finish all of it?* *"I quit!"* *"I didn't even have to count on my fingers!"* *"I'm so fast!"*	V
	Mention performance outcome **without positive/negative judgement**	**Ask about/describe** outcome	*"Do you know the right answer?"* *"I have 98"*	B
Other	Statement is **not growth/fixed**	Reactions to teacher's attempts to order or structure lessons, small talk, filler words, unintelligible, etc.	*"Sorry"* *"What did you say?"* *"I saw a giraffe in the zoo yesterday"*	O

How to Implement the STEAM Coding Scheme

Type of Observational Data

Audio or video data can be used when applying the STEAM coding scheme. Video data may be preferred, as these minimize the risk of unclear verbalizations.

Behavior Parsing

Codes are assigned to the smallest units of speech that have meaning. This method of behavior parsing is recommended because each utterance or verbalization may convey relevant information.

Coding Method

'Time-event-sequential continuous recording' is a form of 'continuous recording' that provides a particularly rich and comprehensive representation of the data (Chorney et al., 2015). This kind of coding registers the start time (i.e., 'point code') of relevant behaviors (e.g., utterances, verbalizations), thus generating an overview of their order of occurrence (but not duration). When coding utterances for which the duration does not have particular meaning, it is sufficient to note the point codes, rather than the start and stop time. This form of coding allows for analyzing frequencies and proportions (see Illustration 1) as well as the temporal changes across time (see Illustration 2).

Materials Required for Coding

To code utterances, it is either necessary to transcribe the observational data, or to use coding software. We used Mediacoder 2017, which is a free web application for annotating videos, written at the Behavioral and Social Sciences faculty of the University of Groningen. It can be used to assign codes from the researcher's coding scheme to the timeline of an online or local video file.

Training Coders

Coders were first familiarized with the general theory of growth and fixed mindsets (Dweck & Molden, 2005) and with the STEAM coding scheme. Coders then took part in two training sessions consisting of two hours each, led by the first author. In these workshops, a sample observation of a math lesson was used as a concrete case for the application of the STEAM codes. The trainer and coders observed the lesson in an utterance-by-utterance fashion, discussing for each teacher and student verbalization how it relates to the STEAM codes. In the first workshop, the emphasis was on showing the coders how to correctly apply the STEAM codes to real-life verbalizations. In the second workshop, coders worked as a group to apply the STEAM codes themselves. Coding each verbalization was done after discussion amongst coders and was followed by feedback from the first author.

Pilot and Demonstration of Implementation of the STEAM Coding Scheme

We formally piloted the STEAM coding scheme using a new sample (see Sample and Procedure below). As we will show in this section, the pilot includes the assessment of the inter-rater reliability and an empirical illustration of the kind of data that is generated using the STEAM coding scheme.

Sample and Procedure

The sample included a female teacher and a student from a grade 1 class during a math lesson. This sample was also taken from data gathered for the larger study mentioned earlier. Both the teachers and the students’ parents gave active informed consent prior to using the film material.

This sample was selected for the pilot because of the relatively frequent one-to-one interaction between the teacher and student. The lesson was approximately one hour long, beginning with 20-minutes of general instruction about the task. Afterwards, the teacher worked closely with this student and one other for the remaining 40 minutes of the lesson (for this demonstration we will focus on one student). Instructions and observation procedures were as described previously.

Assessing Inter-rater Reliability

Six researchers coded the new math lesson, for which inter-rater reliability was calculated. Inter-rater reliability was calculated using R studio (Version 1.1.456) with the Kappa2 package (Gamer, 2019). Cohen’s Kappa was calculated at the level of “sub-category” for teachers and students separately, with a Kappa of K = 0.76 for student verbalizations and K = 0.65 for teacher verbalizations. This indicates that a “substantial” amount of agreement between coders was reached (based on guidelines described by Landis and Koch (1977). A section of the coded transcript and the explanations for each code can be found in the supplementary materials (Table 3).

Empirical Illustration: Teacher and Student Mindset-related Verbalizations from Moment to Moment

The raw nominal data for the dyad can be seen in Figure 1 and 2. For the teacher (Figure 1), fixed-related feedback for the student’s outcomes accounted for the majority of mindset-related verbalizations (i.e., mention outcome without judgement = 47%), followed by the growth-related feedback for the student’s learning behavior (i.e., mention behavior without judgement = 35%). Regarding praise, offering fixed-related praise for outcomes or personal characteristics was given twice as often as growth-related praise for behavior (i.e., compliment for outcome/personal characteristics = 10%; compliment for behavior = 5%). With regard to criticism, both fixed-related criticism of outcome/personal characteristics and growth- related criticism of behavior accounted for only 1% of the mindset-relevant utterances. This was also true for fixed- related references to student grouping, or labelling, (i.e., grouping = 1%).

With regard to the student’s verbalizations, Figure 2 shows that the only type of mindset-related verbalizations that occurred were those that involved mentioning own performance (95%) or learning process (5%).

Figure 1.
Frequency distribution of the teacher’s growth- and fixed-mindset related verbalizations.

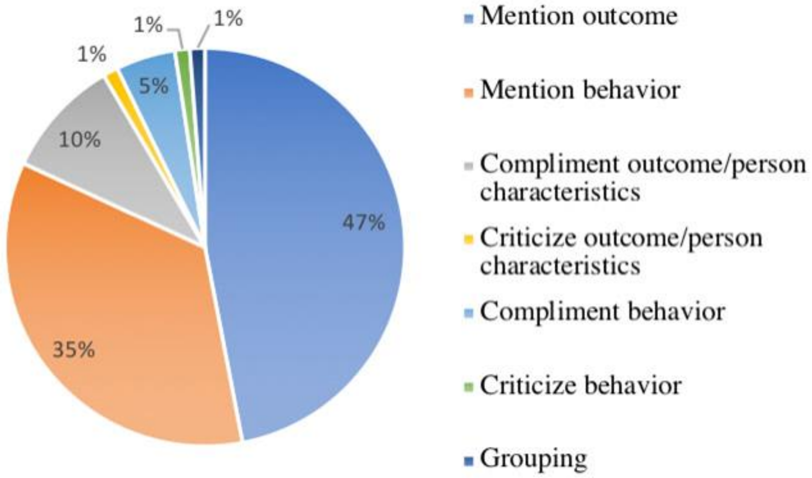
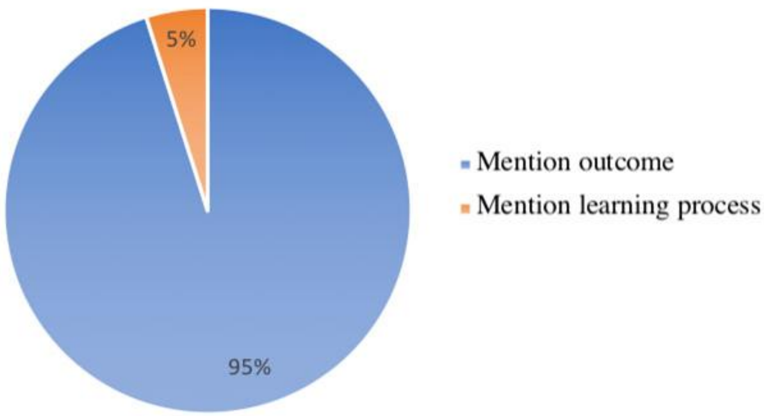


Figure 2.
Frequency distribution of the student's growth- and fixed-mindset related verbalizations.



To examine moment-to-moment dynamics of the above mindset-related utterances, it is useful to have ordinal (rather than nominal) data. For this, we collapsed the nominal data into a fixed and growth code. We gave these categories numerical values: growth = 1; fixed = -1, neutral = 0. These scores were then plotted across time for both the teacher and student.

To help make real-time developmental trends visible (both within- and between-person), smoothing techniques can be applied. The most common method used to smooth noisy time series is the LOESS technique (Cleveland & Devlin, 1988), which we will demonstrate here. LOESS smooths by conducting a regression within a small window of the time series. We did this in a window of 20 data points. The window is sequentially moved across the scores in the time series (i.e., a moving window), thus following the trend of the data (Chen et al., 2004). As the LOESS curve is drawn through fluctuations within a window, it also compresses the scale of the measures. The resulting smoothed time series are shown in Figure 3 below. The length of the time series was 172 points (i.e., events).

Figure 3.
Time series portraying the moment-to-moment dynamics of fixed- and growth-related verbalizations for one teacher and one student.

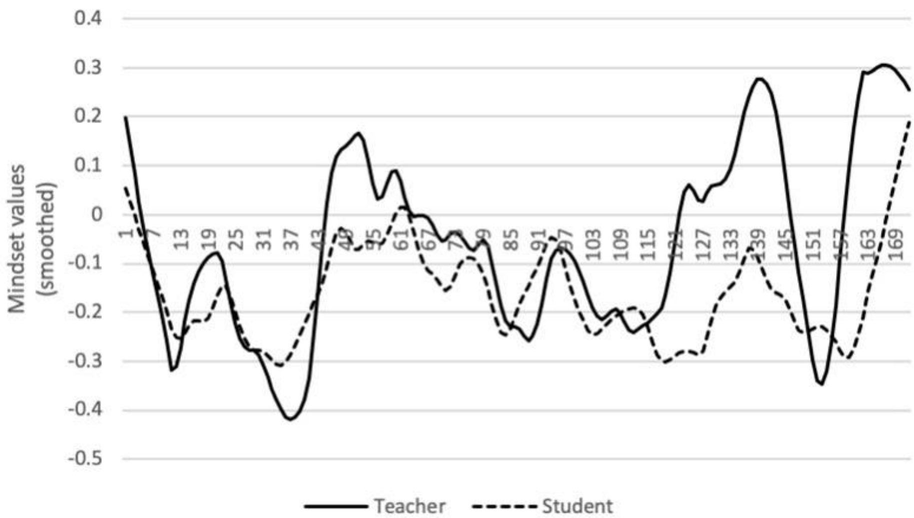


Figure 3 illustrates the dyad's mindset-related language during the interaction. First, it can be seen that the dyad spent the majority of the interaction engaging in fixed-related language ($y < 0$). Second, the trend lines for the teacher and student demonstrate a high sequential association, $r = 0.63$. Third, visually examining the time series reveals that it is not one individual that is 'leading' the fixed- versus growth language used. For example, at $x \cong 120$ and $x \cong 153$ the teacher leads in initiating more growth-related verbalizations (initiating an increase, with the student following shortly behind), whereas at $x \cong 95$ the student leads in initiating more fixed-related verbalizations (initiating a drop, with the teacher following shortly behind).

This form of time-serial data thus provides a way of analyzing the moment-to-moment process of co-regulation between teachers' and students' fixed- and growth-related verbalizations. This kind of information may allow researchers to ask questions such as: Are there moments in which the dyad becomes more synchronous in their mindset-related verbalizations, and if so when? Who is most often 'leading'? Does the interaction become more fixed- versus growth-related across the interaction? When?

Conclusion and Discussion

There is a strong need to better understand how children come to develop a fixed versus growth mindset, and how the development of a growth mindset can be encouraged (Haimovitz & Dweck, 2017). In this regard, the importance of concrete and real-life interactions between adults and students is increasingly acknowledged (Gunderson et al., 2013; Pomerantz & Kempner, 2013; Rattan et al., 2012). A method to systematically examine such interactions, however, has been lacking (Haimovitz & Dweck, 2017; Reis, 2012; Schwarz, 2012; Smith et al., 2018). The current manuscript introduces the STEAM (StudentTEAcher-Mindset) coding scheme for systematically studying student and teacher mindset-related actions in STEM-related educational contexts. STEAM allows researchers to study a comprehensive range of theoretically relevant verbalizations from both teachers and students that may occur in this context.

We have established both the content validity and ecological validity of STEAM, respectively. The former was achieved using expert knowledge about theoretically relevant categories of behavior through the literature review (Step 1; Chorney et al., 2015) and consultation with experts. The latter was achieved through the refinements made to the coding scheme after methodic analysis of sample observations of real-world classroom interactions. Finally, in our pilot, we established substantial inter-rater reliability.

Because we focused on context dependent mindset-related verbalizations, content validity and reliability are the most relevant criteria for scientific utility (Suen, 2010). The promising indices of content and ecological validity and of reliability that we found suggest that the STEAM coding scheme is now ready for implementation in future studies (Chorney et al., 2015). Future studies with both fundamental and practical aims can benefit from the STEAM coding scheme. It can be implemented in fundamental research in order to shed light on the underlying mechanisms for mindset development in children, and it can be used in applied research. For example, the coding scheme can be used to elucidate the way that students respond to teachers' mindset-related verbalizations in class (with regard to their learning behavior or their own mindset-related language), or how teachers help shape long-term development of mindset-related behavior.

To be able to use STEAM to measure more stable variables, such as the mindset beliefs that students or teachers have, researchers are encouraged to additionally assess construct validity before implementing the coding scheme (Suen, 2010). That being said, individuals' beliefs about the nature of abilities do not always correspond to their behavior (De Kraker-Pauw et al., 2017). Indeed, mindset-related actions are inherently contextualized in the immediate interaction, and in the case of adults, driven by theories regarding how best to motivate children (Haimovitz & Dweck, 2017).

To aid implementation of the STEAM coding scheme, this manuscript provides guidelines for the coding process, which address the type of data that the coding scheme can accommodate, behavioral parsing, coding method, and materials necessary for coding. The manuscript also illustrates the use of the coding scheme with a time-series demonstration of how researchers can examine trends across time (e.g., across a dyadic interaction, or a lesson) to potentially address questions of co-regulation and synchrony processes in the context of mindset-related language.

Because teacher-student interactions are pivotal for mindset development (Haimovitz & Dweck, 2017), we hoped to provide a means for researchers to more easily and systematically study relevant behaviors as they occur in situ. This is in line with recent empirical approaches to the study of social phenomena as inherently embodied, embedded, enacted, and dynamic (e.g., Bringmann et al., 2016; de Ruiter et al., 2017; Kupers et al., 2019; Lizdek et al., 2012; Nielsen, 2018; Schmittmann et al., 2013); which are firmly grounded in the sociocultural perspective (Vygotsky, 1978) and complex dynamic systems perspective (Thelen & Smith, 1994; Van Geert, 1994). We hope that the STEAM coding scheme will be a fruitful starting point for new lines of research investigating the dynamics of mindset-related action during teacher-student interactions, and the role of such interactions in the etiology of intelligence beliefs.

Author contributions

NDR conceived and designed the study, collected the data, developed the coding scheme, conducted the analysis, and wrote the paper. KVDK helped collect the data and contributed to the refinement and assessment of the coding scheme. ST provided feedback on the coding scheme and the paper.

Declaration of interests

The authors declare that there are no conflicts of interests.

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Supplementary materials

Table 3. *First 23 events (i.e., utterances and gestures) of the teacher-student interaction with corresponding codes and explanations. Translated to English by the first author.*

Transcript	**Code**	**Explanation**
Teacher: *Speaking to the class.* Plus-children, if you are finished with the assignment you can start making your plus-book. The other children can choose something from the math box.	*Fixed: Grouping/labelling (B)*	Divides the group into two subgroups: the 'plus-children' (who are good at math), and the 'other children'.
Teacher: *Speaking to Student 1.* Okay, do you see the beads?	*Other*	Introduces the task, without growth or fixed statements.
Student 1: *Nods head.*	*Other*	Reacts to the teacher's non-growth/fixed question.
Teacher: Which side are they on? This side or that side?	*Fixed: Mention performance/outcome without judgement (N)*	Asks for an answer. No attribution is given. No mention of strategy.
Student 1: *points to a side.*	*Fixed: Mention performance/outcome without judgement (B)*	Gives an answer to the question. No attribution is given. No mention of strategy.
Teacher: Hey, they are on that side!	*Fixed: Compliment for performance (Z)*	Repeats the correct answer with positive intonation.
Teacher: So, now I'll move some of them to this side, like this.	*Growth: Mention learning behavior without judgement (Y)*	Describes own strategy used for counting.
Teacher: Now you can tell me how many beads there are?	*Fixed: Mention performance/outcome without judgement (N)*	Asks for an answer. No judgement is given. No mention of strategy.
Teacher: *slides three beads to one side.*	*Growth: Mention learning behavior without judgement (Y)*	Demonstrates the strategy.
Student 1*:* Seven.	*Fixed: Mention performance/outcome without judgement (B)*	Gives an answer to the question. No attribution is given. No mention of strategy.
Teacher: How did you know so quickly?	*Growth: Mention learning behavior without judgement (Y)*	Asks student to describe strategy.
Teacher: Did you count five, six, seven maybe?	*Growth: Mention learning behavior without judgement (Y)*	Asks about the student's strategy.
Student 1: Yes, I did.	*Growth: Mentions learning behavior without judgement. (Y)*	Confirms the used strategy.
Teacher: That's great!	*Growth: Compliment for learning behavior (Q)*	Praises the student's strategy.
Teacher: *Speaking to Student 2 with positive intonation*. You also knew the correct answer.	*Fixed: Compliment for performance (Z)*	Praises the student's knowledge.
Student 2: I knew it super fast!	*Fixed:* positive statement about completing task quickly *(V)*	Mentions completing the task quickly with a positive intonation.
Teacher: Yes, you did!	*Fixed: Compliment for performance (Z)*	Praises the student's speed.
Teacher: Okay, watch. *Slides two beads, and another two beads.*	*Growth: Mention learning behavior without judge-*	Demonstrates a strategy.

	ment (Y)	
Student 2: Two!	*Fixed: Mention performance/outcome without judgement (B)*	Gives an answer. No attribution is given. No mention of strategy.
Teacher: Well, let's add two plus two…	*Growth: Mention learning behavior without judgement (Y)*	Shows correct strategy.
Teacher: It's okay to make a mistake, that's why we're here.	*Growth: Statement about mistakes as good/not bad (E)*	States that making mistakes is okay.
Teacher: Okay, we're going to practice this a little bit more.	*Growth: Mention learning behavior without judgement (Y)*	Suggests more practice, without positive or negative judgement.
Teacher: I'm going to help the others, and I'll be back with you soon.	*Other*	Structures the lesson.