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Fostering a growth mindset in secondary mathematics classrooms in the Netherlands

Marloes van Hoeve^{a,b,c}, Michiel Doorman^a and Michiel Veldhuis^{a,d}

^aFreudenthal Institute, Utrecht University, Utrecht, Netherlands; ^bInstituut Archimedes, Hogeschool Utrecht, Netherlands; ^cGoois Lyceum Bussum, Bussum, Netherlands; ^dIPABO University of Applied Sciences, Utrecht, Amsterdam, Netherlands

ABSTRACT

In a search for tools to support students to change towards growth mindsets, interventions were implemented by 17 teachers and their 512 students in 21 classes in 10 different secondary schools. The interventions consisted of classroom material explaining the theory of neuroplasticity and mindset to students, specific teaching methods, and student activities. Data were collected through a mindset questionnaire for students, interviews with students and teachers, and lesson observations. The change in average mindset scores of students showed a tendency to a more growth mindset after the interventions. More importantly, in the interviews and questionnaires right after the interventions, students and teachers indicated that their attitudes in the classroom with respect to mathematics changed, as became clear by their language use and their working with more trust and care. These findings indicate the importance of fostering growth mindsets to make mathematics accessible for all students.

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Growth mindset; the Netherlands; secondary schools; interventions

Introduction

The theory of mindset has the potential to bring a positive change in mathematics education, which could enable teachers to make mathematics less frustrating, while possibly also improving students' learning outcomes (e.g. Boaler, 2016; Canning et al., 2019). The mindset theory provides a method and language for analyzing mathematics lessons (Anderson et al., 2018; Simpson & Haltiwanger, 2017; Sun, 2019). Generally, mindset is defined as: "a person's way of thinking and their opinions" (Cambridge Dictionary). A mindset can be defined as an often unconscious and unexamined set of assumptions that frames our thoughts and actions. It is like a lens that we look through. Students can think "I will never be able to improve my mathematics" and have a feeling they will never succeed. Or they can believe they will never become a "math person". Such a mindset can harm students' self-esteem and motivation, and therefore makes them less capable of succeeding in mathematics (Boaler, 2019).

CONTACT Marloes van Hoeve  marloes.vanhoeve@hu.nl  Padualaan 97, 3584 CH, Utrecht, Netherlands

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Carol Dweck elaborated this idea of mindset. Based on twenty years of research, she distinguished two types of mindsets: a *fixed mindset*, you believe that you have certain talents that remain the same throughout your life; and a *growth mindset*, you believe that what you can do now forms the starting point from which you can develop (Dweck, 2006; Dweck et al., 1995). Her studies show the effects of these different mindsets on how students learn, especially in how they deal with challenges and obstacles. When students have a fixed mindset, they tend to avoid challenges. Students might say: “Suppose I fail, that will prove I cannot do it, and that I will never be able to do it.” On the other hand, students with a growth mindset seek challenges. The outcome is not the only important thing to them, they know and feel that it is important to practice. Students trust they can learn from their mistakes, that their brains are working, and can change (Boaler, 2016; Dweck, 2006). Individuals with a growth mindset believe that motivation can be nurtured (Ng, 2018). In other words, they believe that their attitude and beliefs can change. The stimulation of a growth mindset has also been found to lead to better performances on retention and transfer tests, resulting in better motivation and learning achievements (Xu et al., 2020).

Parents who say “I wasn’t a math person either” can heavily influence a student’s mindset. Also, the emphasis on performance in school systems, i.e. focusing on high grades, causes insecurity and tends to create a more fixed mindset (Dweck, 2006; Dweck et al., 1995; Mueller & Dweck, 1998).

Other research shows that teachers’ beliefs about the fixedness of ability may be an unwitting and overlooked barrier for students (Canning et al., 2019). This research showed that the racial achievement gaps in courses taught by fixed mindset teachers were twice as large as those in courses taught by more growth mindset teachers. The teacher’s mindset is also important when students in a classroom are categorised by level (Larina & Markina, 2020). Teachers with a fixed mindset tend to group their students according to their achievements. Also, when stereotyping, for example by gender or ethnicity, is taken into consideration (Campbell, 2015; Riegle-Crumb & Humphries, 2012), the effects of teachers’ beliefs and mindset can result in more students with a fixed mindset.

In the 2018 PISA report (OECD, 2019, p. 204), the Netherlands are in 51st place (out of 77 participating countries) with their mindset score, which is far below the OECD average. More than 50% of Dutch students believe that “their intelligence is a trait that they can barely change.” This can cause fear of failure, less motivation to finish assignments, and lower self-efficacy (OECD, 2019, p. 203).

For students and teachers alike, it is important to become aware of the effect of their mindset (Dweck, 2006). This awareness, in combination with relatively small social psychological interventions, can allow teachers to persuade students to adopt a growth mindset (Yeager & Walton, 2011). Teachers’ recognition of the mindset theory can change students’ mindsets and their beliefs and attitudes towards mathematics (Boaler, 2016, 2019).

During this research, we kept in mind that there are also studies that show that mindset interventions in general are not the magic silver bullet everyone is talking about. For example, Sisk et al. (2018) found, based on two large analyses, that there were only very weak correlations between mindset and academic achievement. An interactive mindset intervention, including reading and discussing, seemed to have only a

small effect on academic achievement. Burgoyne et al. (2020) found no support for an effect of mindset on motivation and achievement. They concluded that self-efficacy and need for achievement seemed to play a more important role. Both studies focused on school results in general, and not on mathematics specifically.

However, mathematics is eminently a subject in which mindset plays an important role. The following cultural elements contribute to a fixed mindset with respect to mathematics:

- Mathematics as a subject has a prestigious status and is related to certain stereotypes that are widely reported in the media (Hall & Suurtamm, 2020).
- Mathematical ability is seen as something you are either good at (a gift or talent) or not (Larina & Markina, 2020). For many people, students' mathematics grades are an indication of intelligence. In their study on the mathematical mindset of students and teachers, Anderson et al. (2018) concluded that there is a growing movement ready to debunk the myth that people are gifted with mathematical talents.

In sum, how mathematics is often framed, and how students experience mathematics in education, may contribute to rather fixed mindsets.

In this study, we investigate to what extent we can influence the mindset of secondary school students using interventions in their mathematics lessons, and how these interventions can help to improve participation, joy, and performance in mathematical activity. The main aim of this study is to gain new insights in the process of transforming fixed mindsets of secondary school students into growth mindsets during mathematics lessons.

To address the aim of the study, we formulated the following two research questions:

1. What is the effect of mindset-oriented teaching interventions on the mindset of students during mathematics lessons?
2. What is the role of the mathematics teacher during mindset-oriented interventions?

Mindset interventions can have an effect on mindset, performance, and motivation of the students (Boaler, 2016; Dweck, 2006). A recent study shows that a growth mindset is related to more engagement and better achievement in mathematics (Bostwick et al., 2019). After using different types of growth constructs, growth mindset, and growth goals (self-based and task-based), the students' grades in mathematics increased considerably. Also, small changes in mathematical tasks related to the mindset theory resulted in a rise in motivation levels, as measured by questionnaires and by neural correlates of motivation reflected in electroencephalograms (EEG scans: Daly et al., 2019). We expect that interventions that are more carefully constructed based on the mindset theory, in combination with extended mindset theory teaching, can have a significant effect on students' mindsets and their participation in mathematical activities.

Method

The research questions discussed in this paper were investigated in the Netherlands. The possibility to participate in this study was advertised in a nation-wide newsletter for

secondary mathematics teachers. In total, 17 teachers, with their 512 students in 21 classrooms, from 10 schools, participated.

The interventions were developed and implemented in the first years of secondary school (Grade 7, VWO, age 11-13) and in upper secondary school mathematics A classes (mainly Grade 10, HAVO, age 14-16).

The secondary school system in the Netherlands is streamed from Grade 7. It is a three-tiered system. Enrolment in secondary school is based on a state examination (“centrale eindoets”) taken at approximately age 11 in primary school. All schools in the Netherlands are government-funded. In this research we included the middle and the higher stream. The middle stream (labelled HAVO) is a 5-year programme with seven compulsory subjects. The highest stream (labelled VWO) is a 6-year programme with eight compulsory subject exams at pre-academic level.

The first group in this study, Grade 7 VWO students, was chosen because these students recently transitioned from primary school to secondary school. To get accepted at this VWO level, students must have been excelling at all subjects in primary school and may have been given labels such as “high performing,” which might be related to a more fixed mindset (Mofield & Peters, 2019). When they start their first year in VWO these students are in classes with all other “high performing” students. This can be an environment where their mindset can lead them to try fewer new things for fear of failure and to stop being seen as competent (Rimm, 2007).

The second group in this study consisted of Grade 10 HAVO students who had chosen the Mathematics A stream. In Grade 10, the mathematics curriculum is split into Mathematics A (preparing more for humanities studies) and Mathematics B (preparing more for science studies). As Mathematics A is often thought of as easier, these students often feel that they are not “a maths person.” This self-image might be related to a fixed mindset, and it is interesting to see whether this can be changed by the interventions.

Preparation of the teachers: the training event

Mindset research and interventions can vary from only one questionnaire (e.g. Huang et al., 2019), to some input from the teachers, like an explanation on mindset theory (Yeager & Dweck, 2012) to more elaborate interventions, which we tried in the current study. The fact that a change in the mindset of a teacher is an intervention in itself is only rarely investigated (Larina & Markina, 2020; Yettick et al., 2016). However, the effect of the change in teachers’ mindsets is important. Teachers who, for example, believe that their instructions can have an effect on students’ learning abilities tend to teach more effectively (De Kogel et al., 2019). Also, teachers who believe they can positively affect students are likely to do so (Hattie, 2018). Thus, to make a good start, the interventions began with a training event for the teachers.

The 17 teachers who were involved in the intervention joined a 5 h workshop at Utrecht University during which instruction on different elements of the interventions was given. Also, the teachers were taught how to work with their own mistakes in their classrooms; that it is better to acknowledge a mistake, to explain how a mistake is found, and to ask students to help to find mistakes and solutions. During the training event, the trainer also expressed her own doubts and mistakes, paying attention to the

importance of vulnerability. Being confident with making mistakes asks for vulnerability. This intertwines with the work on vulnerability as described by Brown (2019, p. 1):

You will learn that you are worthy of love, belonging, and joy every time you see me practice self-compassion and embrace my own imperfections. [...] We will share our stories of struggle and strength. There will always be room in our home (classroom) for both. [...] We will set and respect boundaries; we will honor hard work, hope, and perseverance. [...] You will learn accountability and respect by watching me make mistakes and make amends, and by watching how I ask for what I need and talk about how I feel.

The presentations from the training, the teaching material, and suggestions for further reading were shared online. Throughout the two months when the teachers performed the mindset interventions, there was a regular exchange of experiences, questions, and information through email with the teachers. All teachers were invited to use a notebook during the lessons with the interventions, either for themselves or for their students. These notes formed extra data for this study.

The mindset interventions

Many ideas for mathematical activities that invite students to develop a growth mindset are provided by Boaler (2016). Some of these interventions, especially the ones that are also described in the studies of Yeager and Walton (2011), Blackwell et al. (2007), and Hattie (2008), had been tested at the Goois Lyceum in 2016-2017. The Goois Lyceum is a secondary school in a small town in the Netherlands. The qualitative evaluation of this pilot of the interventions showed that there were three main elements that were valuable, easy to implement and could be accompanied by fitting tasks: (1) an introduction to the theory of mindset and the importance of neuroplasticity, (2) attention for the importance of learning from mistakes, and (3) classroom as well as individual growth mindset feedback (see Table 1). Below follows a more elaborate description of the interventions.

1) The theory of mindset and the functioning of the brain (neuroplasticity):

Although the theory of mindset is a psychological theory, it is supported by brain research in relation to the plasticity of the brain (e.g. Kania et al., 2017; Maguire et al., 2000; Van Der Helden & Bekkering, 2015; Woollet & Maguire, 2011). The connections between nerve cells, or neurons, can change throughout our lives. This allows the brain to grow a rich distributed dynamic network, creating opportunities to learn new things. This process is referred to as neuroplasticity. It is the capacity to learn, and to adopt new habits. For example, if you are nervous about an upcoming mathematics exam, through training you can learn to become more confident (Hanson, 2009). The field of neuroplasticity is relatively new, and fresh insights are obtained very regularly.

Table 1. Construction of the fitting tasks.

Intervention	Examples of fitting tasks
1. Theory of mindset and neuroplasticity	Starting lessons not with the explanation of new theory by the teachers but by giving good assignments so that students can deduce the new theory themselves.
2. Learning from mistakes	Group assignments with mistakes or "my favorite no"
3. Growth mindset feedback	Low floor / high ceiling tasks

Schroder et al. (2014) tested the effect of explaining neuroplasticity on undergraduate (age 18-20) students' performance on a task. They found that there was more cognitive engagement in the group of participants who had been told that intelligence is malleable in comparison with the group of participants who had been told that intelligence is immutable. Other studies show that inducing this growth mindset by teaching neuroplasticity can have an overall positive impact on motivation, achievement, and brain activity (Boaler, 2019; Sarrasin et al., 2018). Functional Magnetic Resonance Imaging (fMRI), a good method to gain insights into the relative activity of brain regions while performing tasks, has shown a significant positive correlation between growth mindset and intrinsic motivation (Ng, 2018).

During this part of the intervention, all teachers started a lesson with a presentation on the functioning of the brain and on the theory of mindset. The corresponding task was to present the students with a difficult assignment related to a mathematical theory that they had not been introduced to yet. The students might become frustrated, at which point students with a fixed mindset would be expected to give up sooner than those with a growth mindset. The role of the teacher was to regularly remind students to think about neuroplasticity and to invite them to approach the problem with a growth mindset.

An optional element to include was one minute of silence. In her book "Braindactics", Dirksen (2014) mentions the importance of focus, and how to strengthen this by practicing silence and mindfulness in school. Practicing mindfulness has been shown to help to alter the structure and function of the brain (Brefczynski-Lewis et al., 2007; Hölzel et al., 2011). This too can have an impact in the classroom (Hirshberg et al., 2020): being mindful can help reshape neural pathways associated with problem solving, focus, planning, and introspection. Thus, the minute of silence and extended mindfulness teaching can help to enlarge self-awareness and reduce anxiety (Martin & Green, 2017). The minute of silence was introduced in the presentation as an example of how students can learn to focus, and how they can improve their learning.

- 2) **Learning from mistakes:** When people are solving mathematical problems and an error occurs, it has been found that people with a growth mindset show more active brains than people with a fixed mindset (Boaler, 2016, 2019). When students with a fixed mindset do not immediately understand the assignment, they tend to think: "I am not smart, and other people might notice this." They get stressed, and stress hormones may prevent the formation of new connections between neurons (Dirksen, 2014). Students with a growth mindset on the other hand will approach obstacles as challenges (Boaler, 2019). They can see that making a mistake can be the beginning of learning something new, or as Chödrön (2019) writes "failure can be the portal to creativity, to learning something new, to having a fresh perspective." This insight makes them feel more confident, which puts the brain in a responsive mode, which stimulates new connections in the brain (Hanson, 2009).

This part of the intervention started with a presentation on mistakes and the role of mindset. The presentation was followed by an assignment in groups of four in which four different mathematical problems had to be solved. In this assignment, each student tries to solve one problem. When finished, without discussion, the calculations are collected by the teacher. Each group then receives four completed

similar assignments from the other groups. Students are tasked with finding any errors, elaborating on the calculations, and discussing the possible correct answers. The calculations with a wrong answer are categorised on the blackboard and evaluated with the class. Another fitting activity in this part of the intervention was “My favorite no” (Alcala, 2011). It is designed as a warm-up activity for the start of a class. The teacher writes a mathematical problem on the blackboard and hands out individual cards to each student. Students are asked to solve the problem and to hand in the card with their solution. When all cards are collected, the teacher quickly checks the solutions and divides the cards into two piles: one with the correct answer, the other with wrong answers. From the wrong answers the teacher selects the “most beautiful” mistake (a frequent mistake, a conceptual mistake etc.) which is then written down on the blackboard. Students are invited to comment on all the steps that had gone right, and then the mistake is discussed. Both the “find the mistake” and “teacher’s favorite mistake” exercises illustrate how making mistakes when solving mathematical problems can be valuable.

As part of the “Learning from mistakes” intervention the teachers were also challenged to look at their own coping mechanisms for mistakes. For example, how they felt while making a mistake and how they communicated this to their students. And how they themselves as teachers kept learning from mistakes. The teachers were also stimulated to pay close attention to their language while helping the students. This was done by using sentences like: “I want to understand your thinking process when you try to solve the problems, so that together we can discover what the next step is.”

- 3) **The use of growth mindset feedback:** It is important that teachers are aware of the feedback they give, especially when students make mistakes. It is not only the choice of words but also the way the feedback is conveyed; teachers should give feedback not on properties or features but on the process (Boaler, 2016). It might be great to hear that you are smart, however, it is a label that may lead to overconfidence, or self-doubt. Students who are told they are gifted may react more poorly to setbacks because they worry that mistakes, confusion or failures mean that they might lose their “gifted” label (Mueller & Dweck, 1998). Positive feedback on the process should be truthful; only when a student has persisted and worked hard, can they really appreciate to be complimented on this.

The attitude of the teacher is also important; when a teacher, from a fixed mindset, has the opinion that a student’s performance stays the same throughout the school year it can lead to stagnation (Boaler, 2016). On the other hand, when a teacher, from a growth mindset, believes that a student’s performance can grow students, have an easier time growing (Dweck, 2006).

At the start of this intervention, students were shown a short presentation on the importance of growth mindset feedback. They were then presented low-floor-high-ceiling tasks: easily accessible for all students, with plenty of opportunities for curious students to challenge themselves. An example was “What is the largest surface you can make with 36 pieces of fencing of 1 meter?” (Boaler, 2016). Students could start by drawing and calculating, and could end up using trigonometry. The teacher helped them by giving growth and constructive feedback and encouraging them to improve their solutions or ask new questions. Teachers were also encouraged

to be mindful of the feedback students gave each other. The way students talk about themselves can shed a light on their mindsets.

Procedure

Teachers participating in this study were asked – as a minimal requirement – to teach the previously described three interventions (see [Table 1](#)). Furthermore, they were asked to implement at least one growth-mindset task within each intervention. Some teachers also included the minute of silence. Finally, teachers were invited to examine their own attitude towards mistakes and to regularly practice growth-mindset feedback in their classroom. Throughout the interventions, there was email contact with the teachers, providing an opportunity to ask questions and make remarks.

To record our results, we relied on questionnaires, lesson observations, and interviews. To determine students' mindset, at the start and at the end of the interventions, they were asked to fill in a questionnaire. This questionnaire consisted of 25 statements that were taken from the literature of Blackwell and Dweck (Blackwell et al., 2007; Dweck, 2006). Students were asked to label their level of agreement to the statements on a 6-point Likert scale. The 25 statements were divided into four categories: mindset, belief in effort, response to failure, and learning goals. From these questionnaires, the relative effect of the interventions could be estimated in the different categories. Some examples of statements are:

Q1: You have a certain amount of intelligence, and you cannot do much to change it (mindset).

Q3: An important reason why I do my schoolwork is because I like to learn new things (learning goal).

Q16: If you must work hard for a subject, you are probably not very good at it (effort belief).

The final statements were preceded by the following text: “You start a new subject, and you really like the topic and the teacher. You think you know the subject quite well, so you don't learn for the test. When the test is done you think you have done well, even if there were questions that you did not know the answers to. Then you get your grade back, and your score is the lowest in the class. Indicate to what extent the reaction or conclusion that is stated would suit you:”

Q21: I was not clever enough (response-to-failure question)

The teachers also filled in questionnaires about their own mindset (during the training event) and about their experience with the interventions (after the interventions). During the interventions, at four (randomly chosen) schools, a lesson with the intervention was observed and students and teachers were interviewed about their experiences. In addition, at six schools, teachers interviewed their own students. All schools shared the results of the questionnaires.

Analysis

We used the sum scores of students on the questionnaires to quantify their tendency towards a growth or fixed mindset. Subsequently, we calculated the increase of the

average of students' sum scores of each class before and after the intervention. The interviews and lesson observation reports were analyzed from the perspective of the research questions. The notes were transcribed and coded. The coding was done in a combined deductive and inductive fashion. Codes were partly defined in advance, based on the interventions (e.g. neuroplasticity and mistakes) and partly emerged during analyses when a topic was mentioned by several students and teachers (e.g. the teacher and language). We selected representative quotations related to the three mindset interventions to illustrate and provide a deeper understanding of the patterns that we found in the questionnaires.

Results

All teachers had a full schedule, and it was often a challenge for them to include all elements of the interventions. Only the teachers and classes who performed the required minimal elements are included in this research. They came from 10 different secondary schools, labelled A to J. Some of them were already familiar with the mindset theory in their lessons (A, C and D), while for the others it was relatively new. The numbers after the letters refer to different classes within a school. The final numbers (7 or 10) refer to, respectively, the lower and upper secondary classes.

Student questionnaire

In [Figure 1](#), the mean differences in the total score of students on the questionnaire before and after the interventions are shown, giving a global impression of the effect of the interventions. In four classes (all from School C), the total scores after the interventions had gone down, which might indicate an increase in fixed mindsets and a decrease in belief in effort and learning goals and more negative response to failure. In

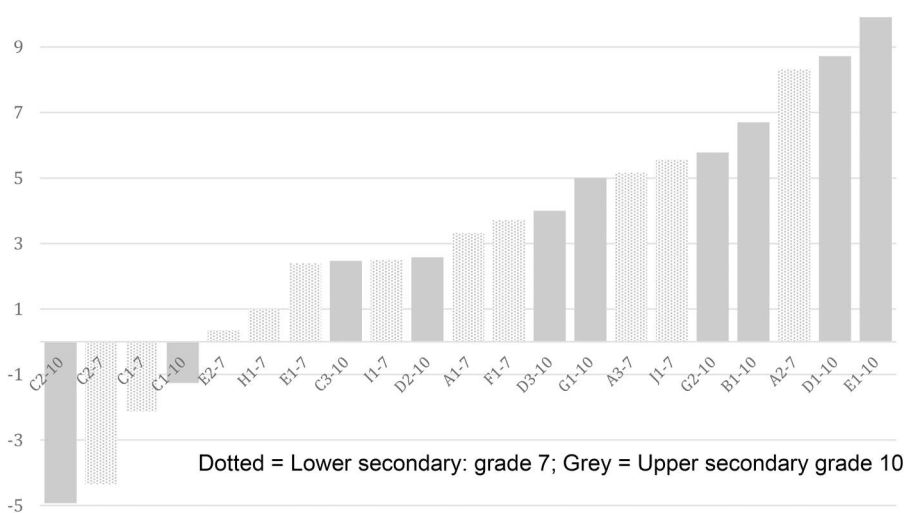


Figure 1. The mean differences in the total scores per class on the questionnaire before and after the intervention. Dotted = lower secondary classes; grey = upper secondary classes.

the remaining seventeen classes, the overall scores went up, which might indicate more growth mindsets and more belief in effort and learning goals and a more positive response to failure. In both Grade 7 and Grade 10 classes, the trend was similar, with two classes with lower scores after the interventions and respectively nine and eight classes with higher scores.

Two of the negatively affected classes had teachers who were already very familiar with the concept of mindset, and the overall scores of the students were already high at the start. It might be that it is harder to notice differences or improvement while these students are on a different, more advanced, point in the learning curve of mindset. The other two classes had novice teachers for whom class management was sometimes challenging. Schools A, D and E, with the most positively affected classes, had teachers that were very enthusiastic about the theory of mindset. They put a lot of effort into the interventions and used the theory on as many occasions as possible. Classes in School A, C and D made intensive use of the minute of silence.

In Table 2, the average scores on the different scales are given for the two grades. The effect of the interventions was most clear for the mindset score (e.g. + 3.1 for the Mindset scale in Grade 7). For both Grade 7 and Grade 10, the post intervention mindset scores were higher ($t(764) = 2.495, p = .0141$). A small, but non-significant, effect of effort belief can be detected, which can be related directly to mindset. The two other scores, learning goals and response to failure, showed a, non-significant, negative difference, meaning that these two elements appeared not to be affected by the interventions. It might be that both working with learning goals and response to failure need more time to be integrated. Also, as one student stated: “I did learn that mistakes don’t matter, but I still don’t like making them.”

In Table 3, changes in individual students’ score patterns show a significant change in mindset score compared to the other scores. The change towards a growth mindset is largest in Grade 7 classes (67.5%). The change towards response to failure is lowest in the Grade 10 classes. Is this a skill that young students learn faster than older ones? One student (School C) said: “So far I could do mathematics intuitively. Now that

Table 2. Results of the pre- and post-test (the questionnaire before and after the mindset interventions) on the different categories (Grade 7 $N = 246$, Grade 10 $N = 137$).

Categories	Grade level	Pretest		Post-test		Difference
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Mindset	Grade 7	27.8	6.8	30.9	6.6	+3.1
	Grade 10	27.1	6.2	29.0	7.0	+1.9
	Total	27.5	6.5	30.2	6.8	+2.6
Learning goals	Grade 7	16.2	3.4	15.6	3.8	-0.6
	Grade 10	14.3	3.6	14.8	3.7	+0.5
	Total	15.5	3.6	15.3	3.8	-0.2
Belief in effort	Grade 7	28.8	3.4	29.0	3.7	+0.2
	Grade 10	27.3	3.3	27.8	3.8	+0.5
	Total	28.2	3.5	28.5	3.8	+0.3
Response to failure	Grade 7	38.8	4.9	38.8	5.0	0.0
	Grade 10	37.5	5.4	36.9	5.8	-0.6
	Total	38.4	5.1	38.1	5.3	-0.3
Total score	Grade 7	111.6	12.9	114.2	12.8	+2.6
	Grade 10	106.3	13.2	108.4	14.8	+2.1
	Total	109.7	13.2	112.1	13.8	+2.5

Table 3. Results of the changes of the individual students.

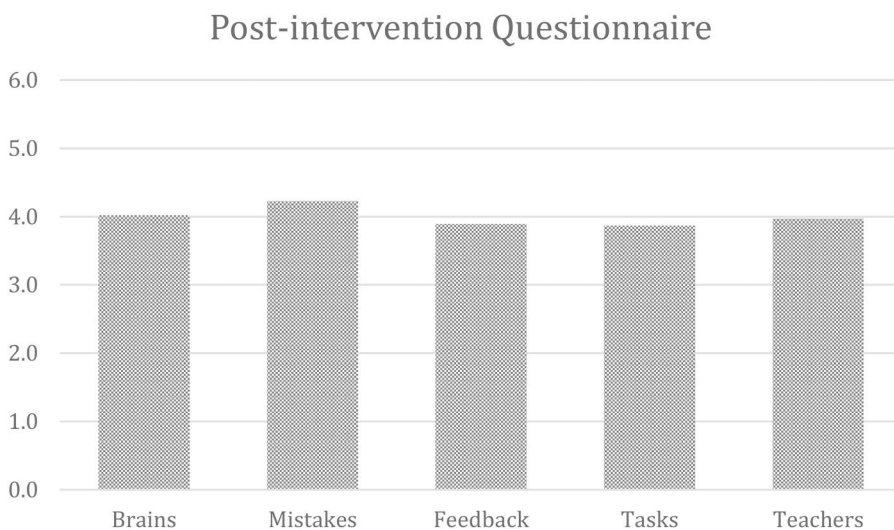
Change on	Percentage of changes* overall	Percentage of changes per grade
Total score	39% negative change 5% no change 56% positive change	Grade 7: 39% negative, 6% =, 55% positive Grade 10: 42% negative, 2% =, 56% positive
Mindset score	29% negative 7% no change 64% positive	Grade 7: 26% negative, 6% =, 68% positive Grade 10: 34% negative, 10% =, 57% positive
Learning goals	45% negative 14% no change 40% positive	Grade 7: 50% negative, 16% =, 34% positive Grade 10: 37% negative, 11% =, 52% positive
Believe in effort	39% negative 15% no change 46% positive	Grade 7: 43% negative, 12% =, 45% positive Grade 10: 34% negative, 19% =, 47% positive
Response to failure	45% negative 14% no change 41% positive	Grade 7: 42% negative, 16% =, 42% positive Grade 10: 52% negative, 11% =, 37% positive

* a negative change is a change towards a fixed mindset; a positive change is a change towards a growth mindset.

does not work anymore, I do need a roadmap. I do need to practice to understand the problem, and to remain confident despite making mistakes. And this is new to me.”

The post-intervention questionnaire for the students included questions about which intervention they valued most (see [Figure 2](#)). Also, another category was included which is intended to measure the value of the teacher’s change in mindset. Scores could vary from 1 to 6; with a standard deviation varying between 1.28 for the tasks and 1.37 for the mistakes. The figure indicates that the interventions on neuroplasticity and mistakes were appreciated more. In addition to the interventions, the teacher’s change in attitude towards the mindset of the students (indicated as “Teachers”) was also valued.

Eight teachers filled out the post-intervention questionnaire. They were asked which interventions they valued most, and which elements they would keep using. All teachers were very positive about “the lesson on mistakes” and the tasks. They would keep using

**Figure 2.** Post-intervention questionnaire; rating of the interventions by the students.

“the lesson on mistakes” and “the lesson on feedback.” The minute of silence (an optional part of these interventions) was highly valued in three schools because of its small effort and large effect. One of the teachers explained: “It marks the start of a new way of thinking in our math class and by doing this every lesson, we stay focused on our mindset.”

Interviews, notes, and lesson observations of students and teachers

In addition to the questionnaires, students and teachers were interviewed, and lessons at four schools were observed. Teachers kept notes and shared interesting details or questions with the researcher via email. This resulted in a large data set of approximately 375 quotes from students and teachers.

All citations were coded with topics related to this study. The first four numbers are the interventions, the other six numbers refer to important elements related to the interventions.

- (1) **neuroplasticity:** In three schools, students made important remarks on the intervention on neuroplasticity, providing insight into their experience. One student (School I) remarked that she learned a lot from the intervention on mindset and neuroplasticity: “More things happen in my head than I thought.” Students and teachers from School G highly valued the PowerPoint with the information on the brain. The teacher of School D advised an underachieving student: “Try talking out loud to yourself and explain what you do and why. If you cannot explain it fluently, maybe some important links are missing.” Both the teacher and the student experienced that explicitly teaching the theory of mindset and the role of neuroplasticity and explaining the importance of struggling helped students persevere.
- (2) **mistakes:** In the general rating (see [Figure 2](#)), as well as in the interviews and notes, this part of the intervention was much appreciated, by students as well as teachers. After the interventions, one student (School G) made the following remark: “I did learn that mistakes don’t matter, but I still don’t like making them.” This gives an insight into the complexity of working on mistakes. The teacher from School G said that the interventions considerably changed her teaching practice; she felt she valued the making of mistakes more. While her lesson with this intervention was observed, she started by explaining the benefit of learning through trial and error. She said: “Your mistakes are more valuable if you know where you went wrong and when you analyze your mistakes.” After a classification of the mistakes, she asked “What have you learned from these mistakes?” One student answered, “I realize that I simplify too quickly.” In School D, during a class discussion, the teacher heard one student say: “Wow, that is a beautiful mistake, our brains are growing.” Here again, we see how giving new words to feelings and emotions on learning helps the students. A teacher from School E explained that “he learned how he could refer to his own mistakes more consciously and that he could be an example for his students in how to deal with them”.
- (3) **feedback:** Although students did not comment on this intervention very often, the teachers often did refer to it. For example, a lesson in School E was observed just after the interventions. Although the teacher had explained the theory, some students still used fixed remarks. For example, one student whispered, “You are so

stupid,” and another student said to himself “I am so dumb.” The teacher talked with these students about the words they used and reminded them of their effect. The effect of feedback is further seen in (6) the teacher and (8) language.

- (4) **tasks:** In all schools, the interventions were accompanied by specific tasks. The teacher in School G really enjoyed the low-floor-high-ceiling tasks. She commented that not all mathematical subjects were equally suitable for this approach (e.g. statistics appeared difficult). The teachers at School E liked to start their lessons with difficult assignments. Some students took it upon themselves to start immediately using different strategies. Others found it hard to start at all. The teachers could now explain how this division is related to mindset, and invited all students to be confident that they could learn, to work with a growth mindset, to enjoy solving problems and to start working without fear of making mistakes. After this, the teachers reported that the assignment with the mistakes was very much appreciated and that the students became very passionate.
- (5) **effort belief:** An important role in the mindset theory is reserved for trust in perseverance while working with a growth mindset. A student from school I said that the interventions helped her to learn. “I often thought that I was unable to learn something new, but because of the mindset theory I learned to persevere to ask others for help.” A student in School G said, “I must stop doubting myself. Instead, I can persevere or try again later.” The teacher stated that the interventions changed her teaching practice considerably, for example, she started to give students more time to think about solution procedures. In School A, the teacher kept a notebook on her desk. She encouraged her students to write, during the lessons, about what and how they were thinking. The remarks from the students were very insightful. For example, a student wrote, “I don’t understand, I quit, it will never work, I don’t get it ... oh wait, what if I just stop right now and try again later.” The students’ reflections on their mindset were also evident. One student wrote “Once I start playing down this exercise in my head it gets easier.” From these notes, she could see how the students reflected on their thoughts and how they really worked on their effort belief.
- (6) **teacher:** In all schools, students made remarks on their teachers, and their role in their changing mindsets. A student in School C noted: “If the teacher does not show that he has faith in me, it is harder for me to have faith in myself.” From the interviews in School G, it was evident that students valued all interventions because of their content and because of the growing changes in their teachers’ attitudes. The teacher at School E reflected on an experience during a lesson. During class, a student complained that she had made a “stupid” mistake. The teacher told the student there are no stupid mistakes. But at the same time, this teacher noticed himself thinking it was a clumsy mistake. So, while communicating with his student about growth mindset, he was experiencing his own fixed mindset. He felt that awareness and reflection are the start of changing his own attitude towards mistakes and his own mindset.

Among the students in School D, there was one high achieving, but very insecure student. His mindset had been influenced by a remark a primary school teacher had made many years ago: that he would probably never succeed. During the interventions, the secondary school teacher gave him a poem, to inspire him to begin with

changing his thoughts: “*Watch your thoughts; they become words. Watch your words; they become deeds. Watch your deeds; they become habits. Watch your habits; they become character. Watch your character, for it becomes your destiny*” (Outlaw, 1977). The student told the teacher later that he felt empowered that a change could start with changing his own way of thinking. The teacher in School D emphasised his role in setting an example; he started to refer to his own mistakes more consciously and he felt that he could be an example for his students in how to deal with them.

- (7) **different effect on different groups:** Remarkably, in School G, among students with an extremely high score on growth mindset, there were two students from a minority group who had relatively low grades. This goes against the hypothesis of this research, namely that students learning with a growth mindset achieve higher scores. The teacher asked herself, “Do cultural differences play a role?” These students rarely asked questions. They seemed very independent and did not think they needed help.
- (8) **language:** During the interviews at all schools, students as well as teachers described the importance of a new language. For example, a student in School C noticed that learning about mindset is like learning a new language. A teacher said that subtle differences in communication in the class motivated students to work harder. Instead of saying “I cannot do it,” they said “I cannot do it yet.” And the classroom felt so safe that students even started to give their teachers feedback: “Sir, this feels like fixed feedback.” After class in school E, the language used in the classroom was discussed. Not only the teacher reminded herself of growth feedback, the students also did so towards their peers and towards themselves. They said that mindset does not seem to be something that can be fixed easily; it is a constant work in progress. The teacher was also more aware of her motivation for her didactic choices. For example, she started to use the online learning tool Socrative more often. Using this tool, students’ mistakes became more visible, which led to important classroom discussions.

An indication of the delicacy of the work came from the following observation (School C): a student explained how the teacher tried to downplay an exercise by saying “We will do this quickly.” But for this student, the task was challenging and time-consuming, and he felt disregarded by the thought that it could be done “quickly.” By doing so, the student referred to the lesson of the teacher on the importance of deep thinking over fast thinking. Many students believe doing their tasks quickly indicates they are intelligent. However, the opposite is more true (Boaler, 2016). Also in School G, although many elements of the interventions were included (students were motivated to try learning through failure, and there was a lot of growth feedback), the language of the teacher subtly disempowered her message. She used the word “maybe” a lot, which made her seem unsure of her own instructions and teaching. The teacher of Class 2E learned to be very supportive with her use of language which could be seen in phrases like “the way you do this is very creative” and “you are doing a great job.” During the lessons in School I the teacher often used the phrase “For a bit/for a moment.” She learned that this phrase could weaken her message and she started being more careful using it. For example, instead of saying “Please be silent for a moment,” she would now use “Be silent for the coming 20 min

of self-work time.” Here the interventions led to a subtle shift in words to clarify communication and to strengthen her teaching.

- (9) **mindset outside the classroom:** The effect of the interventions was not restricted to the mathematics classes. In School E, for example, the teacher noted: “I know it will take some time before this whole theory of mindset is really embedded, such that it becomes a habit.” He stated that the interventions should last longer, and that they should not be restricted only to mathematics. Another teacher said she also tried to use the theory when talking with colleagues about students during report meetings or in the corridors.
- (10) **minute of silence:** In three schools (A, C and D), this element was included. In School D, during one particularly chaotic lesson, one student commented “Teacher, we have forgotten our Zen-moment” (referring to the minute of silence). And on another day, when a student was trying very hard to understand something, meanwhile getting more and more agitated, a fellow student said: “Just be silent for two minutes, so your brain has some rest, afterwards you will probably succeed.” This illustrates how much the students valued this moment of silence.

Conclusion and discussion

Overall, we can see the interventions had two separate effects. Firstly, they appeared to directly influence students’ mindsets. Secondly, they also seemed to affect the way teachers think, and their mindset, which also affects the classroom and indirectly influences students’ mindset.

1. What is the effect of mindset-oriented teaching interventions on the mindset of students during mathematics?

The student questionnaires showed a general increase in growth mindsets after the mindset interventions (Figure 1). In both low and high grades, the mindset scores of four classes decreased and the scores of seventeen classes increased, with no clear difference between Grade 7 and Grade 10 classes.

When completing the post-intervention questionnaire, students knew what the desirable answers were and therefore, might tend to have biased answers. On the other hand, these questions have been used extensively by Dweck (Dweck, 2006; Dweck et al., 1995), and the high internal reliabilities of the measures that were obtained across their studies suggest that this is not a problem.

When zooming in on the different scales (see Tables 2 and 3), the increase in scores was most evident in the questions on mindset. Also, the questions on effort belief, which can directly be related to mindset, showed a clear tendency towards a growth mindset (Tables 2 and 3). Important elements in this belief in effort were perseverance (mentioned for example by a student from Class I1) and the importance of practice (promoted by a teacher from School D). This “tendency towards growth” was less evident from the questions on “learning goals” and “response to failure” (Tables 2 and 3). “Learning goals” was not an integral part or separately mentioned during this research, which may be an explanation for its negative difference. Burgoyne et al. (2020) also found little

relation between mindset and learning goals. “Response to failure” was an integral part of the interventions and it is remarkable that there is nearly zero (Grade 7) to negative (Grade 10) change post intervention. Response to failure is a sensitive topic. Especially in higher grades, in this case the HAVO mathematics A stream, where students’ beliefs can be more set, response to failure might be hard to change. One student commented: “Even though I am taught that it is good to make mistakes, so that we can learn from them, it still feels uncomfortable.” This certainly needs further attention.

The results from individual students (Table 3) showed a more pronounced change towards a growth mindset in Grade 7 classes. This might be related to their younger age and more moldable brains (e.g. Laube et al., 2020). This would mean that it is worthwhile to start mindset interventions early on in secondary school. The change towards response to failure is lowest in the Grade 10 classes, which might be explained by more sensitivity to making mistakes in higher grades of the proximity of summative feedback. Older students might have the feeling they should know by now.

All four elements of the interventions were appreciated (Figure 2), though the lessons on feedback and the tasks were valued less. The effect of the intervention on feedback was probably more related to the role of the teacher and language, which follows below. The role of the tasks was further investigated in more detail in a separate article (see Alpar & Van Hove, 2020).

In one of the schools (G), there was an instance in which minority students scored high in growth mindset but had low grades. In general, Dutch teachers tend to underestimate the performance level of minority students. Students’ performances have been found to be less vulnerable to such stereotyping threats when they were taught about the mindset theory (Anderson et al., 2018; Aronson et al., 2002; Canning et al., 2019; Van Den Berg et al., 2010). The role of stereotyping and mindset is a challenging research subject that should be elaborated on, also with respect to the Dutch school system.

When students are not aware of their own mindset, whether it is fixed or growth, it is difficult to change it. Awareness and reflection are important tools to start changing one’s mindset and to choose a growth mindset while learning mathematics. The minute of silence can help students to raise this awareness. In three schools, experiences with this minute were successful, but more research is needed to reflect on this in more detail.

2. What is the role of the teacher in the teaching of mindset?

Both students and teachers noticed that the mindset of the teacher already switched to a growth one immediately after the training event. This was somehow unexpected, as research indicated that teacher and student mindset are not so closely related (Yu et al., 2022). However, the results show that attending such an event can already contribute to a change. Furthermore, this research highlighted the effect teachers can have on the outcome of the interventions. Porter et al. (2022) found similar results of the importance of the teacher’s role in delivering the mindset message during core English, mathematics or science classes.

Heyder et al. (2020) noted that if teachers have less trust in the mathematics capacities of their students, students are less motivated. In our study, the attitude and effort of the teachers towards the interventions influenced the mindset of the students. Also, the amount of awareness teachers gained about their own mindset in teaching served as a

good example for the students in how to practice with the mindset theory. Those teachers who were very open to learning new things, and who were aware of the importance of their teaching (as inferred from their attitude during the training event, and from the interviews), had more of an effect (see [Figure 1](#), Classes D and E). Although all teachers that joined the programme were very enthusiastic, it was a challenging process to learn new methods and to keep reflecting on one's own process.

Teachers played an important role in the elements “effort belief” and “response to failure.” To keep practicing, to endure, to make mistakes, to learn from them, reflect on them, and be open about them; these are important elements of mindset. All teachers in this study have worked with these elements, and students found this inspiring (see [Figure 2](#)). At times, both teachers and students also remained uncomfortable with making mistakes. However, the fact that teachers showed more of their mistakes and were more vulnerable was appreciated highly by the students. The Latin word for “thinking” is “cogitare”, which is a combination of “co” (together) and “agitare” (set in motion) (Ferguson, 2019). Thus, already in ancient times, thinking and moving together (student and teacher) were seen as two things that depend on each other.

Sikh et al. (2018) concluded that interventions consisting only of the theory being explained by a teacher did not have an effect. However, the more interactive the intervention was, for example including reading and discussing, the more effective it was. Our interventions consisted of several elements; a training event, presentations and tasks, class visits, and interviews. This gives a more complex and complete picture of how the interventions can be done, and how many aspects are involved.

The mindset theory can be very comforting. The fact that people can always change, and that students can always learn, is an encouraging thought. However, there are indications that the success of the interventions depends on the extent to which teachers are willing to be vulnerable and to surrender themselves to the theory of mindset. For example, teachers must be confident with making mistakes. The teacher of Class E1 said, or maybe admitted, that he observed having a fixed mindset more often than he wanted. Reflecting on this requires honesty and vulnerability. Teachers who are more set in their own beliefs will automatically gain less from the interventions. Thus, instead of labelling we need to be aware of these terms, these traits, and their effect. Many people believe that the mindset theory is quite superficial: growth mindset is good, and fixed mindset is bad. However, as Dweck (2015, p. 2) states, the distinction between fixed and growth is very nuanced and changing from one to the other is hard. She says:

Let's acknowledge that we're all a mixture of fixed and growth mindsets, we will probably always be, and if we want to move closer to a growth mindset in our thoughts and practices, we need to stay in touch with our fixed-mindset thoughts and deeds.

She adds that we need to watch our reactions, something we can practice while being silent.

Students and teachers reported that an important element in the mindset theory is language. It takes time to get adjusted to the usage of growth (encouraging) feedback, both for students and teachers. The impact of language is huge. A teacher from Class C2 trying to downplay exercises by, for example, saying “We will do this quickly,” or “This is something I already explained last year,” can unintentionally frustrate the students. Rattan et al. (2012) showed the effect of the mindset of teachers on their students,

in the form of soothing words. Teachers trying to be helpful, for example by saying “It’s ok, not everyone can be good at math,” unintentionally discourage their students. Also, the words the students use are indicative. When teachers are more aware of the language their own students use, they can help them being aware of fixed remarks and change them (as was seen in School A and E). By helping students change their words, teachers also influence students’ self-talk, their attitude, and their mindset.

Can the tendency towards a more growth mindset score also be explained by the relatively simple nature of the questionnaires or by wanting to please the teachers by filling in the (clearly more desired) growth mindset options? Many aspects of mindset are far-reaching and difficult to measure. We have to look deeply at the beliefs of students and teachers, how they play a role and how they can be changed. Also, we have to keep in mind that mindset plays a role mainly during moments of frustration (which can be part of the mathematics lessons). Mindset scores should be measured during this period of frustration; however, no student wants to fill in a questionnaire when he or she is frustrated. Thus, it is always something that is done while reflecting on actions in the past.

In didactic research in general, the differences in teachers, students, and school context make it difficult to formulate clear causal relations between interventions and outcomes. In addition, our results might be biased by working with teachers who were intrinsically interested in the mindset theory. By explaining the positive effects of these interventions also to teachers who are more skeptical, even more progress could be obtained. Finally, we must be careful not to generalise the outcomes of this research. However, we can use the results as guidelines from which to work out individual or classroom interventions.

Recommendations for practice

Despite the limitations of our study, we found promising ways to support students in developing a growth mindset towards mathematics. We invite all teachers to use the small interventions introduced in this study. Tell students about neuroplasticity, invite them to make and learn from mistakes, and use growth feedback. Growth mindset tasks and assignments can be developed on a much larger scale (for inspiration see youcubed.com; see also Alpar & Van Hove, 2020).

The overall role of teachers is very important. They are role models and set the example, in how to deal with mistakes, in sometimes getting stuck and then to persevere, in trying and asking for help, in practicing and believing in effort. This study has taught us that teachers should be invited to always be confident about the possibilities of their students learning. And at moments when this confidence is somehow diminished, they should examine their own mindsets. Teachers also set the stage for a more reflective attitude, in being aware and reflecting on fixed mindset beliefs and growth mindset possibilities. In this study, we worked together as a group of teachers and found it very helpful and encouraging to collaborate. We encourage teachers to collaborate in their study of mindset, for example in lesson visits, lesson studies or mathematics section meetings.

Without exception, every teacher indicated that these interventions should last longer, and they should not be restricted to only mathematics. Other subjects, sports, and their

personal life can all be positively influenced by a change in mindset, as students stated in the questionnaires and during interviews.

All teachers in this research were very open and had an accepting attitude towards mindset interventions. This is, of course, a byproduct of the fact that all teachers carried out the interventions voluntarily; a teacher who is less “into mindset” might be less eager to participate in the same way and show the same effort. This is unfortunate, as teachers, and their students who could benefit even more, are those who do not yet accept the benefit of mindset interventions. Thus, further research also needs to focus on how to include all teachers in fostering growth mindsets among their students to make mathematics more accessible for everyone.

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