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# Factors in the behaviour of mathematics teachers that influence math anxiety amongst high school students

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# Abstract

This study examines which factors in the behaviour of math teachers in their contact with high school students contribute to the developing, worsening or alleviating of math anxiety during mathematics activities. The study was conducted in the form of a survey involving 888 high school students during their math lesson. The survey included several scenarios corresponding to the behaviour of math teachers to which the students could indicate their level of stress. Results show that students indicated to feel significantly higher levels of stress in a scenario where a teacher shows her belief in the growth mindset by forcing a student to try an exercise again after failing once, in comparison with a teacher who shows her belief in the fixed mindset by stating that some students remain to have difficulties with math. In addition, the students indicated to feel significantly lower levels of stress when the teacher writes down the correct answer in their book immediately. The effect sizes of these differences are small and moderate, respectively. Furthermore, it was found that students indicated to feel significantly lower levels of stress, with moderate effect sizes, when a teacher evaluates their work by writing down hints, instead of drawing lines through their mistakes or grading their work in a formative manner. Another important finding of this study was the significantly higher levels of stress students indicated in a scenario where the teacher shows her belief in the fixed mindset by concluding after a few mistakes that a student finds mathematics difficult in general, in comparison with a teacher showing her belief in the growth mindset by emphasizing the learning goal. In conclusion, this study suggests that students might not be experienced in handling exercises alone and feel higher levels of stress when they are forced to do so, even though the teacher shows her belief in the growth mindset.

# Contents

# Chapter 1

# Introduction

In light of the growing demand for mathematics professionals, it is becoming essential to study the existence and sources of math anxiety. Career choices that do not require mathematical skills become more interesting for students that procrastinate in the learning of mathematics due to math anxiety [Ashcraft, 2002], [Akinsola, Adedeji Tella, and Adeyinka Tella, 2007]. There is a large body of literature recognizing the importance of math anxiety in the field of education, for example [Hembree, 1990], [Dowker, Sarkar, and Looi, 2016], [Luttenberger, Wimmer, and Paechter, 2018] and [Commodari and La Rosa, 2021]. Undoubtedly, mathematics teachers want to improve the mathematics performance and motivation in their classroom every day. However, they should not forget to pay attention to math anxiety because of its close connection with mathematics performance. Regardless of all the different styles of mathematics teaching throughout the world, the negative relation between math anxiety and math performance is apparent throughout many countries. In comparison with 64 other countries, the Netherlands seems to have the lowest mean level of math anxiety [Foley et al., 2017], which may serve as an explanation for the lack of attention in the educational research on math anxiety in the Netherlands. However, if teachers follow the growth mindset [Carol S. Dweck and Yeager, 2019], they would believe their teaching can always improve and develop, even though it already seems to be better in terms of math anxiety compared to other countries, according to [Foley et al., 2017]. In this regard, the growth mindset amongst teachers is assumed to be associated with better mathematics outcomes [Bostwick et al., 2020], but an understanding on how the growth mindset of teachers in high school influences math anxiety is limited. Despite these limitations, an existing body of research on the growth mindset by Carol Dweck, David Yaeger and Lisa Blackwell suggests that following a performance goal or a learning goal seems to originate from holding a fixed mindset or a growth mindset [Blackwell, Trzesniewski, and Carol Sorich Dweck, 2007], [Carol S. Dweck and Yeager, 2019]. However, the performance goals have widely suggested to correlate with math anxiety [Zusho, Pintrich, and Cortina, 2005], [Bong, 2009], [Gunderson et al., 2018]. For teachers this is in particular interesting because they can create a climate in their classrooms in which the focus of exercises does not lie on the performance goal but rather on the learning goal.

For example, the way teachers give feedback plays a role in the students' self-image, motivation and performance. [Wiliam, 1999] shows that students receiving feedback in a task-involved way via comments resulted in higher levels of interest, performance and acknowledgement of effort than students receiving feedback in the form of grades and praises, which is mainly focused on the student's self-image and causes constant need for praising in order to feel motivated. In this feedback teachers can additionally pay attention to their attitude towards students' mistakes, because that influences the responses of students to mistakes [Tulis, 2013]. Specifically, students can react in an adaptive way, where they seek challenge and keep on trying to overcome difficulties, while the maladaptive way is defined by avoidance of challenge and giving up when difficulties arise [Carol S Dweck, 1986]. Observation of classes shows that students experience a low error climate when a teacher handles mistakes in a maladaptive way [Tulis, 2013]. However, according to [Tulis, 2013] mathematics teachers appear to react in a maladaptive way more often than found in other subjects. Considering all of these aspects in the behaviour of the math teachers, it seems that the teacher can help students by making small adjustments to their way of interacting with them. However, another aspect in the behaviour of math teachers is not merely related to the way teachers react on students but rather on the perspective towards mathematics they show while they are teaching. Study shows that students with a high level of math anxiety experienced their teacher showing a negative perspective towards mathematics [Hembree, 1990]. The question arises why a mathematics teacher would show a negative perspective towards mathematics, when they have chosen to teach mathematics themselves. Research indicates that math teachers can suffer from math anxiety themselves, which correlates positively with math teaching anxiety, see [Hembree, 1990], [Peker, 2009], [Olson and Stoehr, 2019]. Math teaching anxiety is associated with real or perceived deficits in teaching mathematics and anxiety about them not being able to teach correctly [Peker, 2009], [Olson and Stoehr, 2019]. Even though numerous studies have investigated this subject, they mainly focus on pre-service teachers and elementary school teachers, for example [Harper and Daane, 1998], [Bursal and Paznokas, 2006], [Beilock et al., 2010].

In summary, a lot of research has focused on math anxiety amongst students and the influence of the behaviour of math teachers in this matter. However, it is described previously that there are a few small gaps in the literature concerning these factors, which are: research on math anxiety on Dutch high school students, the influence of teachers showing their belief in the growth mindset on high school students' math anxiety and the consequences of teachers showing signs of mathematics teaching anxiety on the level of math anxiety students experience. Furthermore, it is for teachers difficult to implement all of the evidence into practical use because of the way studies mainly focus on one single factor in the behaviour of math teachers. The originality of this study is that it focuses on several factors in the behaviour of math teachers towards students that influence math anxiety in a practical manner by comparing actions from the teacher. In that way, teachers can learn about the consequences of certain actions which may seem harmless at first. The study was conducted in the form of a survey, with scenarios in a mathematics lesson involving three reactions of the math teacher to which high school students could indicate their implied level of stress. In this way, differences in the behaviour of the math teacher in the connection to math anxiety can be compared and analysed.

The methodological approach taken in this study is Design-Based Research, which is described in detail in [Bakker and Eerde, 2015]. This research methodology develops and tests theory simultaneously such that along the way the researcher, in this case also a teacher, learns about the theory and describes this learning process in detail. This thesis is therefore divided into three iterations, which are: a pilot, the first iteration and the second iteration. Prior to these iterations, a theoretical framework is presented to gather more insight on the influence of math teachers' behaviour in the developing, worsening or alleviating of math anxiety during math activities. The remaining part of the thesis proceeds as follows: the pilot, chapter 3, gives a start to this study by bringing up questions which help formulating research questions, the first iteration, chapter 4, examines these research questions in order to develop hypothesis and finally the second iteration, chapter 5, tests the hypothesis. The thesis ends with a general conclusion and recommendations for future research.

# Chapter 2

# Theoretical framework

> Imperfection is a part of any creative process and of life, yet for some reason we live in a culture that has a paralyzing fear of failure, which prevents action and hardens a rigid perfectionism. It's the single most disempowering state of mind you can have if you'd like to be more creative, inventive, or entrepreneurial.
>
> *Peter Sims*

The following part of this thesis moves on to describe in greater detail the theoretical background of this study. The chapter begins with a section which defines and analyses 'math anxiety' together with an overview of factors that correlate with math anxiety, see figure 2.1. Then a brief analysis of previous work is presented in order to establish what is currently known about the subjects 'growth mindset', 'performance goal and learning goal', 'mathematics teaching anxiety' and 'mistakes', with the underlying focus on math anxiety.

## 2.1 Math anxiety

*Defining math anxiety*

In the field of math anxiety various definitions are found, starting with the following mentioned by [Hartwright et al., 2017, pg.3], using the study of [Hembree, 1990]:

> "Math anxiety (MA) is characterised by negative emotional response such as fear and tension when facing math-related situations, which cannot be reduced to either general anxiety or test anxiety."

Research into math anxiety has a long history. Building on the findings of test anxiety by [Liebert and L. W. Morris, 1967] who divide test anxiety into the classes 'worry' and 'emotionally', two decades later [Wigfield and Meece, 1988] categorizes math anxiety into the negative cognitive component and the affective component. They explain that the negative cognitive component of math anxiety is strongly related to the children's connection with math and their effort in math, while the affective component of math anxiety is strongly related to their impressions about ability, their view on performance and their math performance. Interestingly, a decade later [Ashcraft and Faust, 1994] classify math anxiety in a different way, distinguishing math anxiety inside and outside mathematics classes. They point out that the stress that is felt during a moment of mathematics anxiety results from either nervousness about the manipulation of numbers in mathematics classes, or from nervousness about having to manipulate numbers in everyday tasks.

*Comparison with general academic anxiety and test anxiety*

A variety of studies established the finding that mathematics anxiety distinguishes itself from general academic anxiety and test anxiety, see [Dowker, Sarkar, and Looi, 2016], [Commodari and La Rosa, 2021] and [Ramirez, Shaw, and Maloney, 2018]. Even though these anxieties are distinguishable from each other, they seem to be closely related. Using the results of 151 studies, [Hembree, 1990] presents in his meta-analysis many correlations between math anxiety and factors concerning math anxiety. For example, he found a mean correlation of 0.52 between math anxiety and a measure of test anxiety and found a mean correlation of 0.35 between math anxiety and a measure of general anxiety. [Ashcraft, Kirk, and Hopko, 2021] argue that their data support the correlations found by [Hembree, 1990]. However, [Lukowski et al., 2019] take a different approach and argue that math anxiety can be divided into three factors: anxiety about performing mathematical calculations, anxiety about math in classroom situations and anxiety about math tests.
In their analysis of general academic anxiety and math anxiety in primary school, [Commodari and La Rosa, 2021] describe that general academic anxiety is concerned with negative feelings that involve all the academic situations independent from the subject, whereas math anxiety is related to specific math related or number related tasks.

*Math anxiety and math performance*

Several lines of evidence suggest that high levels of math anxiety correlate with low levels of math performance. In his interesting analysis of factors that are concerned with math anxiety, [Hembree, 1990] presents in one of his tables mean correlations with math anxiety for students between 11-17 years old, for example: IQ-test ($r = -0.17$), computation ($r = -0.25$), problem solving ($r = -0.27$), and grade in math course ($r = -0.30$). Another meta-analysis performed by [Namkung, Peng, and Lin, 2019] showed a negative correlations between math anxiety and mathematics performance of $r = -0.34$ for post-secondary or older students. Similarly, [Zhang, Zhao, and Kong, 2019] showed in a meta-analysis that in junior high school the correlation was $r = -0.39$ and in senior high school that was $r = -0.44$.

Other studies focused on the influence of math anxiety on math performance, rather then the correlation. Much of the literature on this influence pays particular attention to the role of the working memory, see [Eysenck and Calvo, 1992], [Ashcraft and Krause, 2007] and [Berggren and Derakshan, 2013]. While working on mathematical exercises, students use their working memory, which is a control system with limits on both its storage and processing capabilities [Baddely and Hitch, 1974]. Math anxiety is by definition characterised by a negative emotional response. [Ashcraft and Krause, 2007] argue that a student experiencing this negative emotional response suffers from a compromised working memory such that tasks that involve computations become more complicated. They state that in this way, the highly anxious students waste their working memory with their anxiety.

Another important aspect of math performance is math avoidance and procrastination of study. Over 30 years ago, [Beswick, Rothblum, and Mann, 1988] investigated the correlation between procrastination amongst students and several psychological explanations. They found a significant negative correlation between anxiety and depression on one hand and two measures of procrastination on the other hand, which are: time taken to submit a term paper and self-reported frequency of procrastination. As mentioned before, [Hembree, 1990] investigated correlations between math anxiety and many other factors. One of those factors was avoidance, which he categorized into extent of high school math ($r = -0.31$) and intent to take more math (males $r = -0.35$, females $r = -0.25$). More recently, [Ashcraft, 2002, pg.181] concludes: "Highly math-anxious individuals are characterized by a strong tendency to avoid math, which ultimately undercuts their math competence and forecloses important career paths."
Looking at the effect of procrastination later in life, [Akinsola, Adedeji Tella, and Adeyinka Tella, 2007] examined the correlation between academic procrastination and mathematics achievement using a study performed on university undergraduate students. Their results indicate that there is a significant correlation between mathematics achievement and procrastination. Furthermore, they state in their discussion that students who procrastinate in the learning of mathematics are likely to limit their career choices to those that do not require mathematical skills.

To conclude this paragraph, [Carey, Hill, Devine, and Szücs, 2016] claim that their study might indicate a bidirectional relationship between math anxiety and mathematics performance. In that way, the compromised working memory and math avoidance may be consequences of math anxiety as well as causes of math anxiety.

*Factors playing a role in the occurrence of math anxiety*

In a recent study conducted by [Estonanto and Dio, 2019], 69 senior high school students following calculus could indicate what factors they think caused their math anxiety. The researchers identified 8 thematic areas, which are ordered from not frequent to very frequent: (1) lack of self confidence, (2) fear of failure, (3) pressured quizzes & tests, (4) interest & study habits, (5) pressure from parents & peers, (6) poor skills in analysis, (7) teacher factor and (8) abstract math concepts. These factors can be categorized into personal factors and environmental factors.

[Lee, 2009] investigated the structure between math self-concept, math self-efficacy and math anxiety in many countries. Self-concept is the image of the self that is constantly evaluated and supported by personal ideas about oneself and self-efficacy is the image about one's capability to accomplish a result [Bong and Clark, 1999]. [Lee, 2009] concludes that these aforementioned three self-constructs are closely related to each other. He found negative correlations between math anxiety and these two factors: for math self-concept he found a correlation of $r = -0.673$ and for self-efficacy he found $r = -0.450$. His findings are somewhat similar to the findings of [Hembree, 1990] almost 20 years earlier, where he shows a negative correlation of $r = -0.82$ between math self-concept and math anxiety.

One of the personal factors influencing math anxiety is ego-resilience. [Letzring, Block, and Funder, 2005] explain that ego-resilience is one's power to adjust the level of their control in order to meet certain demands. According to them, people with a high level of ego-resilience can adjust their level of control, whereas individuals with a low level of ego-resilience are more bounded by their impulses regardless of demands. Connecting ego-resilience with math performance and anxiety, [Donolato et al., 2020] prove that for children between grades 5 to 8, ego-resilience has a positive effect on mathematics performance. Another finding in this study was that ego-resilience is negatively associated with general anxiety, but not in particular with math-anxiety. However, they also state in their study that general anxiety may still be a risk factor in the development of math anxiety.

Another personal factor influencing math anxiety is gender. [Spelke, 2005] concludes in her critical review that male and female children do not differ in cognitive abilities needed for mathematical thinking. She describes that older boys and girls might differ in cognitive profiles slightly, but that they origin mostly from a difference in strategy. Using math anxiety questionnaires over secondary school children, [Devine et al., 2012] found similarly no differences in mathematics performance between boys and girls. However, they found that levels of math anxiety and test anxiety were higher for girls than for boys. It is now well established from a variety of studies that the levels of math anxiety are indeed higher for girls than for boys, see for instance [Hembree, 1990], [Ashcraft and Faust, 1994] and [Baloglu and Koçak, 2006].

Turning now to the environmental factors, starting with the cultural influences on math anxiety. Using a graph which shows the combination of the mean mathematics score of a country and the mean index of math anxiety through a country, [Foley et al., 2017] have been able to show that the levels of math anxiety differ a lot through countries over the world. Furthermore, they state that most countries with a math performance that is higher than the average tend to have a math anxiety which is lower than average. However, East Asian countries, such as Korea, Japan, Vietnam, Singapore and regions of China, show a high math performance and a high level of math anxiety. On the other hand, taken these countries together they again show a negative correlation between the mean level of math anxiety and math performance. Furthermore, their data shows differences between countries in levels of math anxiety that might show that the source of the anxiety lies mostly in cultural differences instead of math performance. One of the examples they use to illustrate this statement is the difference between Switzerland and Japan. The mean math performance score is similar in both countries, but the mean level of math anxiety is higher than average in Japan and lower than average in Switzerland.

In the same vein, [Stankov, 2010] in his study notes that high academic achievement of students from Confucian Asian countries, which are China, Hong Kong, Singapore, Japan, South Korea and Taiwan, is accompanied by higher levels of anxiety and self-doubt than students from European countries. He also argues that people living in Confucian Asian countries might be more anxious because of certain aspects of the culture in contemporary Confucian Asian countries, where he emphasizes that people from Confucian Asian countries appear to be less forgiving than Europeans.

Another important environmental factor influencing math anxiety are parents. As before, [Hembree, 1990] gives insight on the correlation between math anxiety and the interpretation that the student had of the attitude of their father towards math, which is $r = -0.39$, and their mother, which is $r = -0.37$. [Maloney et al., 2015] offers an explanation for these negative correlations in a large field study of children in the first and second grade. They examined the math anxiety amongst parents and found that children who get help from math anxious parents while doing their homework, learn significantly less math and have more math anxiety by the end of the school year.

The influence of math teachers is the last and most important factor to be discussed in this thesis. Interestingly, the correlation between math anxiety and the interpretation of the student of the attitude their math teacher has towards math is $r = -0.47$ according to [Hembree, 1990], which is lower than the correlation mentioned before between the math anxiety of the student and the interpretation of the student of the parents attitude towards math. This means that students with high levels of math anxiety seem to find the attitude of their math teacher negative. In the next paragraphs, 4 different themes in the behaviour of math teachers will be discussed as well as the impact those aspects have on the math anxiety students experience, which are: (1) Growth mindset, (2) Performance goal and learning goal, (3) Mathematics teaching anxiety and (4) Mistakes.

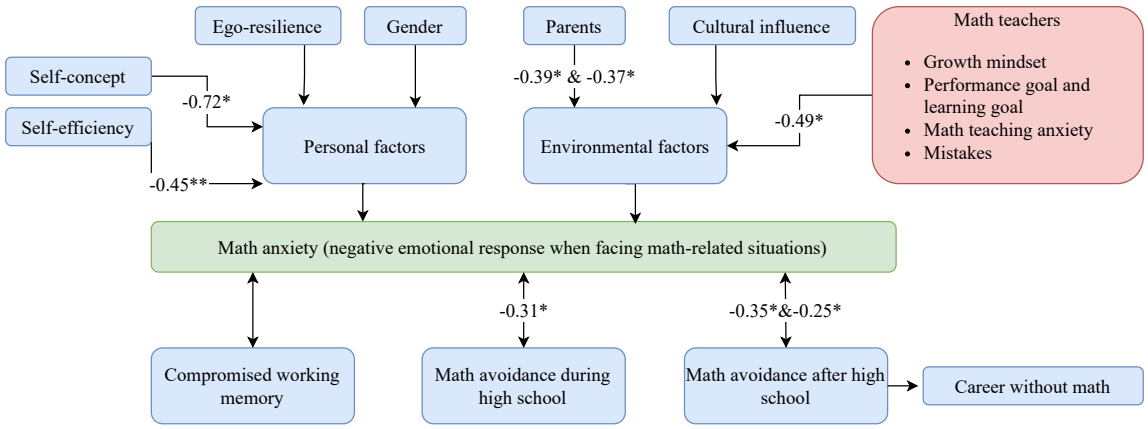


Figure 2.1: Overview of math anxiety (green) as discussed above, together with factors correlated with math anxiety (blue), where the factors involving math teachers (pink) are presented on the right side. The correlations with * origin from [Hembree, 1990] and the correlation with ** origins from [Lee, 2009]. Caution must be applied to the correlations with math avoidance, since they show the correlation between the intent to do more math and math anxiety

## 2.2 Growth mindset

*Defining the growth mindset*

[Yeager and Carol S. Dweck, 2020, pg.1] combine their earlier findings and define the growth mindset and the fixed mindset in the following way:

> "A growth mindset is the belief that personal characteristics, such as intellectual abilities, can be developed, and a fixed mindset is the belief that these characteristics are fixed and unchangeable."

In [Carol S. Dweck and Yeager, 2019], Carol Dweck and David Yeager present a personal retrospective on their broad mindset research. Dweck describes that almost two decades ago, she started to focus on the implicit theories of intelligence, where she defined entity and incremental theories, which she later called fixed and growth mindset. People with a fixed mindset see ability as fixed with the consequences that verifying their ability becomes more important and that a lot of effort is more often associated with low ability. By contrast, people with a growth mindset do not see ability as fixed but rather as something that can grow. As a consequence, these people see improving their ability as more important and a lot of effort is more often seen as a tool.

*The growth mindset and math anxiety*

Unfortunately, there is a relatively small body of literature that is concerned with the effect of students believing in the growth mindset on the level of math anxiety they experience in high school. [Orbach and A. Fritz, 2022] states that there are only rare studies indicating weak correlations between math anxiety and fixed mindsets. However, they also mentioned the study of [Gunderson et al., 2018] on motivational frameworks, math anxiety and math achievement in young children from elementary school. Even though [Gunderson et al., 2018] did not find correlations either, they did describe that their results indicate that a fixed mindset can predict math achievement which indirectly influences math anxiety.

In this study, it is in particular interesting how teachers can help or worsen the mindset of students and therefore might indirectly influence their math anxiety. In six studies by [Mueller and Carol S Dweck, 1998], the way teachers or evaluators praise students was compared. They separate two sorts: praising on intelligence and praising on effort. These sorts of praising are related to the growth mindset and the fixed mindset, in that praising for intelligence teaches children that intelligence is a fixed feature that is reflected in performance; and praising for effort teaches children that intelligence is reflected in effort and is therefore not fixed.
A recent study [Bostwick et al., 2020] shows that teachers believing in the growth mindset is associated with better mathematics outcomes in their classrooms. Furthermore, [Bostwick et al., 2020] also emphasize that highly growth-oriented teachers might assume that students in their classroom only need little help if the levels of growth orientation are high.

Next to praising techniques and growth orientation, teachers can help students learning about the mindset. [Samuel, Buttet, and Warner, n.d.] use a mindfulness and growth mindset approach (MAGMA) to decrease the math anxiety in students from STEM courses at university level. In the MAGMA intervention, teachers show videos that illustrate concepts related to mindfulness and the growth mindset. Before every class, teachers exercise breathing techniques with the students, while the students are told to state five growth mindset statements aloud. Finally, teachers were told not to use red pens in grading, since this might be associated with failure. Results show that students' math anxiety decreased significantly compared to the control group. Similarly, [Yeager, Hanselman, et al., 2019] performed a large study on a treatment to improve the growth mindset for students and showed that this treatment, which lasted at most an hour, improved grades among lower-achieving students and improved overall enrolment to advanced mathematics courses in secondary education.

## 2.3 Performance goal and learning goal

According to a definition proposed by [Elliott and C. S. Dweck, 1988, pg.1], which builds on Dweck's earlier work, a performance goal is a goal

> "...in which individuals seek to maintain positive judgements of their ability and avoid negative judgements by seeking to prove, validate, or document their ability and not discredit it."

and a learning goal is a goal

> "...in which individuals seek to increase their ability or master new tasks."

[Elliott and C. S. Dweck, 1988] claimed that for children following a performance goal their view about their ability was more important in comparison to children following a learning goal. They specifically found that children who thought they were not skilled reacted to feedback about mistakes in a helpless matter, giving up trying to overcome the mistakes, and the children who thought they were highly skilled responded in a mastery-oriented way to difficulties, continuing trying to look for solutions. On the contrary, children following a learning goal responded to feedback about mistakes in a mastery-oriented matter and tried to become more capable in solving the exercises, independent on their view on how skilled they are.

*Performance goal and math anxiety*

Returning briefly to the mindset controversies described in section 2.2, these mindsets play a role in the performance and learning goals of students. [Blackwell, Trzesniewski, and Carol Sorich Dweck, 2007] and [Carol S. Dweck and Yeager, 2019] demonstrate in their study that adolescents having a growth mindset hold on to stronger learning goals so that consequently they prefer strategies which are positive and based on effort when they fail, so that they improve their mathematics achievement. Furthermore, [Blackwell, Trzesniewski, and Carol Sorich Dweck, 2007] show similarly to [Bostwick et al., 2020], that teachers supporting the growth mindset seems to increase the motivation in the classroom. Thus far, following a performance goal or a learning goal seem to originate from holding a fixed mindset or a growth mindset.

Data from many sources have identified the correlation between performance goals and math anxiety, see for instance [Skaalvik, 1997], [Middleton and Midgley, 1997], [Zusho, Pintrich, and Cortina, 2005] and [Lau and Nie, 2008]. For example [Bong, 2009] reported that performance goals correlated positively with anxiety, while learning goals, in his study called 'mastery-oriented goals', did not show a positive correlation. As mentioned before, [Gunderson et al., 2018] also measured relations between motivational frameworks, math anxiety and math achievement. They found that having more performance goals is related to higher levels of math anxiety and math achievement a few months later.
[Furner and Gonzalez-DeHass, 2011] conclude their study by recommending classroom practices that can influence the goals students adopt, with teachers trying to create classrooms where the emphasis is put on the learning goal. They name a few techniques for teachers to influence the goals students have in their classrooms: "[...] educators should strive to create mastery-oriented classrooms by examining the nature of the tasks they assign students, the authority or degree they involve students in academic decision-making, the types of evaluation and recognition they utilize, and the classroom climate they create."[Furner and Gonzalez-DeHass, 2011, p.237].

There are a number of studies focusing on the third technique, which emphasizes the need for using evaluation in such a way that it highlights the individual progress of a student, mentioned by [Furner and Gonzalez-DeHass, 2011]. Grading is a large part of education and the question arises whether a classroom climate supporting the learning goals of students is possible while students are graded regularly. [Furner and Gonzalez-DeHass, 2011] use the study of [Ames, 1984] to demonstrate the way teachers should use evaluation. They claim that if teachers focus on grades and publicly evaluate students, students focus on their own ability and compare themselves with the other students in the classroom. Therefore they state that teachers should privately evaluate students while highlighting the learning aspect and the possibility to improve.
In her study [Butler, 1987] investigated three types of feedback teachers can give to students: task involving (comments), ego-involving (grades and praises) and no feedback. Her focus lied on the comparison between task-involved and ego-involved motivational orientation. As [Wiliam, 1999, pg.2] defined: "...the students attributed successes and failures to themselves (called ego-involvement) or to the work they were doing (task-involvement)." These orientations might be slightly similar to respectively the learning goal orientation, where the student focuses on the learning aspect of the task and in that way focuses more on the tasks itself, and performance goal orientation, where the student focuses on the performance of themselves that follow after the tasks rather than the task itself. The results in [Butler, 1987] show that students receiving ego-involving feedback (grading and praising) showed the highest levels of ego-involvement, without an increase on achievement. On the other hand, students receiving feedback in a task-involved way (comments), showed higher levels of interest, performance and acknowledgement of effort. To conclude this section, [Wiliam, 1999] claims in his review on formative assessment, that giving feedback in the form of grades and praises is focused on the student's self-image. According to him, this leads to a constant need for praising in order to feel motivated. Furthermore, this kind of feedback leads to lower performance, while performance is improved when students receive feedback in a way that they learn what to improve and how.

## 2.4 Math teaching anxiety

*Defining mathematics teaching anxiety*

[Olson and Stoehr, 2019, pg.73] use the study of [Peker, 2009] to define mathematics teaching anxiety in the following way:

> "MTA is defined as anxiety associated with real or perceived deficits in teaching mathematics (Peker, 2009). It is marked by high levels of concern about being able to teach correctly and fear that instructional efforts will confuse students."

*Mathematics teaching anxiety and mathematics anxiety*

It is now well established from a variety of studies that pre-service elementary school teachers experience a high level of mathematics anxiety, see for instance [Hembree, 1990], [Harper and Daane, 1998], [Bursal and Paznokas, 2006] and [Peker, 2009]. Whereas [Bursal and Paznokas, 2006] show that pre-service elementary school teachers with high levels of math anxiety are less confident to teach elementary mathematics and science. For this reason, publications mainly focus on the consequences of math anxiety amongst pre-service elementary school teachers or graduated elementary school teachers instead of secondary or high school teachers.

[Baspinar and Murat, 2016] examined not only the mathematics anxiety pre-service teachers can experience, but the correlation between mathematics teaching anxiety and mathematics anxiety. They divide mathematics teaching anxiety into factors, which are anxiety caused by: (1) content knowledge, (2) self-confidence, (3) attitude towards teaching mathematics and (4) methodological knowledge. Similarly, they divide mathematics anxiety into factors, which are: (1) mathematics test and evaluation anxiety, (2) anxiety towards the mathematics lesson, (3) mathematics anxiety in daily life and (4) self-confidence in mathematics. Results of this study show that mathematics teaching anxiety is positively correlated to mathematics anxiety. Table 3 in [Baspinar and Murat, 2016, pg.221] shows that the highest level of correlation ($r = 0.456$) was found between 'anxiety towards mathematics lesson' and mathematics teaching anxiety in general. Interestingly, the lowest level of correlation ($r = 0.177$) was found between 'anxiety caused by methodological knowledge' and 'self-confidence in mathematics'. In the end the authors conclude that they advice education teachers should pay attention to the possible mathematics teaching anxiety and mathematics anxiety pre-service teachers may experience and help them create a climate which helps them challenge their anxieties.

A qualitative study by [Olson and Stoehr, 2019, pg.74-77] studied reports of three female pre-service teachers about their feelings of mathematics anxiety and found that their levels of math anxiety were relatively high. Therefore, they held many interviews with them to create a clear image of the math anxiety and math teaching anxiety the teachers might have experienced. They were chosen for their high levels of math anxiety, but the analysis showed that their levels of math teaching anxiety was also high. The authors created an interesting figure [Olson and Stoehr, 2019, pg.75] where keywords associated with math anxiety were drawn, the keywords associated with math teaching anxiety and the keywords that were associated with both of these anxieties. What stands out in this figure is the way teachers with mathematics teaching anxiety can feel ashamed for their students, such as 'Shamed' or 'Hide From Students What I Don't Know', and the way teachers can be afraid that they are unable to teach, such as 'Inability to Teach Students' and 'My Fault if Students Don't Understand'. Interestingly, all three of the interviewees thought that their math teaching anxiety is a logical extension of their math anxiety they experienced when they were a student themselves.
The next part of the study describes a quantitative study performed on 53 pre-service teachers [Olson and Stoehr, 2019, pg.77-78]. Similarly as the results of the qualitative study, they found that teachers with high levels of math anxiety also had high levels of math teaching anxiety.

To conclude this section, the next part describes the consequences on students' math anxiety when their teacher suffers from math anxiety. As mentioned before, [Hembree, 1990] investigated the correlation between the perspective of math teachers on students, amongst other correlations. He concludes that students with high levels of math anxiety experienced that their teacher showed a native perspective towards mathematics, with a correlation of $r = -0.49$. A more narrow perspective has been provided by [Beilock et al., 2010] who studied female elementary school teachers and the consequences of their math anxiety on the math performance of, in particular, girls in their class. At the end of the school year the math performance of girls was significantly lower than in the beginning of the school year. The authors claim that the stereotyping that girls are worse in math, plays a role in this lower performance since the girls validated these stereotypes more in the end of the year when their teacher was highly math anxious.

## 2.5 Mistakes

*Teachers handling mistakes*

[Williams, 1988, pg.95] reviewed literature on math anxiety and concluded that: "Most math anxiety has its roots in the teachers and the teaching of mathematics." She mainly focuses on the way math teachers, in particular elementary school teachers, can spread their own math anxiety amongst their students. Furthermore, she recommends in the end of her study that teachers should be careful with their reaction on questions students ask. She wants teachers to create a classroom climate in which students feel free to ask questions and students' and teachers' reactions to each other's wrong answers, are monitored. She claims that negative reactions by others can decrease participation in the classroom.

[Butler, 1998] shows that children who were focused on their ability, were the least likely to ask questions to the teacher. Building on this study, [Turner et al., 2002] suggest that in the same way, these students who are focused on ability might prefer not solving problems because they fear that they make a mistake and consequently seem incompetent. In the end of their study, [Turner et al., 2002] reveal that their data suggest that students showed more avoidance in the classroom when a teacher did not focus on helping students understanding the material. On the contrary, in classrooms where the teacher appeared to be oriented towards learning goals, asking questions and learning from mistakes was interpreted as part of the learning process.

The way students handle mistakes and factors that influence these patterns was examined by [Zander, Kreutzmann, and Wolter, 2014]. They state that their results show that students were less afraid to make mistakes when their level of self-efficacy was higher. Furthermore, they believe that the anxiety students feel towards making a mistake can be reduced when they are advised to go to their classmates and prevent the reactions they are afraid of from happening. A year earlier, [Tulis, 2013] pointed out that responses to errors are influenced by the attitude teachers and students have towards errors. She focuses on the difference between adaptive [Reusser, 2000] and maladaptive ways for teachers to handle mistakes their students make. [Carol S Dweck, 1986] explains in her study that children can follow an adaptive or maladaptive pattern, where she defines those in the following way: "The adaptive ('mastery-oriented') pattern is characterized by challenge seeking and high, effective persistence in the face of obstacles [...] In contrast, the maladaptive ('helpless') pattern is characterized by challenge avoidance and low persistence in the face of difficulty." [pg.1040]. Furthermore, she explains that children following the maladaptive pattern could increase the anxiety students experience. Unfortunately, [Tulis, 2013] found that in particular in mathematics classes, teachers pay very little attention to the learning aspect of making mistakes. They show only little positive acceptance of students choosing a wrong strategy.

In an attempt to compare classrooms which have a so-called high error climate to classrooms with a low error climate, [Tulis, 2013] investigated 11 different categories of teacher responses to student's mistakes and compared these two classrooms. She explains that in a classroom with a high error climate, students feel that the teacher has a high tolerance of errors and in a classroom with a low error climate students feel that the teacher does show a less adaptive way in handling mistakes. As mentioned before, [Tulis, 2013] has put the emphasize on the difference between adaptive and maladaptive responses and she has therefore split up these 11 categories of teacher responses into these two factors. Results from the first study of [Tulis, 2013] suggested that the following categories are maladaptive: "Ignoring mistake [1], criticizing the student [2], redirecting the question to another student [3], humiliating/laughing [4], and disappointment/hopelessness [5]" and the following adaptive: "Correction by the student [6], discussion with whole class [7], correction by the student [8], waiting [9], encouraging student [10] and impeding negative reactions from classmates [11]", see table 6 in [Tulis, 2013, pg.64]. From the table it can be concluded that teachers use a maladaptive way of reacting to students less often than the adaptive way, when the category 'redirecting question to another student' is excluded. Furthermore, it can be seen from this table that redirecting the question to another student is most often observed, while more then 10% of the students indicate that they see this kind of reaction as negative, see figure 5 in [Tulis, 2013, pg.64]. Interestingly, their study also shows that in the subject mathematics teachers appear to react in a maladaptive way more often than found in other subjects. [Tulis, 2013] claims that mathematics is special in a way because answers to exercises are either good or wrong.

# Chapter 3

# Pilot

> Every intellectual needs to be capable of considering himself relatively and measuring the immensity of his ignorance. But he must also have confidence in himself and in his possibilities of succeeding through the constant and tenacious search for truth.
>
> *Laurent Schwartz*

## 3.1 Introduction

This pilot examines the feelings of math anxiety high school students experience and the contribution of the math teacher to this matter. Eventually, this pilot gives a start to a thesis which explores how teachers' behaviour towards students can create or worsen someone's math anxiety. As the pilot starts without a clear research question, the results will bring up questions which help formulating this research question.

In line with Design Based Research, this research starts with a pilot in which a survey is tested on a small group of students. Before filling in the survey, the students are shown a short video where the subject 'math anxiety' is explained. The reaction of the students on the video contributes to the decision whether to show the video beforehand, or let the students start the survey without an explanation. Other purposes of this pilot are estimating the time spent on the questions and checking whether students are able to comprehend the questions.

Another important purpose of this pilot is to measure the impact of certain behaviour of math teachers on the math anxiety students experience. This information plays a role in determining the focus of future iterations and helps formulating the main research question.

## 3.2 Setting

Before proceeding to examine the results of the pilot, it is important to describe the setting in which this pilot takes place. On the 10th of November the pilot takes place in the school Stanislascollege Westplantsoen in Delft. The students are in the 4th grade of high school so they are between 14 and 16 years old. They follow 'havo' education, which is a level of education known in the Netherlands.

### 3.2.1 Havo

The term 'havo' is roughly translated as 'higher general high school education' and it is the middle level of high school education in the Netherlands. The lowest level of high school education is called 'vmbo'. This type of education is focused on practical learning, while the highest level of education, 'vwo', is focused on theoretical learning. Similarly, havo is focused on theoretical learning, but on a lower level than vwo. After finishing this type of education, students are not able to go to university but can go to a certain college 'hbo', which is more or less similar to 'university of applied sciences'. In the fifth and final year of their high school, they have to pass a final exam.

### 3.2.2 Mathematics A, B and C

In the first three years of their studies students follow a general course of mathematics, which is the same for everyone of their level. From the 4th grade on, the students are split up into mathematics A, B or C. The focus in mathematics B lies on algebra and geometry, while in mathematics A and C the focus lies on statistics, probability and applied analysis. In Stanislascollege Westplantsoen mathematics teachers agree that students experience mathematics B as being more difficult than mathematics A and C.

### 3.2.3 Maatwerk

The pilot takes place during a lesson called 'maatwerk', which is roughly translated as 'measure work'. It is necessary here to clarify what kind of a lesson this is. It is not a regular math lesson, but a class for students who would like to put extra effort into mathematics. Every month the students choose three courses they want to focus on. During that month, the students follow one extra hour per course, given by a teacher who might be someone else rather than their main teacher of that course.

During the maatwerk lesson of the 10th of November, there will be three students who know the teacher well, as it is their own main mathematics teacher and there will be five students who know the teacher less good, since it is only their maatwerk teacher.

| | |
|---|---|
| Date | 10th of November 2021 |
| Place | Stanislascollege Westplantsoen, Delft |
| Room | Classroom for mathematics |
| Lesson | Maatwerk, 4th grade, havo, mathematics B |
| Participants | 8 students |
| Survey given by | Dominique van den Bosch |
| Relation | Main teacher (3/8) and maatwerk teacher (5/8) |
| Instruction | Video about math anxiety |

## 3.3 Video

Prior to the survey the students are shown a video in which the concept and background of math anxiety is explained. The video is made by TEDed with Orly Rubinsten being the main educator [Rubinsten, 2017]. She is a professor in the department of Learning Disabilities at the University of Haifa, Israël. Through the years Rubinsten published many articles about math anxiety, for example [Rubinsten, Marciano, et al., 2018], [Rubinsten, Bialik, and Solar, 2012] and [Rubinsten, Eidlin Levy, et al., 2015]. In the video statements are made about the extent of math anxiety through society, the consequences on individuals and some recommendations for people suffering from it. While a female voice goes through these subjects, playful animated figures are shown for better understanding. Since the video is in English, there are Dutch subtitles for the students to read.
The video starts with the example of Laurent Schwartz suffering from math anxiety [Schwartz, 2001], even though he won the Fields medal, which is the most coveted prize in mathematics. The video mentions different symptoms people can suffer from during a moment of anxiety. Next, Rubinsten mentions the ratio of people suffering from math anxiety. With the example of Laurent Schwartz, Rubinsten suggests that math anxiety is not a consequence of a lack of math skills. She explains in her video that math anxiety decreases the working memory, which could result in people suddenly struggling to solve simple math problems. All of these statements above are similar to those reported by [Dowker, Sarkar, and Looi, 2016]. Furthermore, Rubinsten claims that academic anxiety happens more in the field of math and causes more harm in that subject. The statement that acadamic anxiety causes more harm in the field of math is also shown in a recent article written by Elena Commodari [Commodari and La Rosa, 2021]. However, the statement that anxiety happens more in the field of math, is more difficult to check with the recent studies on this subject. Dowker describes that there exists a general assumption that people show more anxiety towards mathematics than other courses, but she states that, at that time, there have not been many studies which compare mathematical anxiety with anxiety in other courses. Even though the article of Dowker was written many years ago, there are still relatively few studies in this area.

In the subsequent part of the video, Rubinsten starts to focus on several factors that are responsible for developing math anxiety. Firstly, she mentions the way parents and teachers talk about math like something challenging and unfamiliar, which is similar to statements of [Dowker, Sarkar, and Looi, 2016]. Secondly, she states that teachers, who are suffering from math anxiety, reflect their anxiety on their own students, which is similarly pointed out by [Olson and Stoehr, 2019]. Thirdly, she mentions the time pressure kids experience, as [Boaler, 2014] similarly describes, and at last she mentions the cultural pressure kids experience, which is explained in more detail by [Foley et al., 2017].

After analysing the factors that are responsible for developing math anxiety, Rubinsten describes strategies which could help overcoming math anxiety. She describes that reevaluating stressful experiences by writing down worries could help. In a recent article of [Johnson, Clohessy, and Chakravarthy, 2021] strategies are investigated for students to gain self-regulation, in order to overcome math anxiety. Johnson describes that self-awareness like identifying, naming and understanding emotions, is an important first step in self-regulating. Physical activity is another strategy Rubinsten mentions, which is examined in greater depth in [Sneck et al., 2019]. The last strategy Rubinsten argues to be helpful is creating knowledge about the growth mindset. Numerous studies have attempted to explain the valuable role of the growth mindset in students' math anxiety. [Boaler, 2019b] describes that the research of Carol Dweck on the differences between growth mindset and fixed mindset had a great impact on educational practices. According to Boaler, the fixed mindset is one of the reasons why there is a widespread math trauma in the United States. Rubinsten argues for teachers and parents to help students develop the growth mindset, since that can be developed at any time in life. In addition to this, she argues that it is important to be playful with young children and focus on creative aspects. Likewise, [Boaler, 2019a] encourages parents to learn children to play with puzzles, shapes and numbers and think about their relationships.

After demonstrating the importance of the growth mindset, Rubinsten argues that children should be able to have enough time while working on math exercises. [Boaler, 2014] argues similarly that timed tests cause math anxiety and she encourages teachers and parents to give children time to work through their answers. In the end of the video, Rubinsten mentions the 'myth' that girls are worse at math than boys. Numerous studies investigated the difference in terms of perfomance and math anxiety in boys and girls. For example, Dowker describes in [Dowker, Sarkar, and Looi, 2016] that in countries where education is equal for both boys and girls, there is no or very little difference in performance.

## 3.4 Survey

Once the students finish watching the video, they have to fill in the survey via Google Forms, with the advantage that Google Forms generates an overview in Google Sheets where the responses can be gathered. Another advantage of Google Forms is that students need less time to complete the survey since they do not have to write down the answers. The survey is not anonymous for the researcher, since in the very end of the survey the students state their name if they want. However, the responses will be anonymous for the reader of this thesis. In Stanislascollege Westplantsoen teachers use Google in several ways for teaching purposes. The names of the students and their educational progress is known by Google. For that reason this survey affects the privacy matters little. The original survey can be found via the link survey pilot.

### 3.4.1 Introduction

The survey starts with an introduction in which the name and the educational background of the researcher is stated. In this introduction there is explanation on how the survey is divided into parts. In the end the participants are told not to haste in answering the questions, since this will influence the results.

### 3.4.2 First part: general feeling of math anxiety

In the first part of the survey students have to fill in a short questionnaire. The questionnaire is a seven-item scale based on [Estonanto and Dio, 2019] and [Carey, Hill, Devine, and Szűcs, 2017], ranging from no stress to a lot of stress. The questionnaire contains 17 scenarios, such as 'You hear the word mathematics', where the students have to picture the scenario in their head and decide how much stress they think this scenario will cause them. The checklist is designed to measure the general feeling of stress a student experiences with mathematics, which is valuable information for the second part of the survey, where the impact of the teachers' behaviour on the students' math anxiety is investigated. The first part of the survey ends with two open-ended questions which ask students to explain the thoughts and feelings they experience in scenarios where they indicated a seven, in order to understand their math anxiety better.

### 3.4.3 Second part: behaviour of the math teacher

The second part of the survey is designed similarly to the first part where the survey questions involve scenarios students have to imagine. They have to respond using a seven-item scale, ranging from no stress to a lot of stress. The focus in the second part of the survey lies on the behaviour of the mathematics teacher. In this survey the way teachers behave towards students and the way they communicate is divided into four categories: growth mindset; performance goal and learning goal; mathematics teaching anxiety; and perceived teacher expectation. Every category contains two scenarios together with three reactions of the teacher to the student.

**a) Growth mindset**

In the first category, the focus of the scenarios lies on the subject growth mindset, which is described in detail in section 2.2.

*You complete a difficult exercise at once during a math lesson. The teacher sees this and walks up to you. The teacher says: 1) 'You are smart' 2) 'You are good in mathematics' and 3) 'You did this exercise well'.*

The last reaction 'You did this exercise well' is only focused on the performance of the exercise itself, while the first two reactions praise on the general qualities and intelligence of the students. According to [Mueller and Carol S Dweck, 1998] praising students' intelligence has more negative consequences on students' achievement motivation than praise for effort has. In order to determine whether these praises have consequences on the math anxiety students experience, this scenario is included in the survey.

In the second scenario the student is not able to complete a simple exercise and the teacher walks up to the student again.

*You are not able to complete a simple exercise during a math lesson. The teacher sees this, walks up to you and 1) says 'It does not matter, not everyone is good at math' 2) says 'Think again' 3) writes down the good answer in your exercise book.*

In many articles, such as [Yeager and Carol S. Dweck, 2020], Dweck describes the difference between a growth mindset and a fixed mindset. The first reaction is an example in which the teacher shows her belief in the fixed mindset of the student and the second reaction is an example in which the teacher shows her belief in the growth mindset of the student. In the last scenario it is unclear whether the teacher believes in the growth mindset of the students, since the teacher does not give the student an opportunity to try. This scenario helps to find out whether students experience more anxiety when a teacher shows her belief in a fixed mindset.

**b) Performance goal and learning goal**

The next category describes two scenarios concerning performance goals and learning goals, which is described in detail in section 2.3.

*The teacher hands out a form with a few exercises everyone in the classroom has to solve. Before you start with the form, the teacher tells the class what he/she will do with the form afterwards. The teacher says: 1) 'I will check the form and you will get a grade which will not be part of your final grade' 2) 'I will check the form and I will draw lines through the mistakes you made' and 3) 'I will check the form and write down hints next to certain exercises'.*

Clearly, in the first reaction the formative assessment is linked to a grade, so it is very likely that the students write this exercise with a performance goal, which could have an effect on the stress the students experience during these exercises. In the second reaction, the teacher draws lines through the mistakes and it is unclear whether the students will write down the exercise with a performance goal or a learning goal. However, in the last reaction the teacher does not focus on the mistakes of the students and therefore it is more likely that the students write down the exercises with a learning goal. Unfortunately, this option is very dependent on the way a teacher writes down the hints.

*The teacher is giving a trial exam during the lesson. You will not get a grade for the trial exam but the exam will be checked by the teacher. You ask the teacher why you have to participate in this trial exam. The teacher says: 1) 'I would like to know how well you understand everything' 2) 'Then you can see for yourself how well you understand everything' and 3) 'You can learn from it'.*

In the first two reactions, there is a difference in the perspective of the teacher, which could create a different goal for the student. It is plausible that the students are more focused on the performance goal in the first reaction, since the teacher is checking whether the student understands the subject. However, in the second reaction the student is likely to be focused less on the performance goal directed to the teacher and more on the performance goal they create for themselves. In the third and last reaction, the student is more likely to be focused on the learning goal, since the teacher instructs the student to learn from the task. The purpose of this scenario is to compare the stress students experience when they work with a performance goal and with a learning goal.

**c) Mathematics teaching anxiety**

Regarding mathematics teaching anxiety, the following two scenarios help to distinguish between the consequences on the math anxiety the students experience while participating in a math lesson with an anxious math teacher and participating in a math lesson with a confident math teacher. Mathematics teaching anxiety is described in detail in section 2.4.

*During math lesson the teacher explains a subject in front of the class and the subject is difficult for you. You 1) notice that the teacher herself finds the subject difficult 2) notice that the teacher herself finds the subject very easy and 3) do not know whether the teacher finds the subject difficult or easy.*

There are two options why the students feel that the teacher finds the subject difficult. The first option is that the teacher does not find the subject difficult, but is afraid of not understanding the subject and is therefore failing in showing confidence in this matter. As mentioned in section 2.4, [Olson and Stoehr, 2019] show that there is an overlap between mathematics anxiety teachers can suffer from and mathematics teaching anxiety. They list keywords associated with mathematics anxiety and mathematics teaching anxiety. In that list it is shown that teachers who suffer from mathematics teaching anxiety fear that they do not know enough about mathematics. The second option for the students to feel that the teacher finds the subject difficult is that the teacher indeed has difficulties understanding the subject. [Olson and Stoehr, 2019, pg.73] state the following about pres-service teachers: "Further, the experience of MA disrupts PSTs' ability to process information, thus inhibiting learning and performance in mathematics methods and content courses." Due to this, the scenario helps to distinguish between teachers who are certain about their knowledge and teachers who experience certain insecurities because of their mathematics teaching anxiety or because of some knowledge they are missing, which could be a consequence of their mathematics anxiety.

Turning now to the second scenario considering mathematics teaching anxiety.

*The teacher makes a mistake on the board during math lesson. The teacher 1) pretends that she did not make a mistake 2) corrects her mistake and becomes nervous in front of the class and 3) corrects her mistake and continues in the same way she did before the mistake.*

In the first reaction, the teacher pretends that she did not make the mistake and this scenario could be connected to mathematics teaching anxiety. As mentioned above, [Olson and Stoehr, 2019] lists key words associated with mathematics anxiety and mathematics teaching anxiety. One of the key words on the side of mathematics teaching anxiety is to 'hide from students what I don't know' which is similarly stated in the first reaction. The second reaction shows that the teacher becomes insecure, which is again a sign which could be connected to mathematics teaching anxiety. The last reaction shows no sign of insecurity.

**d) Perceived teacher expectation**

In the last category the scenarios are associated with perceived teacher expectation, which is slightly related to the category growth mindset since the comments show whether the teacher believes in the growth mindset of her students.

*During math lesson you receive your grade for a small exam. You have a high grade. The teacher hands out the exam and says: 'What a beautiful grade!'. After that the teacher says: 1) 'I did not expect this from you. Normally you have much difficulties with mathematics' 2) 'I expected this from you, since you are good in mathematics' and 3) 'You did this exam well'.*

In the first comment of the teacher, there is a clear expectation from the teacher towards the student that the student will fail. This comment suggests that the teacher does not believe in the growth mindset of the student.
The second comment seems harmless at first, but returning to the growth mindset, praising students' intelligence has more negative consequences for students' achievement motivation than praise for effort has [Mueller and Carol S Dweck, 1998]. Therefore it could be harmful to mention that the student is good in mathematics. The last comment is only focused on the particular exam the student made. Therefore, the teacher does not express any kind of expectation towards the student.

Turning now to the second scenario regarding perceived teacher expectation.

*During math lesson you receive your grade for a small exam. You failed the exam. The teacher hands out the exam and says: 'What a shame that you failed the exam'. After that the teacher says: 1) 'It does not matter, since not everyone is good in mathematics' 2) 'You are good in mathematics, but this was a bad moment' and 3) 'You did not do this exam well'.*

The first comment seems comforting at first, since the teacher says that it does not matter that the student failed. However, [Rattan, Good, and Carol S. Dweck, 2012] describe that accepting weaknesses in this way, is not as positive as intended. They define this kind of comment as 'comfort feedback' and they mention among other things that this kind of feedback leads to students feeling less motivated and expecting lower final grades. In the second comment the teacher makes, she says that the student is good in mathematics and that this exam is just an unfortunate moment. As explained earlier, this kind of feedback could have negative consequences on students' motivation. The last comment is only focused on the particular exam the student made. Therefore, the teacher does not express any kind of expectation towards the student. These two scenarios help in gathering information on the stress students experience when a teacher shows her expectations towards the students.

### 3.4.4 Closure

The last questions of the survey are designed to gain more personal information on the participants. Personal information asked is: name, age, grade, gender and email. The major advantage of knowing the name of the student is not for the researcher but for the teacher herself. The way a particular student thinks and feels about mathematics is valuable information. As mentioned before, the names of the students and their educational progress is already known by Google. For that reason this survey affects the privacy matters very little. On the other hand, the disadvantage of knowing the name of the student is that the relationship between the student and the teacher could interfere with the results. The questions about age, grade and gender were selected for the researcher to get more information on differences in perception within these groups. Since in this pilot the research questions are not clear yet, it is possible to add these additional personal questions. At last the email of the students is asked, so that the researcher is able to contact the student if something in the given answers is unclear to the researcher.

## 3.5 Results

All students were sent an invitation via their student email to fill in the survey. The eight students completed the survey on their Chromebook they received from school. The first student completed the survey after seven minutes and the last students completed the survey after fifteen minutes. In the next pages, the results are shown. The table on the first page shows the responses of the students on the questionnaire, which is the first part of the survey. The first part of the survey contained short questions aimed to measure the general feeling of stress a student experiences with mathematics. This part of the survey ends with two open questions, for which the answers are shown on the second page. The questions are translated in English, since the survey itself was in Dutch.
Because of the small number of responses ($n = 8$), the data is presented without statistical analysis. In order still get an overview of the data, the average is calculated and the number of students who choose the lowest number possible (no stress) together with the number of students who choose the highest number possible (a lot of stress).
The tables on the next two pages show the responses of the students on the second part of the survey. The second part of the survey contains questions separated into different categories. These categories are not given and therefore not known for the students. Similarly to the first part of the survey, in the second part the questions in the tables are translated to English.
After the students completed the survey, the researcher asked a couple of questions to the students. The first thing the researcher asked the students was whether they understood the questions. All students responded that the questions were completely clear to them. Afterwards, the researcher asked what they thought of the length of the survey. Overall, the students thought the length of the survey was good, except for one student who though it was a little too long. Furthermore, the researcher asked what their opinion was on the short video which was shown before the survey. One student responded that he/she found it very interesting to learn something about this subject. In the end the researcher asked whether they have any recommendations for the survey. One of the students responded with a comment on one of the questions in the closure of the survey. The student asked: 'What if you are non-binary?'. The student referred to one of the questions where the student is asked to fill in the sex. The options were: female, male and 'I rather not say'.

Table 3.1: Questionnaire ($n = 8$)

| **Questionnaire** | | | |
|---|---|---|---|
| | Average | Times 1 chosen | Times 7 chosen |
| You hear the word mathematics | 2.375 | 3 | 0 |
| You read the word mathematics | 2.375 | 2 | 0 |
| You open your math book | 3 | 1 | 0 |
| You are doing your math homework alone at home | 3 | 1 | 0 |
| You are doing your math homework with friends at home | 2.375 | 3 | 0 |
| You are doing your math homework with family members at home | 2.125 | 5 | 0 |
| You are doing your math homework during a 'maatwerk' lesson [see subsection 3.2.3] | 1.75 | 4 | 0 |
| You are doing your math homework during a math lesson | 2.25 | 2 | 0 |
| The teacher explains a new subject in front of the class | 3.375 | 0 | 0 |
| The teacher asks you a question on personal level, such that others are not able to hear it | 2.5 | 3 | 0 |
| The teacher asks you a question in front of the class, such that everyone is able to hear it | 4.125 | 0 | 0 |
| You are thinking about an exam scheduled for next week | 4.125 | 0 | 0 |
| You are thinking about an exam scheduled for the next day | 5.25 | 0 | 0 |
| You are studying for an exam scheduled for the next day | 4.875 | 0 | 1 |
| You are writing an unexpected small exam | 6.5 | 0 | 6 |
| You are writing an expected small exam | 4.375 | 0 | 0 |
| You are writing an expected exam | 4.875 | 0 | 0 |

Table 3.2: Open questions ($n = 7$) since one student did not answer a question with a 7.

| **First open question** | |
|---|---|
| Look at the scenario(s) where you filled in a seven. What are your thoughts in these moment(s)? For example: I can not do it, I am afraid that I will make a mistake, etc. | |
| **Answers** | **English translation** |
| 'Ik twijfel of ik het wel kan.' | 'I am not sure whether I am able to do this' |
| 'Dat ik het mischien hellemaal fout doe en daardoor een laag cijfer' | 'That I might do it all wrongly and therefore a low grade' |
| 'Als er een onverwachtse toets is weet ik niet zeker of ik een goed cijfer kan halen' | 'When there is an unexpected exam, I am not sure whether I am able to get a good grade' |
| 'ik ben bang dat ik het fout doe en ga falen' | 'I am afraid that I will do it wrongly and that I will fail' |
| 'Ik ben bang dat ik het fout doe en een slecht cijfer krijg.' | 'I am afraid that I will do it wrongly and I will get a bad grade.' |
| 'ik weet niet of ik goed genoeg heb geleerd of goed genoeg begrijp' | 'I am not sure whether I studied well enough or understand it well enough' |
| 'ik denk dat het fout gaat' | 'I think it will go wrong' |
| **Second open question** | |
| Look at the scenario(s) where you filled in a seven. What do you feel in your body in these moment(s)? For example: a high heart rate, sweaty hands etc. | |
| **Answers** | **English translation** |
| 'Zweet, hoge hartslag, stress' | 'Sweat, a high heart rate, stress' |
| 'Als er een onverwachtse toets is weet ik niet zeker of ik een goed cijfer kan halen' | 'When there is an unexpected exam, I am not sure whether I am able to get a good grade' |
| 'nou me hartslag gaat iets omhoog en en heel erg scherp veel scherpen dan normaal' | 'well my heart rate goes up a little and very sharp, way sharper than normally' |
| 'hoge hartslag' | 'high heart rate' |
| 'zweethanden en lichaam wordt helemaal heet van binnen lijkt wel verstijfd eigenlijk' | 'sweaty hands and body becomes fully hot inside, looks like it is stiffened actually' |
| 'Een hoge hartslag' | 'A high heart rate' |
| 'krijg het wat warmer' | 'I feel a little more warm' |

Table 3.3: Behaviour of the math teacher in the category growth mindset and the category performance goal and learning goal ($n = 8$)

| **Growth mindset** | | | |
|---|---|---|---|
| You complete a difficult exercise at once during a math lesson. The teacher sees this and walks up to you. | | | |
| | Average | Times 1 chosen | Times 7 chosen |
| The teacher says: 'You are smart' | 1.125 | 7 | 0 |
| The teacher says: 'You are good in mathematics' | 1.125 | 7 | 0 |
| The teacher says: 'You did this exercise well' | 1.25 | 6 | 0 |
| You are not able to complete a simple exercise during a math lesson. The teacher sees this and walks up to you. | | | |
| | Average | Times 1 chosen | Times 7 chosen |
| The teacher says: 'It does not matter, not everyone is good at math.' | 3.125 | 1 | 1 |
| The teacher says: 'Think again.' | 2.75 | 1 | 0 |
| The teacher writes the good answer in your exercise book. | 2.125 | 3 | 0 |
| **Performance goal and learning goal** | | | |
| The teacher hands out a form with a few exercises everyone in the classroom has to solve. Before you start with the form, the teacher tells the class what he/she will do with the form afterwards. | | | |
| | Average | Times 1 chosen | Times 7 chosen |
| The teacher says: 'I will check the form and you will get a grade which will not be part of your final grade. | 2.75 | 1 | 0 |
| The teacher says: 'I will check the form and I will draw lines through the mistakes you made. | 2.5 | 1 | 0 |
| The teacher says: 'I will check the form and write down hints next to certain exercises. | 1.875 | 3 | 0 |
| The teacher is giving an trial exam during the lesson. You will not get a grade for the trial exam but the exam will be checked by the teacher. You ask the teacher why you have to participate in this trial exam. | | | |
| | Average | Times 1 chosen | Times 7 chosen |
| The teacher says: 'I would like to know how well you understand everything.' | 2.75 | 2 | 0 |
| The teacher says: 'Then you can see for yourself how well you understand everything.' | 1.75 | 3 | 0 |
| The teacher says: 'You can learn from it.' | 2 | 3 | 0 |

Table 3.4: Behaviour of the math teacher in the categories math teaching anxiety and the category perceived teacher expectation ($n = 8$)

| **Mathematics teaching anxiety** | | | |
|---|---|---|---|
| During math lesson the teacher explains a subject in front of the class and the subject is difficult for you. | | | |
| | Average | Times 1 chosen | Times 7 chosen |
| You notice that the teacher herself finds the subject difficult. | 4.5 | 0 | 1 |
| You notice that the teacher herself finds the subject very easy. | 2 | 3 | 0 |
| You do not know whether the teacher finds the subject difficult or easy. | 2.875 | 1 | 0 |
| The teacher makes a mistake on the board during math lesson. | | | |
| | Average | Times 1 chosen | Times 7 chosen |
| The teacher pretends that she did not make a mistake. | 4.125 | 0 | 1 |
| The teacher corrects her mistake and becomes nervous in front of the class. | 3.625 | 0 | 0 |
| The teacher corrects her mistake and continues in the same way she did before the mistake. | 1.375 | 7 | 0 |
| **Perceived teacher expectation** | | | |
| During math lesson you receive your grade for a small exam. You have a high grade. The teacher hands out the exam and says: 'What a beautiful grade!'. After that the teacher says: | | | |
| | Average | Times 1 chosen | Times 7 chosen |
| 'I did not expect this from you. Normally you have much difficulties with mathematics.' | 2.5 | 1 | 0 |
| 'I expected this from you, since you are good in mathematics.' | 1.5 | 5 | 0 |
| 'You did this exam well.' | 1.375 | 5 | 0 |
| During math lesson you receive your grade for a small exam. You failed the exam. The teacher hands out the exam and says: 'What a shame that you failed the exam'. After that the teacher says: | | | |
| | Average | Times 1 chosen | Times 7 chosen |
| 'It does not matter, since not everyone is good in mathematics.' | 3.375 | 1 | 0 |
| 'You are good in mathematics, but this was a bad moment.' | 3.125 | 2 | 1 |
| 'You did not do this exam well.' | 3.625 | 1 | 0 |

## 3.6 Conclusion and discussion pilot

In this pilot, the main goal was to gather research questions. The second goal of this pilot was to evaluate the survey together with the introduction video. Despite the exploratory nature of this pilot, the study still offered some insight into the limitations of the survey. Having presented the results in section 3.5, this section will discuss the most relevant findings.
What stands out in Table 3.1 is the anxiety students experience before and during an exam. These anxieties are much higher than the anxiety the students experience during math homework. One scenario however is not connected to a math exam but still has an average above the middle level 3.5. Apparently, the students feel more anxiety in a scenario where they are asked a question in public, instead of a question in which only the student and the teacher can hear each other. The data shows that all the eight students who participated felt more anxiety when a question is asked publicly. This result raises the question whether students fear more for the public opinion then for the personal opinion of the teacher.
Surprisingly, the students suggested that they feel the least fear in the scenario where they make their math homework during a 'maatwerk' lesson. Even more striking is the fact that they reported to feel more anxiety when they open their math book. Since math homework is made with an open book, these results seem contradictory. This inconsistency may be due to the fact that the researcher of this experiment is also the students' teacher for the 'maatwerk' lesson. It could be argued that the positive results were due to their loyalty towards their teacher, since they know that their answers are available for the teacher. The concern with this argument is that more results are biased because of this loyalty.
Turning now to the two open questions in the end of the first section of the survey. The most interesting word in the answers of the students is 'fout', because it is appearing in over half of the answers. This word could be translated to 'mistake' or 'wrong'. This table reveals that some students think about mistakes while experiencing a moment of math anxiety. However, statements about proportions in this matter are not reliable, since there is a very small sample size. Despite these concerns, the question remains whether mistakes play a big role in math anxiety and more importantly, what is the role of teachers in this matter?
The next section of the survey was concerned with the behaviour of the math teacher, which is separated into four categories, see table 3.3 and table 3.4. Contrary to expectations, the students do not feel anxiety (or very little) when a teacher comments positively on their intellect. As discussed in section 3.4, praising students' intelligence has negative consequences for students' achievement motivation. Therefore, it is rather surprising that the students do not feel anxiety in this scenario. A possible explanation is that students do not feel anxiety at the moment that the teacher is commenting them positively on their intellect because they might only feel anxiety when struggling with math, after being called intelligent or capable in mathematics.

In other words, the students might not be able to understand the connection between the anxiety during a struggle and a positive comment from their teacher on their intellect. Since in this pilot the interest lies on the direct impact of the behaviour of the math teacher on the math anxiety of the students, the impact of positive comments on intelligence is therefore less important. After the category 'growth mindset', the students were asked to imagine scenarios which are related to the category 'performance goal and learning goal'. The results of this category are more difficult to analyse, since the differences are very small and the amount of fear the students experience is very low for all the scenarios. The scenarios involved formative testing and surprisingly, there are very little differences in formative testing which ends up in a formative grade and formative testing with only comments from the teacher. Partly because of the small sample size, it is still unclear whether the performance goal increases the degree of anxiety students experience.

Turning now to the third category 'math teaching anxiety'. A common view amongst the students was that teachers who express that they find a certain subject difficult, cause more anxiety than teachers who seem to find a certain subject easy. The fear that exists amongst these students is the highest in the second part of the survey. The only scenarios which are similar to these levels of anxiety are the scenarios which are connected to a math exam.

Another interesting finding is the high degree of anxiety students experience when a teacher pretends that she did not make a mistake, while she did, and when a teacher gets nervous after making a mistake. These findings are likely to be related to the insecurity the students see in the behaviour of the teacher.

In the last category students were asked to imagine a scenario where they get a high grade and a low grade. Surprisingly, the students feel less anxiety when the teacher tells the students that she expected less from the student if the student did the exam well in comparison with the same scenario if the student did not do well. The reaction of the teacher is very similar, but apparently students feel more anxiety when this reaction comes after a low grade. Even more surprising is the fact that students feel the highest fear in this category if the teacher does not show any expectation at all. The question arises whether students prefer to receive comments from the teacher which imply that the teacher had expectations of the students.

At last, it is important to bear in mind that it is unknown how often the students experienced scenarios similar to scenarios they were asked to imagine. Because of this a note of caution is due here since students could respond to the questions with (a lot) experience or without any experience. In other words, students might choose to answer with great fear when they experienced a certain scenario many times. For example, it is not clear how often they were following a lesson from a teacher who shows signs of insecurity. A student who never had a nervous mathematics teacher, might guess about the feeling he/she will experience when it would happen.

In summary, the findings in this pilot raised the following questions and comments:

- Do students fear more for the opinion of their peers than for the personal opinion of the teacher? If so, what is the role of the teacher in this matter?
- How can it be prevented that the loyalty of the students toward their teacher, influences their answers in the survey?
- Does the word and concept of 'mistakes' play a big role in the math anxiety students experience? If so, what is the role of the teacher in this matter?
- The focus of this study will not lie on the impact of positive comments on intelligence, made by the math teacher towards the students.
- It is still unclear whether there are differences in terms of anxiety students experience when they work on an exercise with a performance goal in comparison to an exercise with a learning goal.
- The students experience anxiety when they notice the teacher having difficulties or insecurities about teaching mathematics.
- Do students prefer to receive comments of the teacher which imply that the teacher had expectations of the students?
- How often did students experience scenarios similar to the ones they have to imagine?

## 3.7 Recommendations pilot

The findings of this pilot suggest a number of changes in the survey for further iterations.
First of all, the small sample size of the pilot did not allow to perform any statistical tests, so further iterations should involve more participants. Another approach to gain more valuable results is to investigate certain participants further. The following iteration should therefore provide an extra survey for certain participants where they can reason their given answers. This extra survey involves more open questions, which focus on the reasoning behind the answers.
Another subject discussed in the conclusion and discussion is the fear for public opinion, in particular the role of the teacher in the fear of students feel for the public opinion of the other students in the classroom. A greater focus on the fear for public opinion could produce interesting findings so this subject should be a part of the survey in further iterations.
Another note pointed out in the conclusion and discussion was the indication that the students felt loyal towards their teacher, which had an influence on the results. There are two ways to reduce this bias in the results. These are: creating an anonymous survey and making sure that the researcher is not the teacher of the students.
Turning now to the word and concept of 'mistakes'. Looking at the four categories the survey is divided into, one of the categories is known to be associated with this concept, which is: 'performance goal and learning goal'. A natural progression of this pilot would be to analyse this concept and involve this subject into the second category of the survey. In this way, the survey gives information about the role of this concept in developing or worsening math anxiety.
As suggested in the conclusion and discussion, the impact of positive comments on intelligence should not be part of the next iteration, for reasons explained earlier.
In summary, two subject should be added to the next iteration, which are: fear for public opinion and the concept of mistakes, and one subject should be removed, which is: positive comments on intelligence. The survey is originally divided into four categories (1) growth mindset (2) performance goal and learning goal (3) mathematics teaching anxiety and (4) perceived teacher expectation. The subject that should be removed is partly stated in the first and partly in the fourth category. As described earlier, these two categories are intertwined so they could be easily merged into one category to make room for the new subjects.
The last note pointed out in the conclusion and discussion is the experience students have in the scenarios they have to imagine. To reduce this uncertainty, questions should be added to the survey which estimate how often students are in scenarios similar to the ones they have to imagine.
The remaining questions described in the last section, can be investigated in an iteration which involves a higher number of participants or a deeper conversation with certain participants.

## 3.8 Research questions

To conclude this pilot, the main research question together with sub-questions are formulated which will be answered in the next iteration.

*Which factors in the behaviour of math teachers in their contact with high school students, contribute to the developing, worsening or alleviating of math anxiety during math activities?*

- *What is the impact of math teachers showing their belief in the fixed mindset on high school students' feelings of stress they experience during math activities?*
- *What is the impact of math teachers mentioning the performance goal prior to a mathematical exercise on high school students' feelings of stress they experience?*
- *What is the impact of teachers showing signs of mathematics teaching anxiety on high school students' feelings of stress they experience during math activities?*
- *What is the impact of teachers forcing students to publicly answer questions involving math on the feelings of stress students experience in upcoming math activities?*
- *What is the impact of math teachers focusing on mistakes high school students make during their math activities on their feelings of stress they experience?*

# Chapter 4

# First iteration

Babies and infants love mathematics.

*Jo Boaler*

## 4.1 Introduction

This iteration examines which factors in the behaviour of math teachers in their contact with high school students, contribute to the developing, worsening or alleviating of math anxiety during math activities.
In the previous chapter, a pilot made a start to this thesis which explores this question. The main aim of this iteration is to investigate the research questions established in the pilot and provide hypothesis concerning these questions. To explain the term 'Math anxiety', students are shown a video, which is the same video used in the pilot. Once the video is finished the students start filling in a new survey, slightly different from the survey used in the pilot. By interviewing a few students after the completion of the survey, both qualitative and quantitative data will be gathered in this iteration. The analysis of the data can lead to a better understanding of the role math teachers have in developing, worsening or alleviating math anxiety high school students experience. In order to focus on the research questions, the second part of the survey will be classified into four categories. Since the research questions are focused on the behaviour of the math teachers, this classification helps distinguish between these types of behaviour. Finally, conclusion and discussion follow in order to answer the research questions and determine recommendations for further iterations.

## 4.2 Setting

Before proceeding to examine the results, it is important to describe the setting in which this iteration takes place. The participating students are from three distinct classes, which are: 3rd grade vwo, 4th grade havo mathematics B and 5th grade mathematics A. In section 3.2 the different levels of education are described as well as the different types of mathematics given in high schools in the Netherlands. The students participating in the study are between 13 and 17 years old. For the group of students from the 3rd grade, the math teacher is also their mentor. The role of a mentor in Stanislascollege Westplantsoen is to help students in matters that are not connected to any specific course. In general, this includes study techniques, social issues in school or at home, extra medical or practical help and mental support. However, the daily practices of mentors differ a lot since there is no clear study program for them. The table below shows an overview of the setting described previously.

| | |
|---|---|
| Date | March 16th and 17th 2022 |
| Place | Stanislascollege Westplantsoen, Delft |
| Room | Classroom for mathematics |
| Lessons | Math lesson, 3rd grade, vwo (24) |
| | Math lesson, 4th grade, havo, mathematics B (19) |
| | Math lesson, 5th grade, vwo, mathematics A (13) |
| Participants | 56 students |
| Survey given by | Dominique van den Bosch |
| Relation | Math teacher and mentor (3rd grade, vwo) |
| Instruction | Video about math anxiety |

## 4.3 Survey

As was mentioned in the introduction, the survey used in this iteration is slightly different from the survey used in the pilot. For a detailed description of the survey used in the pilot see section 3.4. In this section, the differences between these surveys will be described.
As before, the students were sent a link to Google Forms, where they can start the survey with their own student email, known by the researcher. For the reasoning behind choosing Google Forms and the anonymity of the students see section 3.4. The survey of this iteration can be found via the link survey first iteration.

### 4.3.1 Introduction

The survey starts with an introduction in which the name and the educational background of the researcher is stated. The introduction in the survey used for the pilot was clear for the students, so the introduction in this survey only differs slightly. In the end of the introduction, there is an additional part which encourages students to be cautious that they do not focus on their own math teacher, but rather try to think of all math teachers they experienced through their life. In the conclusion of the pilot, see section 3.6, it is suggested that the students felt loyal towards their teachers, which influenced their results. To rule out the possibility that students answer their questions with this loyalty, the participants are now warned not to think about their math teacher of this year only.

### 4.3.2 First part: general feeling of math anxiety

Using a seven-item scale ranging from no stress to a lot of stress, this part measures the general feeling of stress a student experiences with mathematics. Since this part of the survey was clear for the students in the pilot and there were no objections in the conclusion of the pilot, no changes have been made.

### 4.3.3 Second part: behaviour of the math teacher

Similarly to the first part, the students have to answer questions which involve scenarios they have to imagine in order to determine the role of certain behaviour of the mathematics teacher on the math anxiety the students experience. However, the structure of the second part of the survey differs from the survey used in the pilot in that it contains additional questions to gather information about the amount of times students experience the scenarios they have to imagine. In the conclusion of the pilot, see section 3.6, it is pointed out that students might choose to answer with great fear when they experienced a certain scenario many times. To decrease this uncertainty, every three questions concerning a certain scenario are followed by a combined question which asks the students to rate how often they experienced these scenarios by choosing between four options: never, sometimes, often or very often. Another recommendation from the pilot is to add the category 'Concept of mistakes' to the second part of the survey, since open questions in the beginning of the survey used in the pilot pointed out that some students are focused on the word and concept of 'mistake'. The subject that is removed in order to create space for the new category, is the impact of positive comments on intelligence since students might not understand the possible connection between the anxiety during a struggle and a positive comment from their teacher on their intellect. As a result of this, the survey is divided into the following categories: growth mindset; performance goal and learning goal; mathematics teaching anxiety; and the concept of mistakes. Every category contains two scenarios together with three reactions of the teacher to the student. As mentioned before, every scenario is followed by a combined question designed to measure the experience students have with the reactions of the teacher.

### a) Growth mindset

Both the first and the second scenario in this category origin from the pilot, where the first scenario was stated in the category 'Growth mindset' and the second scenario was stated in the category 'Perceived teacher expectation'. See section 3.4 for an explanation of the scenarios.

*You are not able to complete a simple exercise during a math lesson. The teacher sees this, walks up to you and 1) says 'It does not matter, not everyone is good at math' 2) says 'Think again' 3) writes down the good answer in your exercise book.*

*During math lesson you receive your grade for a small exam. You failed the exam. The teacher hands out the exam and says: 'What a shame that you failed the exam'. After that the teacher says: 1) 'I expected this since you are not so good in mathematics' 2) 'I did not expect this because normally you are so good in mathematics' and 3) 'You did not do this exam well'.*

The previous iteration only focused on the difference in expectations in this scenario and have failed to address another aspect which is important in the comparison between these three reactions. In the first reaction, the teacher shows low expectations towards the student, since she says that she expected a low grade. However, she also states that the student is not so good in mathematics, which is a criticism on the ability of the student. In the second scenario the teacher shows high expectations, since she says that she expected a high grade and praises the student's ability. In the last reaction the teacher does not show any expectations, criticism or praises and focuses on the exam itself.

### b) Performance goal and learning goal

This category contains the same scenarios used in the pilot, see section 3.4.

*The teacher hands out a form with a few exercises everyone in the classroom has to solve. Before you start with the form, the teacher tells the class what he/she will do with the form afterwards. The teacher says: 1) 'I will check the form and you will get a grade which will not be part of your final grade' 2) 'I will check the form and I will draw lines through the mistakes you made' and 3) 'I will check the form and write down hints next to certain exercises'.*

The pilot did not treat the first reaction of this scenario in much detail, so this iteration focuses shortly on the first reaction where the teacher tells her students that they will be formatively graded for the exercise. Formative grading was chosen over summative grading because none of the scenarios described in the second part of the survey are taking place during an exam. As can be seen in table 3.1, the average of the scenarios concerning participation in exams, are much higher. Therefore it is out of proportion to deal with summative grading in this scenario.

*The teacher is giving a trial exam during the lesson. You will not get a grade for the trial exam but the exam will be checked by the teacher. You ask the teacher why you have to participate in this trial exam. The teacher says: 1) 'I would like to know how well you understand everything' 2) 'Then you can see for yourself how well you understand everything' and 3) 'You can learn from it'.*

**c) Mathematics teaching anxiety**

Again, these scenarios are equal to the scenarios described in the pilot, see section 3.4.

*During math lesson the teacher explains a subject in front of the class and the subject is difficult for you. You 1) notice that the teacher herself finds the subject difficult 2) notice that the teacher herself finds the subject very easy and 3) do not know whether the teacher finds the subject difficult or easy.*

*The teacher makes a mistake on the board during math lesson. The teacher 1) pretends that she did not make a mistake 2) corrects her mistake and becomes nervous in front of the class and 3) corrects her mistake and continues in the same way she did before the mistake.*

**d) The concept of mistakes**

The conclusion of the pilot, see section 3.6, introduced the new category 'The concept of mistakes'. The purpose of the first scenario is to elicit information on the influence of the learning orientation of the teacher towards mistakes, on the feeling of stress students experience.

*During math lesson you are working on homework exercises. The teacher walks besides you and sees you made a few mistakes. She says: 1) 'Good that you made mistakes, because that means that you learned something' 2) 'Do not worry, there are a few questions you did well' and 3) 'I can see you have difficulties with math, since you make a lot of mistakes'.*

In the first reaction, the teacher focuses on the learning aspect of the mistakes made by the student. By contrast, the second reaction and third reaction are not focused on the learning aspect but rather on the mistakes themselves. The second reaction shows a positive attitude towards the mistake and the third reaction shows a negative attitude towards the mistake. For more details about these attitudes teachers have towards mistakes, see section 2.5.
In section 3.6 the question was raised whether students fear more for the opinion of their peers than for the personal opinion of the teacher. Because of this, the second scenario focuses more on the way the teacher handles a public mistake in a classroom. In [Tulis, 2013] 11 different categories of teacher responses to student's mistakes are investigated splitted into adaptive and maladaptive responses, see section 2.5 for a detailed description. One of the maladaptive responses is the redirection of the question to another student, which is also called 'Bermuda triangle of error correction'. One of the adaptive responses is correction by the student and one of the responses which is neither maladaptive nor adaptive is correction by the teacher. These three reactions were observed the most in the study [Tulis, 2013] and therefore used in the second scenario.

*During an explanation of the teacher in front of the class, the teacher asks a question in which you answer wrongly. The teacher says that the answer is wrong. Next, the teacher 1) asks another students who knows the right answer 2) tells the right answer and 3) gives an hint so that you can give the right answer yourself.*

**Closure**

The closure in this iteration and in the pilot identical.

## 4.4 Student interviews

In the pilot, it has been recommended to investigate certain participants further to gain more valuable results. Therefore, in this iteration three students will be invited for an interview where they have the chance to further elaborate on their answers. Only 3 students were chosen because of the expected difficulty in obtaining time for the interviews. The three students from three different classes were selected because of their relatively high feeling of stress they indicate in the survey. The high levels of stress they indicate might help them picturing the scenarios better and therefore help them to explain the reasons behind these feelings of stress. To identify the three students with the highest feeling of stress in their class, the average of the first part of the survey, where the general feeling of math anxiety is investigated, and the weighted average of the second part of the survey, where the influence of the behaviour of the math teacher is investigated, are taken together.

## 4.5 Results

This section presents the analysis of the results obtained from the survey described in the previous chapter. All analyses were carried out using R.

### 4.5.1 First part: general feeling of math anxiety

The first set of questions aimed to measure the general feeling of stress students experience during math activities. The results must be approached with some caution because the list of questions asked in the first part is rather small and these results do not include all the potential stressful scenarios students can experience during math activities. Table 5.1 shows the mean and standard deviation of the level of stress students indicated per question. The mean $\overline{x}$ and standard deviation $s$ were calculated in the following way. The degrees of freedom used in the calculation of $s$ is $n-1$, where $n$ is the sample size. Let $x_i \in \{1, \dots 7\}$ be the level of stress the students indicate where $i \in \{1, \dots, 56\}$. Then we have

$$\overline{x} = \frac{\sum_{n=1}^{56} x_i}{56}, s^2 = \frac{\sum_{n=1}^{56} (x_i - \overline{x})^2}{55}. \tag{4.1}$$

The first part of the survey ended with two open questions about the thoughts and feelings of students when they experience the highest level of stress. The total number of responses for the first question was 29 and for the second question that was 33. One of the reasons why not all students (56) responded to these questions is the fact that not every student indicated the highest level of stress for any scenario in the first part of the survey. When asked about the thoughts of the students, 8 of the 29 students mentioned thoughts of a grade. Furthermore, 9 students said: 'I can not do it' and 5 students wondered whether they learned the material well enough. When asked about the feelings of the students, 11 of the 33 students reported to feel a high heart rate in a scenario where they indicated the highest level of stress and 10 students reported sweating more in a moment like this.

Table 4.1: Questionnaire ($n = 56$)

| **Questionnaire** | | |
|---|---|---|
| | Mean ($\overline{x}$) | Standard deviation ($s$) |
| You hear the word mathematics | 2.590 | 1.616 |
| You read the word mathematics | 2.446 | 1.426 |
| You open your math book | 3.232 | 1.727 |
| You are doing your math homework alone at home | 3.357 | 1.623 |
| You are doing your math homework with friends at home | 2.518 | 1.293 |
| You are doing your math homework with family members at home | 3.286 | 1.713 |
| You are doing your math homework during a 'maatwerk' lesson [see subsection 3.2.3] | 2.607 | 1.344 |
| You are doing your math homework during a math lesson | 2.607 | 1.334 |
| The teacher explains a new subject in front of the class | 3.429 | 1.571 |
| The teacher asks you a question on personal level, such that others are not able to hear it | 2.679 | 1.503 |
| The teacher asks you a question in front of the class, such that everyone is able to hear it | 4.125 | 1.789 |
| You are thinking about an exam scheduled for next week | 4.518 | 1.727 |
| You are thinking about an exam scheduled for the next day | 5.286 | 1.626 |
| You are studying for an exam scheduled for the next day | 4.804 | 1.762 |
| You are writing an unexpected small exam | 5.821 | 1.574 |
| You are writing an expected small exam | 4.071 | 1.736 |
| You are writing an expected exam | 4.607 | 1.765 |

### 4.5.2 Second part: behaviour of the math teacher

As was mentioned in the previous chapter, the second part of the survey was divided into four categories. Each category contained two scenarios which again contained three reactions from the teacher towards the student. Each scenario ended with a combined question designed to determine the frequency of the reactions.
For the purpose of analysis, the responses of the students on the frequencies of the reactions are transformed into weights. The weights are natural numbers from 1 to 4, corresponding to: 'never', 'sometimes', 'often' and 'very often'. The weighted average $\overline{x}_w$ and the weighted standard deviation $s_w$ are calculated in the following way. Let $x_i \in \{1, \dots 7\}$ be the level of stress the students indicate and $w_i \in \{1, \dots 4\}$ the corresponding weights to the reactions where $i \in \{1, \dots, 56\}$. Then we have

$$\overline{x}_w = \frac{\sum_{n=1}^{56} w_i \cdot x_i}{\sum_{n=1}^{56} w_i}, s_w^2 = \frac{\sum_{n=1}^{56} w_i (x_i - \overline{x}_w)^2}{\sum_{n=1}^{56} w_i}. \tag{4.2}$$

The next part of this section describes the results of every category separately, including figures in order to compare, summarise and visualize. Per category, the first two figures show in top row the level of stress students indicated for each reaction to the scenario and they show on the bottom row the amount of times this reaction occurred according to the students. The weighted averages with weighted standard deviations of the reactions to the scenarios are shown in the following figures. The last two figures show the weighted boxplots corresponding to the two scenarios. The analyses of every category ends with discussions about the interviews with students. Three students were invited for interviews and two of them decided to participate in the survey. In an attempt to make each interviewee feel as comfortable as possible, the interviewer did not record the conversation but wrote the answers down in a google form. In the end of the interviews, the interviewee showed the answers to the students and asked them to check whether they are correct.

**a) Growth mindset**

The first set of questions aimed to gather information on the impact of math teachers showing their belief in the growth mindset or the fixed mindset on high school students' feelings of stress they experience during math activities.

*Scenario 1*
*You are not able to complete a simple exercise during a math lesson. The teacher sees this, walks up to you and*
*1) says 'It does not matter, not everyone is good at math' (fixed mindset)*
*2) says 'Think again' (growth mindset)*
*3) writes down the good answer in your exercise book. (mindset unclear)*

It is apparent from figure 4.1 that students indicated very different levels of stress in the first reaction, where the teacher shows her belief in the fixed mindset. However, there were no students indicating the highest level of stress and closer inspection of this figure shows that there are more students indicating a level of stress lower or equal to level three. Caution must be applied since in the bottom row of figure 4.1 shows that the majority of the students ($\sim 71\%$) indicated that they have never been in a scenario in which the teacher reacted to them in the way reaction 1) describes. The results of the second reaction, where the teacher shows her belief in the growth mindset, are similar to the results of the first reaction. The students indicate very different levels of stress to both of the reactions. However, comparison with the first reaction shows that there are more students who indicate a higher level of stress after the second reaction, such as a 5 or a 6. Furthermore, the occurrence of the second reaction and third reaction differ from reaction 1 in that more students experienced the scenario at least one time. The third reaction shows a steady decline in the level of stress students indicate. In this reaction, where the teacher does not reveal her belief in either the fixed mindset or the growth mindset, most students estimate their stress with a number 4 or lower.

*Scenario 2*
*During math lesson you receive your grade for a small exam. You failed the exam. The teacher hands out the exam and says: 'What a shame that you failed the exam'. After that the teacher says:*
*1) 'I expected this since you are not so good in mathematics' (low expectations and criticism on ability)*
*2) 'I did not expect this because normally you are so good in mathematics' (high expectations and praises on ability)*
*3) 'You did not do this exam well'(no expectations, criticism or praises)*

From the histogram in figure 4.2 it can be seen that a small majority of students ($\sim 54\%$) indicated a level of stress than 4 to the first reaction, where the teacher shows low expectations towards the student and criticises on the ability of the student. On the other hand, 25% of the students indicated higher levels of stress than a 5 in this reaction. However, these results need to be interpreted with caution because of the high proportion of students ($\sim 89\%$) never experiencing this reaction, shown in the bottom row of figure 4.2. What stands out in the figure is that there are only slight differences between reactions 2) and 3). Both reactions show a big difference between the levels of stress students indicated.

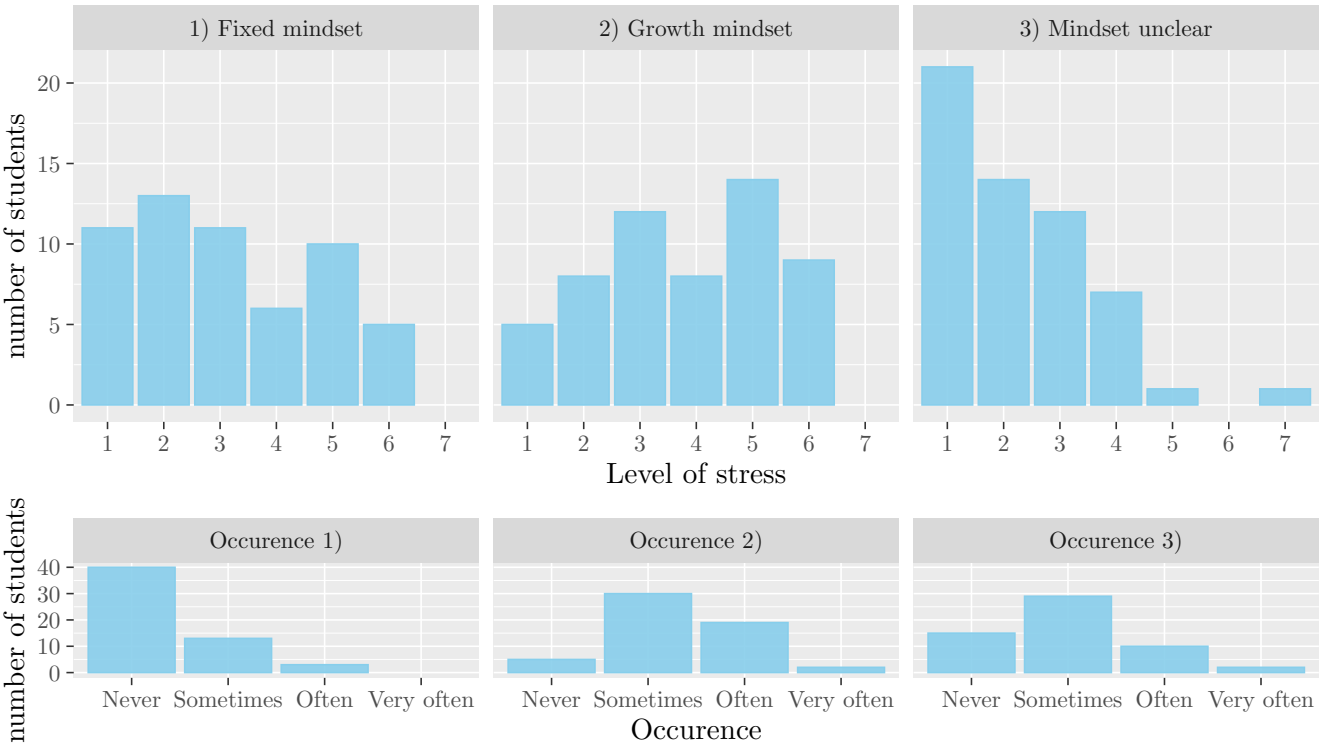


Figure 4.1: Growth mindset histogram scenario 1 ($n = 56$)

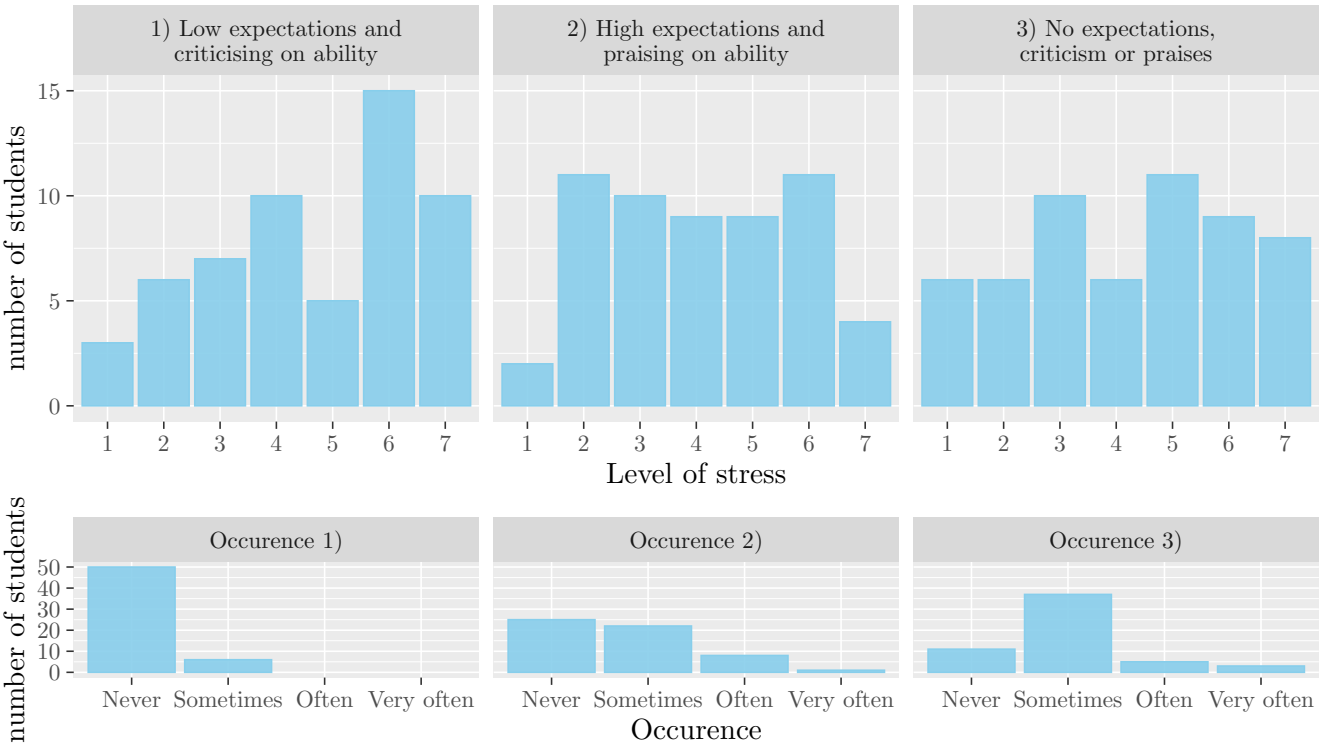


Figure 4.2: Growth mindset histogram scenario 2 ($n = 56$)

Interestingly, in the first scenario the weighted average of the level of stress students experienced is considerably higher in the second reaction where the teacher shows her belief in the growth mindset, than for the other two reactions in scenario 1, see figure 4.3. However, comparison between figure 4.1 and figure 4.3 reveals that the difference in weighted averages could be attributed to the high number of students that indicated 'Never' in the first reaction. So far this section has focused on comparison of the reactions of the teachers, but it is apparent from figure 4.3 that the weighted averages of the results concerning all the reactions of the second scenario are higher than the reactions concerning the first scenario. Viewed altogether, these results suggest that the students experience more stress in the second scenario in general. Therefore caution is due in comparing the reactions to both scenarios since students might feel that the second scenario itself is stressful and not in particular the reactions to this scenario.
The weighted boxplot representing the results of the first scenario, see figure 4.4, shows that the distribution of the feeling of stress students experience is higher in the first reaction of scenario 1, where the teacher shows her belief in the fixed mindset. As figure 4.3 shows as well, the distributions in scenario 2 are very similar. Finally, it is clear from the weighted boxplots that in the first scenario it seems that all the medians differ from each other and that in the second scenario it seems that only the second reaction differs from the other two.

The last part of this subsection presents the results of the interviews with students M. and I. Since the comments of the two students are comprehensive, they are listed in the appendix in table 7.3. In the first scenario the student is not able to complete a simple exercise and the teacher comments to that. One of the two interviewees I. argued that the reaction of the teacher should have nothing to do with the fact whether the student is good in mathematics or not. The other interviewee M. referred to the level of confidence, stating that the first reaction, where the teacher shows her belief in the fixed mindset, would not help her confidence level. Commenting on the confidence, M. states that the second reaction, where the teacher shows her belief in the growth mindset would not make her feel insecure. Interestingly, student I. describes that this reaction would influence her thoughts in a way that she will not be able to solve any mathematical problem anymore. She stated: "If somebody says: think well about it for another time, than the only thing I think is that I have to think very well about it and then I don't think about the exercise itself anymore. I forget what I have to do (I actually forget everything)." To the last reaction, where the teacher shows her belief in neither the fixed mindset nor the growth mindset, both interviewees reported that they would prefer to have explanation from the teacher and not only an answer to the issue. Student M. shows her concerns about the exam if the teacher would leave her without an explanation.
In the second scenario the student fails an exam for which the teacher says that she had low expectations and criticises on the ability of the student. Student I. emphasises the importance of her hard work in preparation for the exam. As student I. put it: "Even though I am not able to do it, I did do my best. If a teacher says that he/she expected this, then he/she says that before he/she knows whether I did my best or not." In the second reaction, the teacher shows high expectations and praises on ability, but the students are still uncomfortable with this reaction. Student M. commented that there is still an expectation from the teacher, which you have to fulfill as a student. In the last reaction, the teacher simply states that the student did not do the exam well, not showing any expectations. Both students explain that it is still difficult to deal with this reaction. As student M. said: "It is reality so you don't have to say that again." This last reaction might emphasize that the second scenario is stressful in general since it is probable that the student feels discomfort with the bad grade itself.

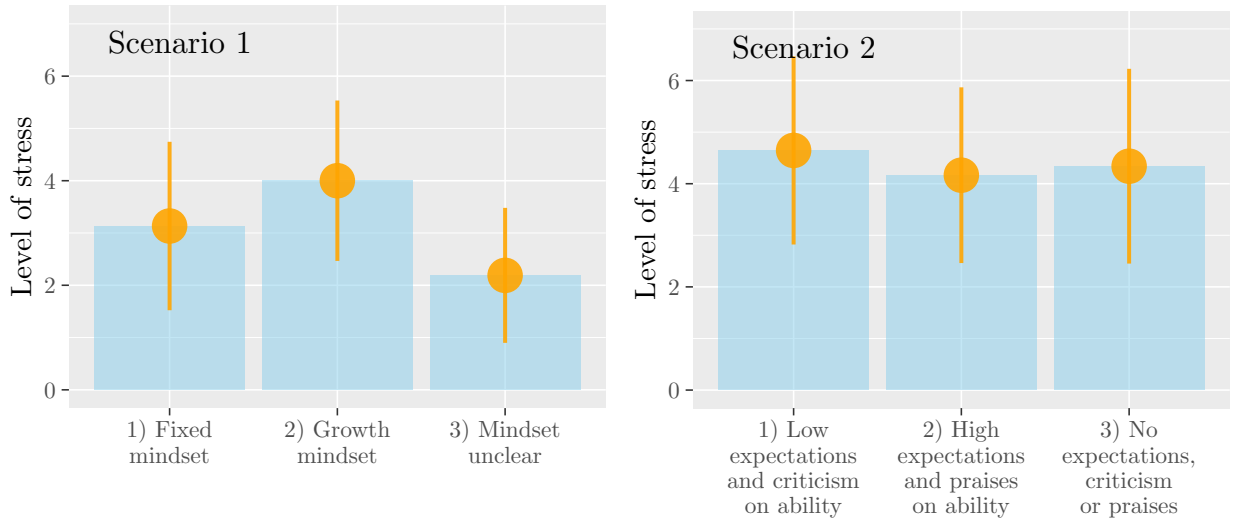


Figure 4.3: Growth mindset weighted average ($n = 56$), where the orange dots show the levels of the weighted averages and the orange lines the sizes of the weighted standard deviations.

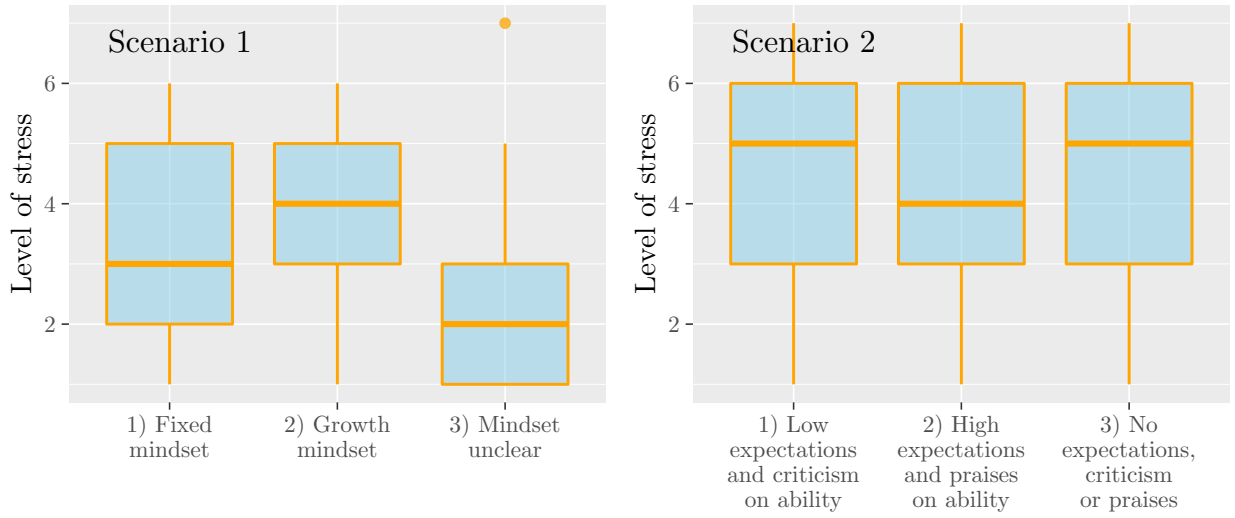


Figure 4.4: Growth mindset weighted boxplot ($n = 56$). The outliers of a boxplot are drawn as dots. Outliers are, by default in R, defined as observations outside the interval $q_1 - 1.5 \cdot IQR; q_3 + 1.5 \cdot IQR$ where $q_1, q_3$ and $IQR$ are the first quartile, the third quartile and the difference between the first and the third quartile respectively.

**b) Performance goal and learning goal**

The second set of questions aimed to compare scenarios in which teachers mention their performance goal towards a student prior to a mathematical exercise with a scenario in which teachers mention their learning goal prior to a mathematical exercise.

*Scenario 1*
*The teacher hands out a form with a few exercises everyone in the classroom has to solve. Before you start with the form, the teacher tells the class what he/she will do with the form afterwards. The teacher says:*
*1) 'I will check the form and you will get a grade which will not be part of your final grade' (performance goal with grade)*
*2) 'I will check the form and I will draw lines through the mistakes you made' (performance goal with lines)*
*3) 'I will check the form and write down hints next to certain exercises' (learning goal with hints)*

A majority of the students indicated a level of stress lower than 3 to each of the reactions of the teacher, see figure 4.5. However, in the third reaction, where the teacher explains the learning goal of the exercise, this majority is the highest ($\sim 80\%$). Surprisingly, only a minority of the students indicated higher levels of stress in the first reaction, where the teacher promises to grade the exercise in a formative matter. In the lower part of figure 4.5 it is apparent that the first reaction and the third reaction from the teacher are not very common for the surveyed. Almost half of the students ($\sim 48\%$) never experienced the first reaction and just over half of the students ($\sim 54\%$) never experienced the third reaction. In the second reaction this proportion is lower ($\sim 38\%$).

*Scenario 2*
*The teacher is giving a trial exam during the lesson. You will not get a grade for the trial exam but the exam will be checked by the teacher. You ask the teacher why you have to participate in this trial exam. The teacher says:*
*1) 'I would like to know how well you understand everything' (performance goal towards teacher)*
*2) 'Then you can see for yourself how well you understand everything' (performance goal towards student)*
*3) 'You can learn from it' (learning goal)*

As can be seen from figure 4.6, the responses of the students to the reactions of the teacher show similarity in that the majority of students indicate levels of stress lower than a 4. This majority seems smaller in the first reaction where the teacher explains that she wants to see how well the students understands everything, which emphasizes the performance goal towards the teacher. Unfortunately, there was no further insight on the difference in stress students experience through these reactions.

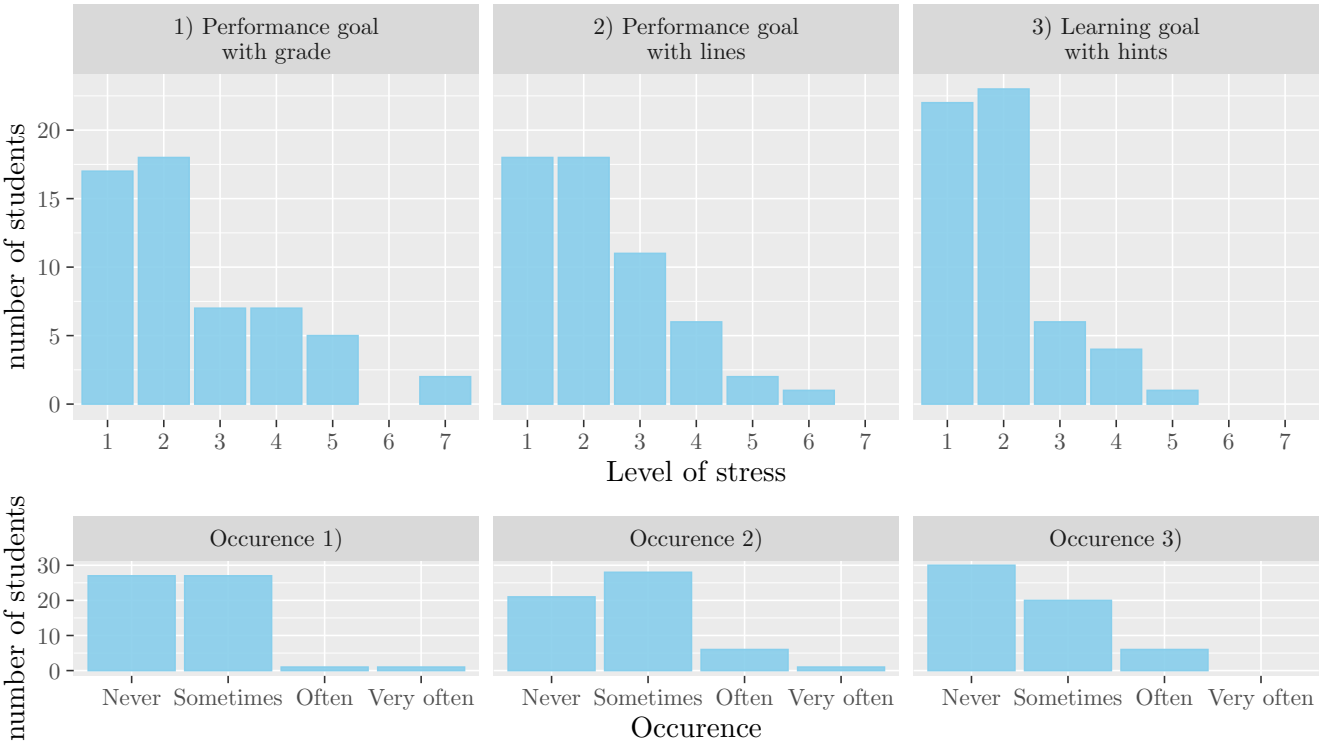


Figure 4.5: Performance goal and learning goal histogram scenario 1 ($n = 56$)

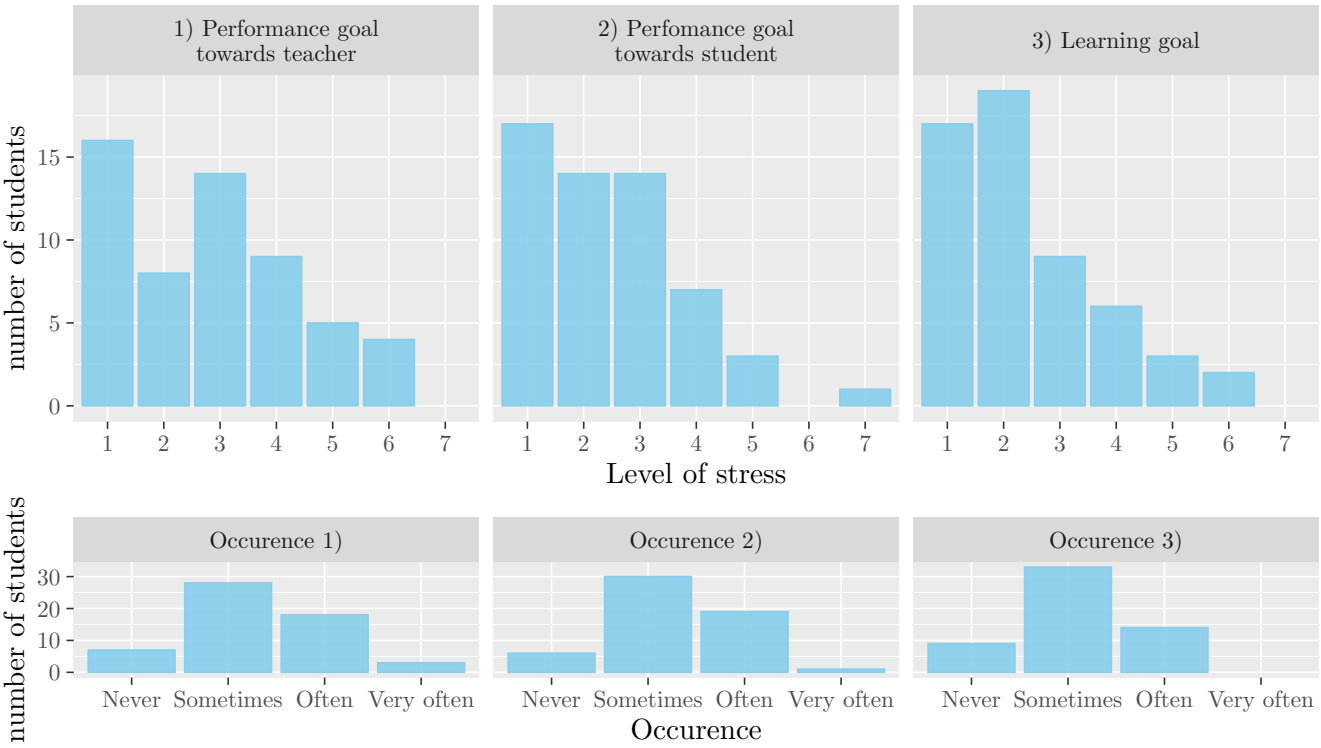


Figure 4.6: Performance goal and learning goal histogram scenario 2 ($n = 56$)

Surprisingly, the weighted averages of all three reactions to the first scenario are almost identical, differing only slightly in the first reaction, where the teacher asks a students to complete a mathematical exercise with a performance goal with a grade, see figure 4.7. Closer inspection of this figure shows that the weighted standard deviation is smaller for the second and third reaction. Comparison with figure 4.8 shows that the median of these reactions seems to be identical, but the maximum level of stress a minority of students indicated differs per reaction. In the first and second reaction, half of the students indicated levels of stress higher than the median 2, but this half of the students differ a lot from each other. Whereas in the third reaction, half of the students indicated higher than the median too, but that half differs less in their indications.

The second scenario is similar to the first scenario and their differences are best shown in figure 4.8. In the second scenario, half of the students indicated lower than a level of 3 to the first reaction, which is a higher median than the responses to the second and the third reactions show.

Before proceeding to the next category, where the influences of mathematics teaching anxiety are examined, it is important to look into the results of the student interviews on the scenarios involving performance goal and learning goal. In the first scenario, the teacher instructs the class to fill in a form and tells the students what she will do with the form. Comparison between the two students' answers is interesting, because they differ a lot. For student M. her level of stress depends on the place where the grade ends up. If the grade is visible for her parents, she would feel extra stress because of possible disappointment from her parents, while she would feel less stress if her parents are not able to check the grade. By contrast, student I. argues that she would not feel stress in the scenario where she gets a formative grade because of the fact that the grade will not be part of her final grade. In the following two reactions the students emphasize the importance of the teacher explaining the parts of the form which they did not do well. Both interviewees mention irritation when they receive hints from the teacher which are not helpful enough for them to understand their mistakes on the subject.
In the second scenario, the teacher gives a trial exam and explains the goal of the exam to the students. To the first reaction of the teacher a rather unexpected statement from student M. appears. She mentions that the way she pays attention in multiple courses influences the level of stress she experiences. She explains that the teacher can 'find out' that she still does not know much about the subject. To the second and third reaction, where the teacher explains the performance goal towards the students and mentions the learning goal respectively, student M. states that after this trial exam, she can understand where her attention should go.

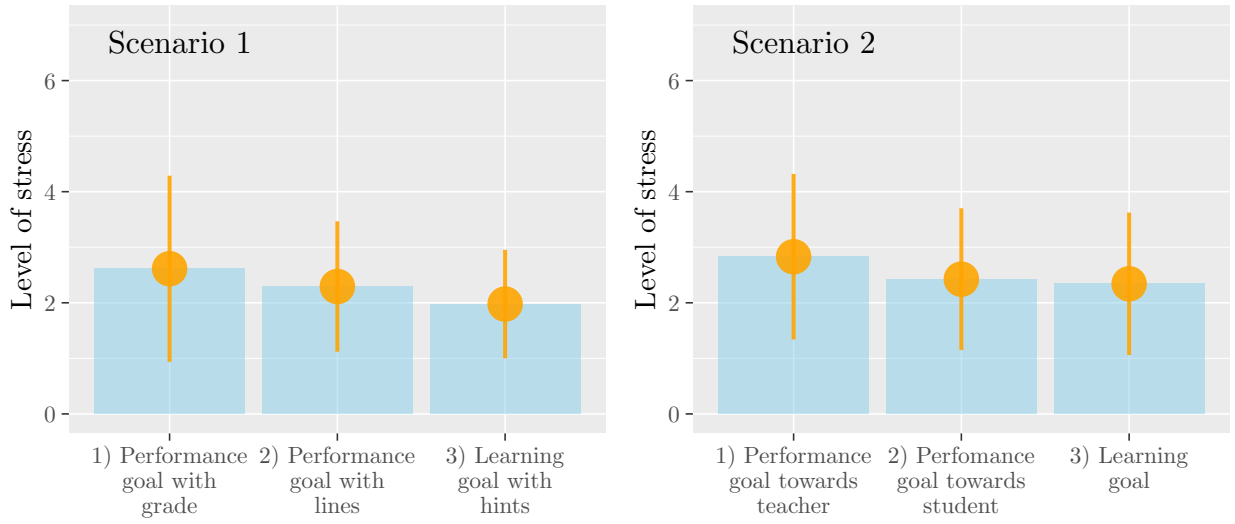


Figure 4.7: Performance goal and learning goal weighted average ($n = 56$), where the orange dots show the levels of the weighted averages and the orange lines the sizes of the weighted standard deviations.

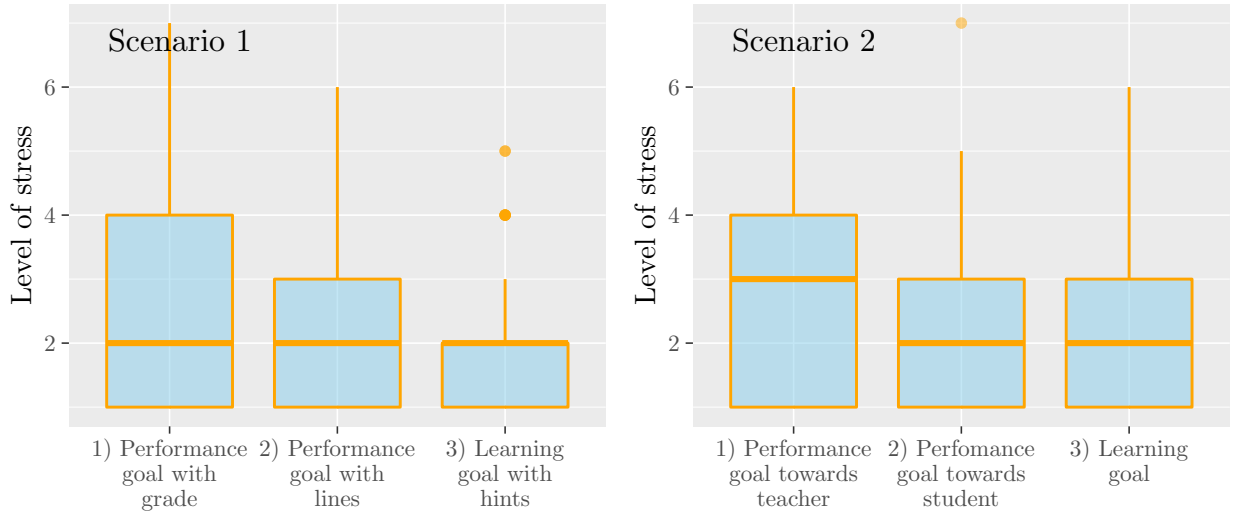


Figure 4.8: Performance goal and learning goal weighted boxplot ($n = 56$). The outliers of a boxplot are drawn as dots. Outliers are, by default in R, defined as observations outside the interval $q_1 - 1.5 \cdot IQR; q_3 + 1.5 \cdot IQR$ where $q_1, q_3$ and $IQR$ are the first quartile, the third quartile and the difference between the first and the third quartile respectively.

**c) Mathematics teaching anxiety**

The following part of the survey measured the impact of teachers showing signs of mathematics teaching anxiety on the level of stress students experience during math activities. The first set of questions are aimed to illustrate a scenario which helps distinguish the level of mathematics teaching anxiety a teacher can suffer from.

*Scenario 1*
*During math lesson the teacher explains a subject in front of the class and the subject is difficult for you. You*
*1) notice that the teacher herself finds the subject difficult (insecure)*
*2) notice that the teacher herself finds the subject very easy (confident)*
*3) do not know whether the teacher finds the subject difficult or easy (unclear)*

The results to these types of behaviour can be compared in Figure 4.9. An interesting aspect of these histograms is the distribution of the level of stress students indicated to the first behaviour. For every level of stress, there are at least 5 students who indicated that level, with the majority of the students indicating a 3 ($\sim$ 25%) or a 5 ($\sim$ 27%). The first histogram in this figure has to be interpreted with some caution since it is shown in the lower part of the figure that over half of the students ($\sim$ 59%) indicated that they have never had an explanation about a subject by a mathematics teacher who seemed to find the subject difficult herself. The most surprising aspect of this data is the considerably large amount of students indicating their level of stress higher than a 4 ($\sim$ 25%) in the scenario where the teacher shows confidence about the mathematical subject. This result is somewhat counterintuitive. However, there is a clear trend of decrease visible in the histogram corresponding to this scenario. In the last scenario the students had to imagine not knowing whether the teacher feels confident about the topic. Unfortunately, this result gives only little insight since the distribution is large. However, a majority of students ($\sim$ 86%) indicated levels of stress lower than a 4. For both the second and the third behaviour shown by the teacher, a majority of students experienced the scenario at least ones.

*Scenario 2*
*The teacher makes a mistake on the board during math lesson. The teacher*
*1) pretends that she did not make a mistake (hiding mistakes)*
*2) corrects her mistake and becomes nervous in front of the class (insecure showing mistakes)*
*3) corrects her mistake and continues in the same way she did before the mistake (confident showing mistakes)*

What stands out in figure 4.10 is the large proportion of students ($\sim$ 86%) not experiencing the first reaction to this scenario, where the teacher hides her mistake. It is important to bear in mind that students might not have realised at certain moments that teachers were hiding mistakes since they could lack knowledge or confidence. Therefore, the results to the first reaction of this scenario should be interpreted with caution. From the top half of the figure it can be seen that there is a wide distribution in the first and second reaction and a clear trend of decreasing proportions of students indicating higher levels of stress in the third reaction. Altogether, the students differ a lot from each other in their feeling of stress when the teacher seems insecure after making a mistake and almost half of them agreed ($\sim$ 48%) that they would feel no stress at all when the teacher seems confident after making a mistake.

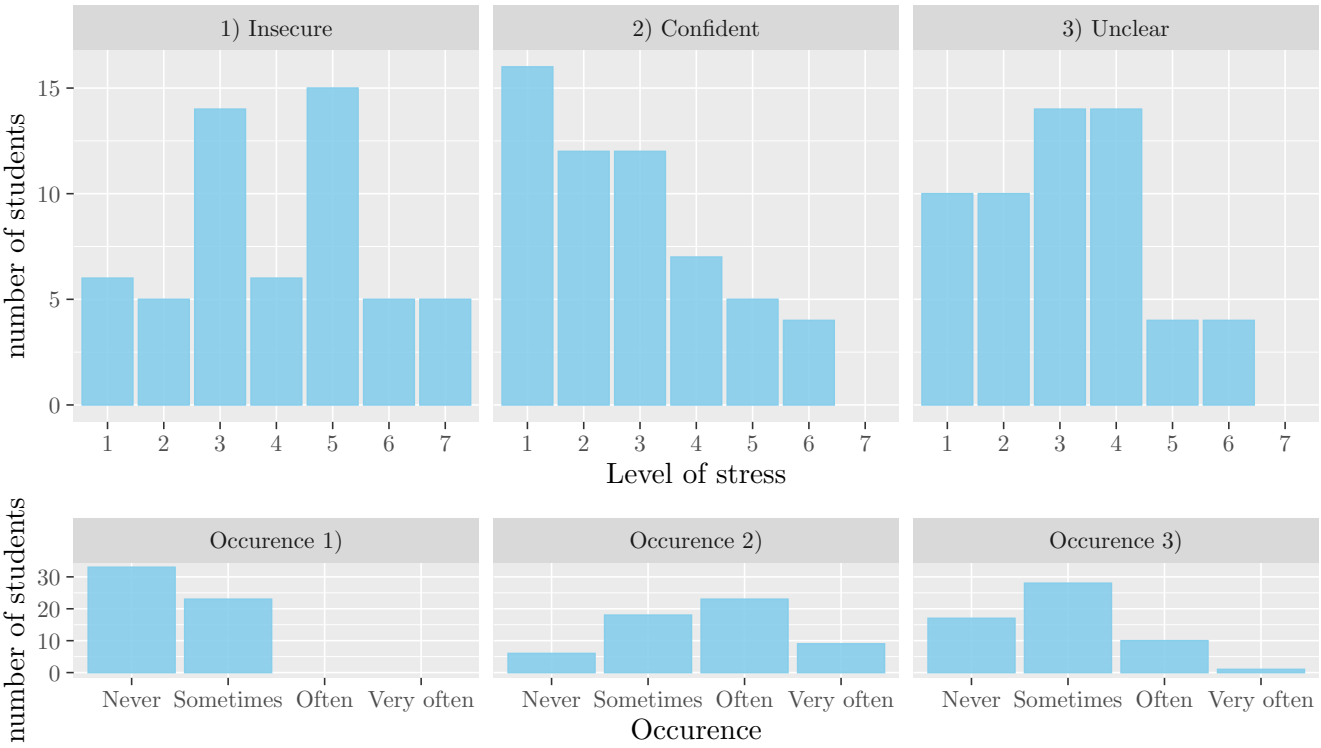


Figure 4.9: Mathematics teaching anxiety histogram scenario 1 ($n = 56$)

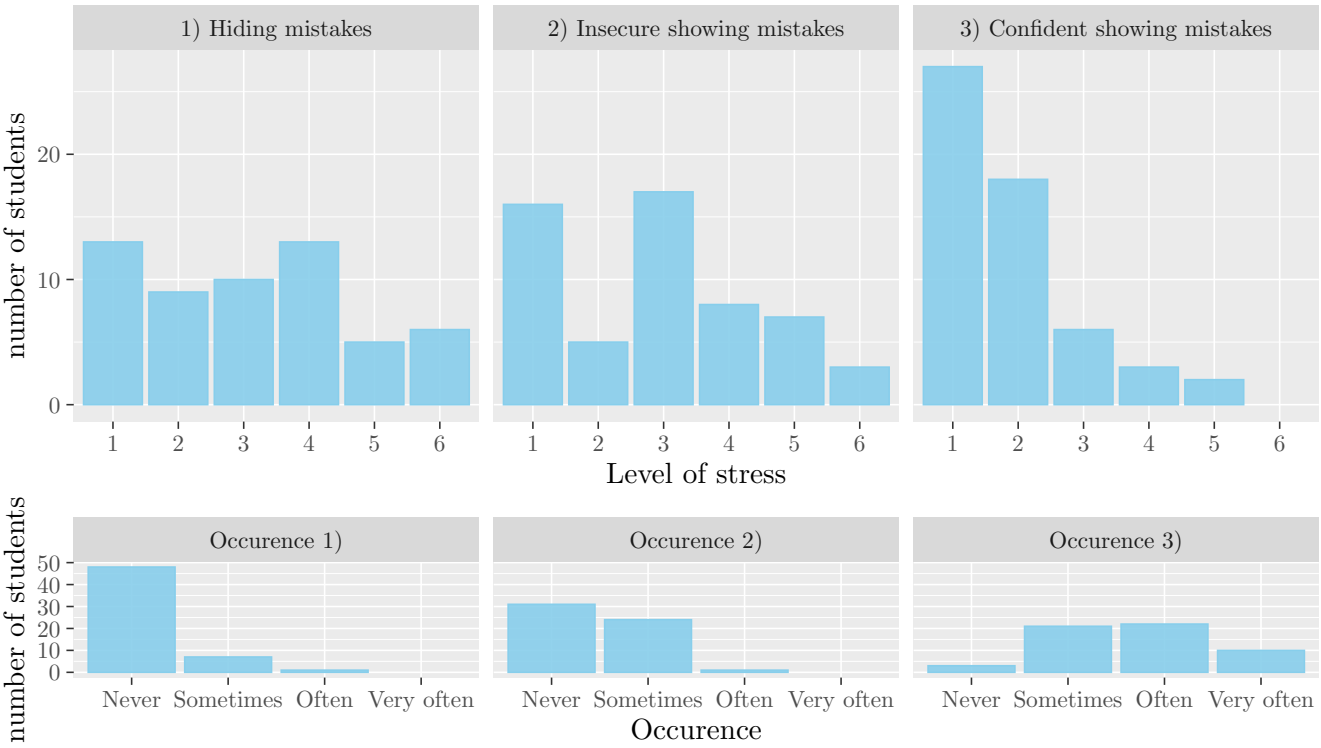


Figure 4.10: Mathematics teaching anxiety histogram scenario 2 ($n = 56$)

Figure 4.11 presents the weighted averages of the reactions to the scenarios described previously. As can be seen on the left side of the figure, the weighted average of the first reaction, where the teacher seems insecure in her knowledge about a mathematical subject, is higher than the weighted average for the confident behaviour shown by the teacher. The weighted boxplot concerning the first scenario, see figure 4.12, is revealing in several ways. First, unlike the histogram and the weighted average described previously, this figure shows that half of the students indicate a level of 3 or lower to the teacher who shows her confidence about the subject and that only a quarter of the students indicated a level of 3 or lower to the teacher who seems insecure about the subject. Secondly, the distribution of the students is narrower in the first reaction, where there are more outliers. And finally, the median of the insecure impression of the teacher is one level higher than the medians of the other two reactions.
The second scenario compares different ways on the way a teacher behaves after making a mistake. It is apparent from figure 4.11 that the weighted average of the last reaction, where the teacher shows her mistake and seems confident, is the lowest. The weighted average of the first two reactions, where the teacher hides her mistake or shows her mistake but seems insecure, are similar to each other. In the weighted boxplot considering scenario 2, see figure 4.12, it is apparent that very few students indicated levels of stress higher than a 3 for the third reaction to the scenario. Furthermore, in this figure it is quite revealing in that there is a wide distribution in the results of the second reaction. Students differ a lot in their level of stress they are experiencing when a teacher makes a mistake and shows insecure afterwards. Furthermore, the medians of the first two reactions are one level higher than the median of the last reaction where the teacher continues her lesson confidently after a mistake.

Having discussed the results of this part of the survey, the final part of this section discusses the interviews with students M. and I. on this subject, see table 7.3. To distinguish between different types of math teaching anxiety, the first scenario aimed to compare a teacher who seems to find the subject difficult with a teacher who seems to find the subject easy. One concern expressed regarding a teacher who seems to find the subject difficult was whether the subject is too difficult for the students if the subject is already difficult for the teacher. Another concern was expressed about the explanation of a teacher which could get more chaotic when the teacher does not exactly know how to explain the subject in the best way. A common view amongst the two interviewees was that a teacher who seems to find the subject easy creates less feeling of stress. Similar to the second reaction, the students felt less stress in a lesson where it is unclear whether the teacher finds the subject difficult.
When asked about the first reaction to the second scenario, where the teacher makes a mistake on the board and hides the mistake, the students differ in their feeling of stress and interestingly, differ a lot in their explanation. Student M. focuses on the fact that it is weird from the teacher to do this but emphasizes with her and explains that it does not give her extra stress. On the other hand, student I. reported that kids will learn the subject in a wrong way and therefore this student indicated a higher level of stress to this scenario. Commenting on the second reaction of the teacher, where she corrects her mistake and becomes nervous, student M. shows her empathy towards the teacher by stating: “I do understand that teachers find that difficult but I don’t get extra stress from that. The mistake has been recovered. Therefore it is clear now.” Considering the last reaction, where the teacher corrects her mistake and continues in a confident manner, both interviewees agreed that they feel no stress in this scenario.

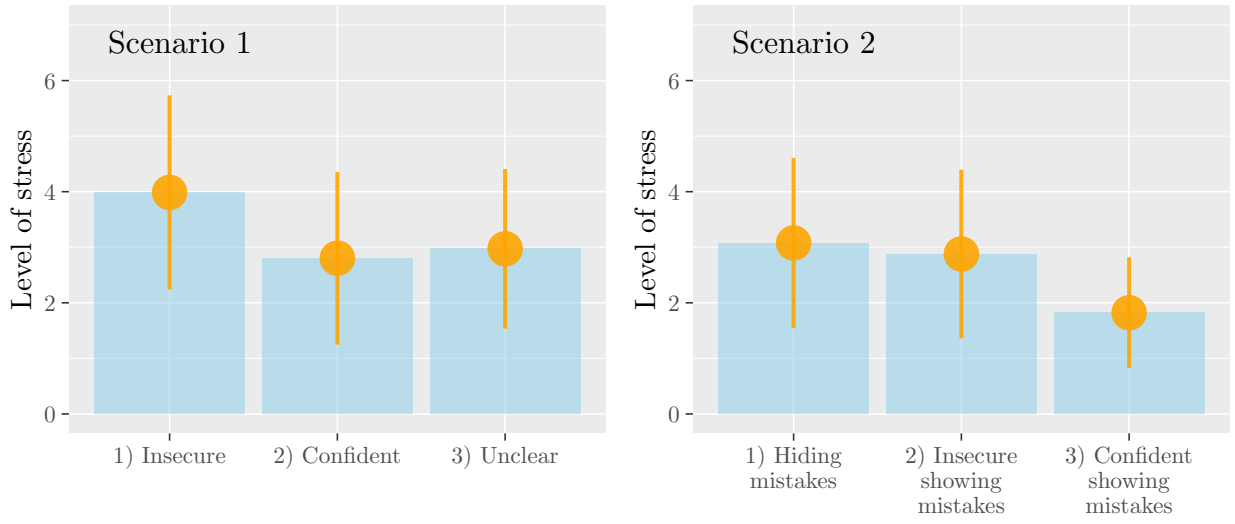


Figure 4.11: Mathematics teaching anxiety weighted average ($n = 56$), where the orange dots show the levels of the weighted averages and the orange lines the sizes of the weighted standard deviations.


Figure 4.12: Mathematics teaching anxiety weighted boxplot ($n = 56$). The outliers of a boxplot are drawn as dots. Outliers are, by default in R, defined as observations outside the interval $q_1 - 1.5 \cdot IQR; q_3 + 1.5 \cdot IQR$ where $q_1, q_3$ and $IQR$ are the first quartile, the third quartile and the difference between the first and the third quartile respectively.

**d) Concept of mistakes**

In the final part of the survey, students were asked to imagine scenarios which involve mistakes they made while doing their homework exercises or in front of the class.

*Scenario 1*
*During math lesson you are working on homework exercises. The teacher walks besides you and sees you made a few mistakes. She says:*
*1) 'Good that you made mistakes, because that means that you learned something' (focus on learning)*
*2) 'Do not worry, there are a few questions you did well' (positive focus on mistakes)*
*3) 'I can see you have difficulties with math, since you make a lot of mistakes' (negative focus on mistakes)*

Figure 4.13 shows a comparison between these three reactions of a teacher concerning mistakes a student made while making homework exercises. The students on the whole indicated quite different levels of anxiety, but in response to reaction 3), where the teacher focuses negatively on the mistakes, the students seem to report higher levels of anxiety in comparison with the focus on learning and the positive focus on mistakes. The most interesting part of the histogram concerning the first scenario is the similarity between the first two reactions. Apparently, the students reported similar levels of anxiety to a scenario where the teacher focuses on their learning goal and to a scenario where the teacher focuses on mistakes in a positive way. In both of the scenarios, approximately 68% of students agreed that the level of stress they would feel in the first two reactions is below a 4. As can be seen from the lower part of figure 4.13, over half of the students indicated that they have never experienced the first reaction where the teacher shows the importance of learning from mistakes. Reaction 3) is another scenario which students indicated to be quite uncommon.

*Scenario 2*
*During an explanation of the teacher in front of the class, the teacher asks a question in which you answer wrongly. The teacher says that the answer is wrong. Next, the teacher*
*1) asks another students who knows the right answer (redirecting question)*
*2) tells the right answer (correction by teacher)*
*3) gives an hint so that you can give the right answer yourself (correction by student)*

The second scenario was designed to compare different approaches from the teacher to react to a wrong answer from a student to a public question. Opinions differed as to whether redirecting the question gives a high feeling of stress, see figure 4.14. Two levels of stress, 2 and 4, where chosen by a large amount of the interviewees for this reaction of the teacher. Furthermore, it appears from the bottom part of figure 4.14 that exactly half of the students experience the redirecting option often. However, comparing the indicated occurrences of the six reactions in this category, it can be seen that these three scenarios occur more in general than the previous three.

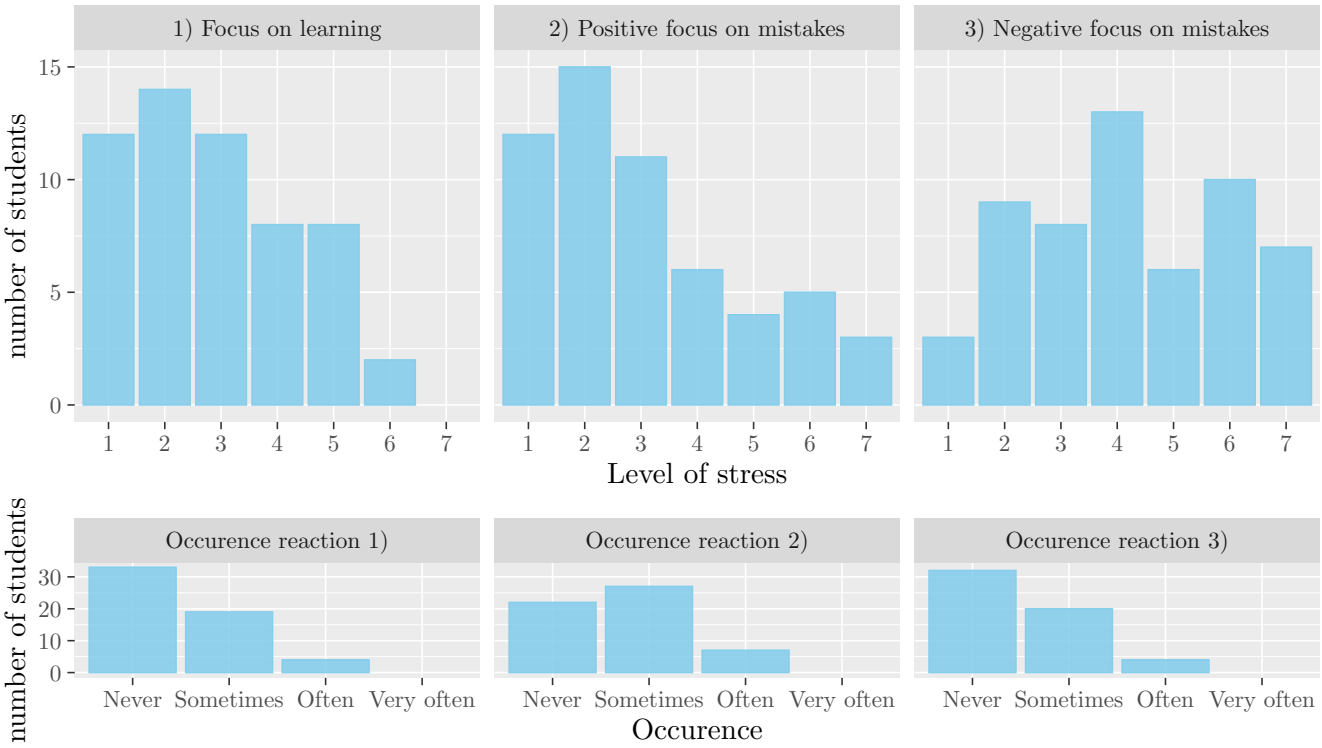


Figure 4.13: Concept of mistakes histogram scenario 1 ($n = 56$)

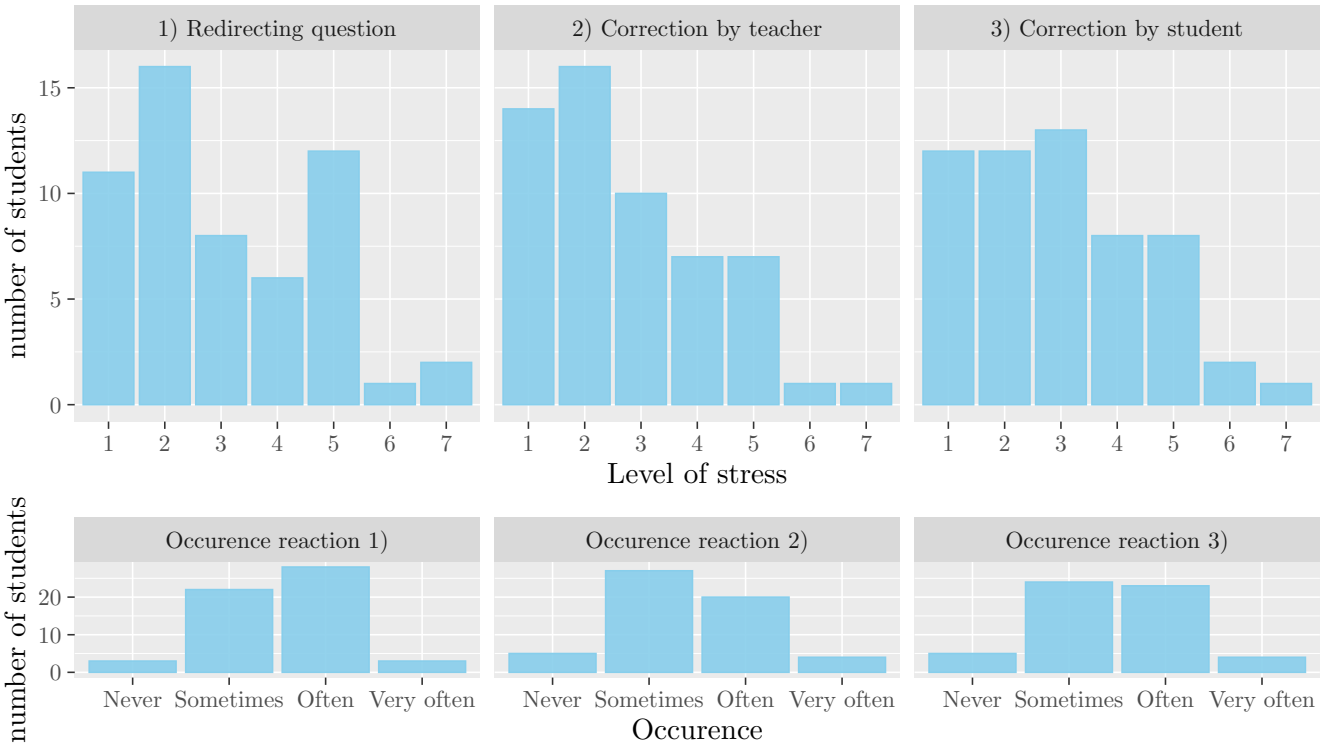


Figure 4.14: Concept of mistakes histogram scenario 2 ($n = 56$)

Turning now to the weighted averages concerning the two scenarios including the three possible reactions from the teacher. As can be seen from figure 4.15, the weighted average of the last reaction, in which the teacher focuses in a negative matter on the mistakes a student makes, is the highest. Both figure 4.15 and figure 4.16 show a wide distribution amongst the students for all reactions in this category. Apparently, students differ a lot in the level of stress they indicate in a scenario in which the teacher reacts on a private or a public mistake they made. The weighted boxplots in figure 4.16 provide a better comparison between the reactions in the second scenario. It can be seen from the weighted boxplots of the second scenario that every level of stress is represented by students, but more students indicated a lower level of stress in the second reaction. Approximately 50% of the students indicate a level of 2 or lower for the stress they experience when a teacher correct their public mistake, while in reactions 1 and 3 where the teacher redirects the public question or another students corrects the question, this proportion is approximately 25%.

In the final part of this subsection the comments of students M. and I. will be discussed, see 7.3. When asked about the scenario in which the teacher focuses on the learning aspect of making mistakes, the students agreed that this reaction is positive and creates less stress. In the second scenario however, student M. felt that the reaction is negative since the teacher implicates that very few exercises were made without mistakes. Student I. explains that her feeling of stress depends on the way the teacher formulates this reaction. To the last reaction, in which the teacher says that the student has difficulties with math since they made a lot of mistakes, student I. stated the following: “Then they base that on my mistakes while that does not have to be that way always. The difficulties are mostly due to thinking too much and then not understanding the material.” With this comment student I. seems to demonstrate that she prefers teachers not to jump into conclusions when the teacher sees a few mistakes.
In the last scenario described in the survey, a public question is raised by the teacher and a student responds with a wrong answer. The first reaction of the teacher is to redirect the question to another student who does know the right answer. Interestingly, student M. states: “... Also when another student gets the turn, I think: this I knew.” while student I. states similarly: “...than I get the feeling that I should have known it as well.” Both of these answers show that these students react in a frustrated matter since they believe that either they knew it already or should have known it. Surprisingly, student I. explains that she does not feel bad in a scenario where the teacher tells the right answer. As student I. put it: “Not really bad because here I don’t feel as stupid.” Comparing these two reactions it can be seen that student I. only feels incompetent when another student does know the answer, while she feels alright when there is no other student visible knowing the answer. In the last reaction, the teacher gives a hint so that the student can still give the right answer and student I. reports that she would not feel bad in this scenario since she learned something new.

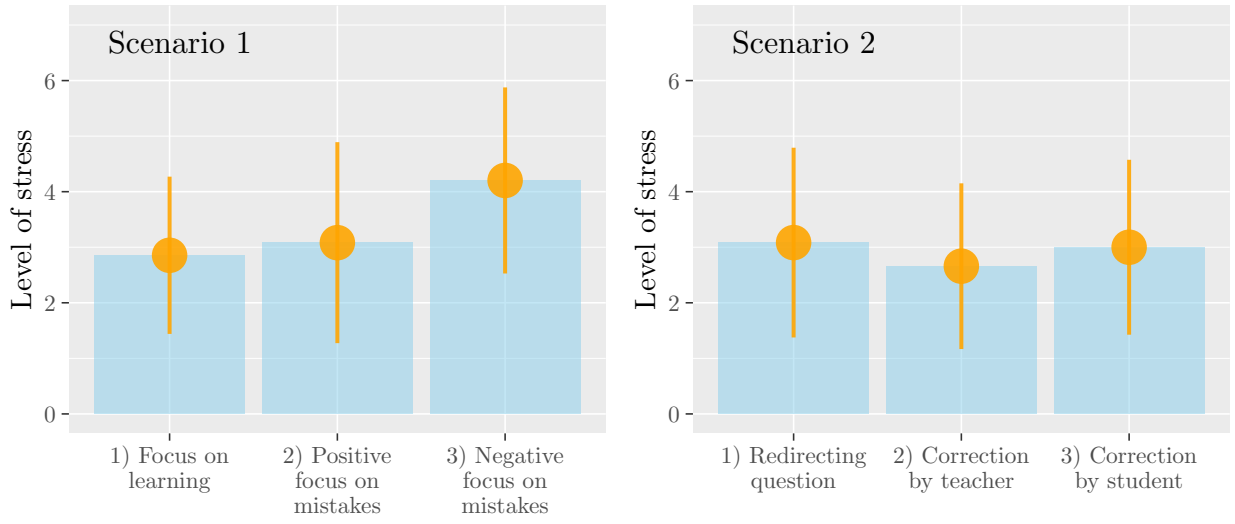


Figure 4.15: Concept of mistakes weighted average ($n = 56$), where the orange dots show the levels of the weighted averages and the orange lines the sizes of the weighted standard deviations.

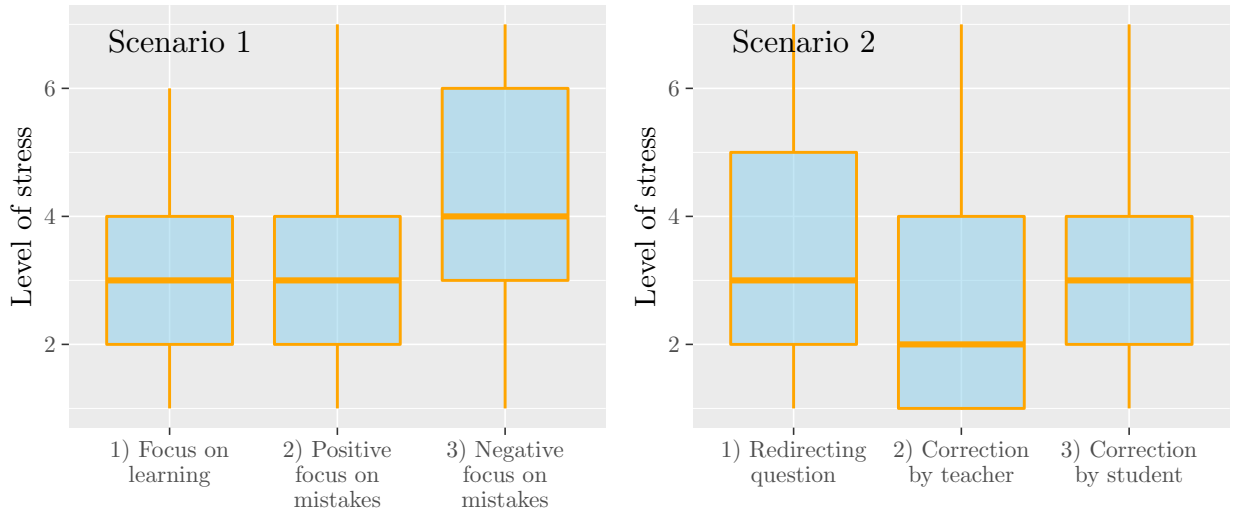


Figure 4.16: Concept of mistakes weighted boxplot ($n = 56$). The outliers of a boxplot are drawn as dots. Outliers are, by default in R, defined as observations outside the interval $q_1 - 1.5 \cdot IQR; q_3 + 1.5 \cdot IQR$ where $q_1, q_3$ and $IQR$ are the first quartile, the third quartile and the difference between the first and the third quartile respectively.

### 4.5.3 Comparison first part and second part

In the last part of this section, a comparison is presented between the first part of the survey, were the general feeling of stress during math activities is measured, and the second part of the survey, where the role of certain behaviour of the teacher in the feeling of stress students experience, is measured.

The average of part 1 and the weighted average of part 2 were compared in order to get insight on the relative impact of the scenarios described in the second part. For the purpose of measuring this impact, every students average level of stress of the first part ($\overline{x}_i^1$) and the weighted average of the second part ($\overline{x}_i^2$) of the survey were calculated, where $i \in \{1, \ldots, 56\}$. In the the second step the difference between these two was calculated ($d_i = \overline{x}_i^1 - \overline{x}_i^2$) and analysed. A positive $d_i$ means that the average student $i$ indicated in the first part of the survey was higher than the weighted average the student indicated in the second part of the survey. This means that the student indicates to feel more stress in the described general scenarios than in the scenarios where there is certain interaction between the teacher and the student. Figure 4.17 shows that the majority of the students, which is approximately 80.3%, indicated higher levels of stress for the first part of the survey and the average level of $d_i$ was approximately 0.713.

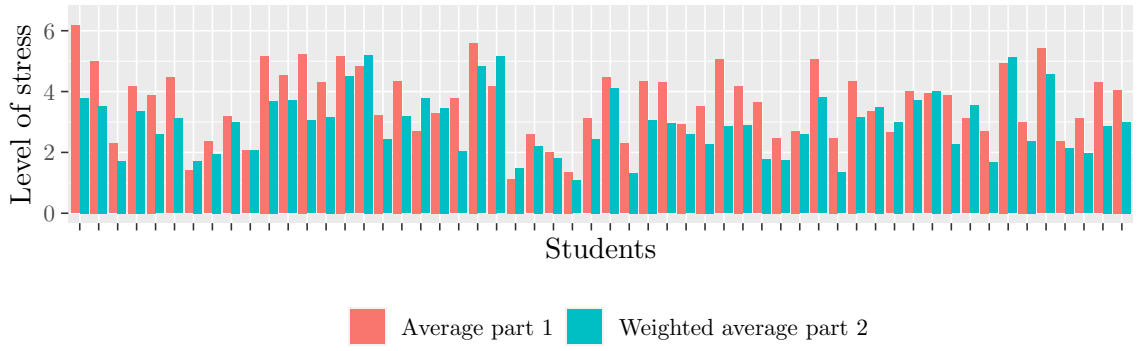


Figure 4.17: Comparison average part 1 and weighted average part 2 ($n = 56$)

## 4.6 Conclusion and discussion of the first iteration

This thesis was designed to determine which factors in the behaviour of math teachers in their contact with high school students, contribute to developing, worsening or alleviating math anxiety during math activities. The aim of the present iteration was to examine this main research question together with sub-questions stated in section 3.8 and develop hypotheses concerning these questions. The following part of this section moves on to analyse these sub-questions in greater detail, starting with the first question concerning the category 'Growth mindset'.

*What is the impact of math teachers showing their belief in the fixed mindset on high school students' feelings of stress they experience during math activities?*

With respect to the first research question, it was found in the first category that more students feel high levels of stress when teachers show their belief in the growth mindset rather than in the fixed mindset. When it is not clear whether the teacher believes in the fixed mindset, the majority of students indicate low levels of stress. Furthermore, the results of the second reaction of the category 'Growth mindset' show that students indicate similar levels of stress when a teacher criticises on ability while showing low expectations, praises on ability while showing high expectations or does not criticise or praise while showing no expectations. These findings are unexpected since it is a widely held view, see [Rattan, Good, and Carol S. Dweck, 2012] and [Canning et al., 2019], that students report lowered motivation and lower expectations for their own performance when the instructor shows her belief in the fixed mindset and shows low expectations. Therefore it is somewhat surprising that more students indicate higher levels of stress when they experience a scenario in which a teacher shows her belief in the growth mindset. However, in the survey the teacher shows her belief in the growth mindset in a way that students are forced to try to solve an exercise again, after failing once before.
The first explanation for these unexpected results may be the lack of experience students have in handling exercises alone without a helping hand of the teacher. A teacher who seems to believe in the growth mindset asks the student to try again and a teacher for whom it is unclear what her belief is, directly writes the good answer in the book of the student. This explanation is also in accordance with the way one of the interviewees commented on this reaction. Talking about this issue she said that she forgets everything about mathematics when the teacher asks her to try again, see table 7.3. This would highlight the importance of interventions to learn students how to participate in math activities with a growth mindset prior to teaching with a growth mindset in order to reduce students' math anxiety. However, there is another explanation for the results in the first category, where also the median level of stress found in the weighted boxplot is higher for a teacher showing her belief in the growth mindset than in the fixed mindset.
The majority of students indicated that they have never been in a scenario in which the teacher reacted to them in the way that is described in the first reaction. These results therefore need to be interpreted with caution since the lower weighted average in the reaction where the teacher shows her belief in fixed mindset could be attributed to the high number of students indicating 'Never' to this reaction. At last, another note of caution is due here since the sample size is rather small and no statistical tests have been performed to check whether the median levels of stress are significantly different from each other.

Regarding the category 'Performance goal and learning goal', the following research question is examined.

*What is the impact of math teachers mentioning the performance goal prior to a mathematical exercise on high school students' feelings of stress they experience?*

The second category was designed to compare teachers mentioning the performance goal and the learning goal via two scenarios with three different reactions from the teacher. The responses to the reactions were similar and therefore the results give only little further insight to the question, apart from two observations. The first observation in this category concerns the scenario in which the teacher explains how she will evaluate a formative assessment. As expected, there is a large number of students indicating the lowest levels of stress when the teacher writes down hints next to the mistakes the student made, in comparison with grading or drawing red lines through mistakes. The second observation is the differences in the median levels of the reactions to the scenario in which the teacher gives a trial exam and explains in three different ways what the goal is for participation in this exam. The median level of math anxiety was found to be one level higher when the teacher emphasizes that she wants to know how well the student understands the material, in comparison with the teacher stating that she wants the students to check for themselves how well they understand the material or in comparison with the teacher only stating the learning goal of the exam. However, caution is due since it is unclear whether these differences between the medians are significant.

The next research question is analysed within the category 'Mathematics teaching anxiety'.

*What is the impact of teachers showing signs of mathematics teaching anxiety on high school students' feelings of stress they experience during math activities?*

The third question sought to determine the role of mathematics teaching anxiety by creating scenarios in which the student have different impressions about the confidence of the teacher. The results of the analysis of the weighted averages show that the students seem to indicate higher levels of stress when the teacher shows signs of mathematics teaching anxiety, such as an insecure impression while explaining a difficult subject or showing signs of insecurity after making a mistake on the board. Another interesting observation is that the weighted average of the level of stress students indicate when a teacher seems to find a mathematical subject difficult is higher than when a teacher seems to find the subject easy, or when it is unclear whether a teacher finds the subject difficult. The weighted boxplot concerning this scenario, see figure 4.12, supports this result since the median level of stress students indicated to a scenario in which the teacher seems insecure was found to be higher. In the second scenario, the weighted averages reveal that the students indicated to feel more stress when the teacher was hiding mistakes on the board or became insecure after making a mistake. The level of stress students indicated when a teacher fixed the mistake and continued confidently was considerably lower. Again, the weighted boxplot, see figure 4.12, confirms this result because the median level of this reaction was also lower here when the teacher continued her lesson confidently. However, it is not checked in this iteration whether the differences in median are significant. Another note to bear in mind is the possible bias in these responses since the majority of students reported that they never experienced a scenario in which the teacher was hiding mistakes. It may be that these students did not realise a mistake was made by the teacher when the teacher was hiding the mistake well.

Turning now to the last two research questions regarding the category 'Concept of mistakes', where the first question focuses on students publicly giving the wrong answer to a question.

*What is the impact of teachers forcing students to publicly answer questions involving math on the feelings of stress students experience in upcoming math activities?*

The second scenario in the last category was designed to measure the level of stress student experience when a public question is asked. Throughout reactions of the teachers, the role of the teacher could be examined. First of all, the feeling of anxiety in this scenario, where the teacher is asking a public question to a student, does not show higher levels of stress than in other categories. However, the results of the questionnaire in the first part of the first iteration shows that the average of the level of stress students indicate when a teacher asks a question in public, is still considerably higher than when a teacher asks a question on a personal level. Closer inspection of the weighted averages, see figure 4.11, and the weighted boxplots, see 4.12, in the category 'Concept of mistakes' shows that correction by the teacher seems to give the lowest weighted average and median of the level of stress students indicate. This result reflects the result found in the category 'Growth mindset' where more students seem indicate high levels of stress when they were asked to try an exercise once again after they have tried it before. These findings raise questions regarding the ability of students solving a problem by themselves without a helping hand of the teacher. As indicated previously, the differences between the median levels of stress students indicate to the reactions has to be interpreted with caution because of the absence of statistical tests.

The last research question was designed to give insight on the role of math teachers in their way of handling students' mistakes on the level of stress students experience.

*What is the impact of math teachers focusing on mistakes high school students make during their math activities on their feelings of stress they experience?*

With respect to the last question, it was found in the first scenario of the last category that students seem to indicate considerably higher levels of stress in a scenario where the teacher focuses on a mistake the student made in a negative matter. Surprisingly, only little differences were found between the teacher focusing on the learning aspect of a mistake and the teacher focusing on the mistake itself in a positive matter.

This section has analysed the research questions and the next part of this thesis will discuss general findings which are more loosely related to the research questions.

The most obvious finding to emerge from the analysis is that some scenarios were somewhat uncommon for the students, which are: the scenario in which the teacher shows her believe in the fixed mindset (category 'Growth mindset'), the scenario in which the teacher shows low expectations and criticises on the ability of the student (category 'Growth mindset'), the scenario in which the teacher seems insecure (category 'Mathematics teaching anxiety') and the scenario in which the teacher is hiding a mistake she made on the board (category 'Mathematics teaching anxiety'). Therefore these findings may be somewhat limited by the ability of students imagining a scenario which they have never experienced before.

Another finding emerging from the analysis is coming from the comparison between the first part of the survey and the second part of the survey. This iteration was designed to determine the factors in the behaviour of math teachers that contribute to the developing, worsening or alleviating of math anxiety, but this finding gives insight on the influence of these factors in comparison with general scenarios involving math activities. Comparison reveals that the average level of stress of part 1, where the students imagined scenarios concerning general math activities, is higher for the majority of the students than the weighted average of part 2, where students imagined scenarios concerning potential contributing factors in the behaviour of math teacher influencing the math anxiety of students. The present iteration raises the possibility that the factors described in the second part of the survey, categorized into 'Growth mindset', 'Performance goal and learning goal', 'Mathematics teaching anxiety' and 'Concept of mistakes', are not dominant in the math anxiety students experience.
Before proceeding to examine the main research question, it is necessary to analyse one last finding. The survey was designed in a way that every category consists two scenarios with each three reactions of a teacher. Disregarding the reactions of the teacher, these scenarios can be stressful. Therefore, it is important to bear in mind that students might answer to certain reactions with high levels of stress when they actually feel that the scenario itself is stressful.

The main research question aimed to combine the previous questions.

*Which factors in the behaviour of math teachers in their contact with high school students, contribute to the developing, worsening or alleviating of math anxiety during math activities?*

In spite of its limitations in sample size, this iteration offers valuable insights into the role of the teacher in the development, contribution or alleviation of math anxiety amongst high school students. One surprising finding is that more students seem to indicate higher levels of stress in scenarios where the teacher shows her belief in the growth mindset by encouraging students to try an exercise again. This finding reflects the observation that students seem to indicate low levels of stress when the teacher helps the student out after making a mistake in public by correcting the mistake directly. This is an important issue for future research. This finding, while preliminary, suggests that it might not be useful to show your believe in the growth mindset as a teacher in a way that you force a student to try exercises themselves, when the students might not be ready to handle exercises with only little help from the teacher.
Regarding mathematics teaching anxiety, this iteration seems to support the view that students indicate higher levels of stress when the teacher shows signs of mathematics teaching anxiety, such as insecure behaviour or hiding mistakes.
The last factor in the behaviour of the math teacher influencing the math anxiety is the way teachers handle mistakes. This iteration shows that students indicate higher levels of stress when a teacher focuses in a negative matter on a mistake. However, they indicate similar levels of stress when a teacher focuses on the mistake positively or focuses on the learning aspect of the mistake.

## 4.7 Recommendations of the first iteration

A further iteration needs to be carried out in order to validate the findings found in this iteration or to gain more insight on parts which this iteration failed to give insight to. In particular, the analysis of the results was problematic because of the small sample size and the lack of statistical tests. A reasonable approach to tackle this issue could be to carry out the same survey, with small adjustments, to a large group of students from the same high school.
Another way to improve the analysis of the results is to add more variety in the participants of the survey. A great number of students from 11 to 19 years old could be included, originating from havo or vwo. This would also give an opportunity for a greater focus on the development of the math anxiety through the years of high school and the role of the high school teacher in this matter.

There are a number of important changes which need to be made to the survey.
As mentioned before, some scenarios were not familiar to students which might make it harder for the students to imagine these scenarios. The weighted averages, standard deviations and weighted boxplots helped reducing the influence of the answers students gave who have never experienced certain scenarios. However, the scenarios might be more recognisable to students after small adjustments. The two sentences in the category 'Growth mindset' where students imagine the teacher saying '...you are not good in mathematics' could be replaced by '... you find mathematics difficult', which is less harsh from the teacher and therefore possibly more common. The two reactions in the category 'Mathematics teaching anxiety' remain the same since it is important to focus on the signs of mathematics teaching.
In order to help the young students following their first year in high school, a short sentence should be added to the introduction saying that these students are allowed to imagine the scenarios while thinking of a teacher they had in elementary school. In this way, the students can combine experiences with different teachers in order to make the indications of stress more appropriate.

## 4.8 Hypotheses

Finally, the findings of this iteration provide insights for hypotheses. Throughout this iteration several scenarios with reactions of teachers have been described and the levels of stress students indicated to these scenarios have been analysed. Several times it has been stated that the weighted averages and median levels of stress differ from each other, but no statements are made about the significance of these differences. In this study, the median levels of stress give more insight on the research questions than the average level of stress because it is mainly interesting to find the most typical level of stress students indicate, without the distraction of outliers. Therefore, it is hypothesized that the median levels of stress are equal through the reactions.

$$H_0 : \text{The median of reaction 1 is equal to the median of reaction 2} \tag{4.3}$$
$$H_1 : \text{The median of reaction 1 is not equal to the median of reaction 2} \tag{4.4}$$

# Chapter 5

# Second iteration

> It is less stressful but that is not in particular better because I know less about how well I understand it.
>
> *Student I.*

## 5.1 Introduction

Previous iterations have examined factors in the behaviour of math teachers influencing the math anxiety high school students experience during math activities. This second iteration focuses on the research questions established in the pilot, see section 3.8 together with the hypotheses established in the first iteration, see section 4.8. The previous iteration provided valuable insights in answering these questions and made recommendations for further iterations. Using a survey in which students indicate their level of stress in several scenarios concerning the behaviour of math teachers, comparison was made in order to answer the research questions. Data from the first iteration suggests that students indicate higher levels of stress in a scenario where a teacher shows her belief in the growth mindset in a way that she forces a student to try exercises themselves. Students might not be ready to handle exercises with only little help from the teacher. The next part of the survey was concerned with scenarios involving mathematics teaching anxiety, where students indicated higher levels of stress in scenarios where the teacher shows signs of mathematics teaching anxiety. For scenarios involving mistakes, students indicated to feel higher levels of stress when a teacher focuses in a negative matter on a mistake but indicate similar levels of stress when a teacher focuses positively on a mistake or focuses on the learning aspect of the mistake. Since the previous iterations failed to specify whether the differences found in the data were significant, this iteration will be carried out amongst a large group of high school students.
The study begins with the same video used in the previous iterations and the survey that follows will differ only slightly from the survey used in the first iteration. Analysis of the data will be carried out in order to conclude and discuss the research questions.

## 5.2 Setting

As mentioned before, this study will be carried out amongst a large group of high school students, aging from 11 to 19 years old and differing in the level of mathematics they follow, which are regular mathematics, mathematics A, mathematics B, mathematics C and mathematics D. The different sorts of mathematics are explained in the pilot, see section 3.2. For all students participating in the study the survey is not given by their math teacher nor by their mentor. The researcher will visit math classes, shows the video, explains the survey and helps the students with questions. In order to visit as many math classes as possible, a schedule was made and shared with the math teachers involved. Classes were only included if the researcher was able to visit the class in the time it was given by the math teacher. The schedule can be found via the link schedule.

| | |
|---|---|
| Date | 22-05-13 until 22-06-03 |
| Place | Stanislascollege Westplantsoen, Delft |
| Room | Classroom for mathematics |
| Lessons | 1st grade, vwo (5 classes) |
| | 1st grade, havo/vwo (5 classes) |
| | 2nd grade, vwo (5 classes) |
| | 2nd grade, havo (2 classes) |
| | 3rd grade, vwo (6 classes) |
| | 3rd grade, havo (2 classes) |
| | 4th grade, vwo mathematics B (6 classes) |
| | 4th grade, havo mathematics A (1 class) |
| | 4th grade, havo mathematics B (1 class) |
| | 5th grade, vwo mathematics A (2 classes) |
| | 5th grade, vwo mathematics B (1 class) |
| | 5th grade, vwo mathematics D (1 class) |
| Participants | $\sim$ 900 students |
| Survey given by | Dominique van den Bosch |
| Relation | Researcher |
| Instruction | Video about math anxiety |

## 5.3 Survey

As was mentioned in the introduction, the survey used in this iteration is only slightly different from the survey used in the first iteration. For a detailed description of the survey used in the pilot see section 3.4 or for the one used in the first iteration, see section 4.3. In this section, the small adaptations to the survey will be described.
As before, the students were sent a link to Google Forms, where they can start the survey with their own student email, visible for the researcher. For the reasoning behind choosing Google Forms and the anonymity of the students see section 3.4. The original survey of this iteration can be found via the link survey second iteration.

### 5.3.1 Introduction

The introduction of this iteration is almost identical to the introduction of the previous iteration except for one additional note. In the recommendations of the first iteration, see section 4.7, it is suggested that young students could be helped answering the questions of the survey by adding a short sentence saying that these students are allowed to imagine the scenarios while thinking of the teacher they had in elementary school. In this way, the students can combine experiences with different teachers in order to make the indications of stress more appropriate.

### 5.3.2 First part: general feeling of math anxiety

Using a seven-item scale ranging from no stress to a lot of stress, this part measures the general feeling of stress a student experiences with mathematics. Since this part of the survey was clear for the students in the pilot and in the first iteration, no changes have been made.

### 5.3.3 Second part: behaviour of the math teacher

Similarly to the first part, the students have to answer questions which involve scenarios they have to imagine in order to determine the role of certain behaviour of the mathematics teacher on the math anxiety the students experience. However, the structure of the second part of the survey differs from the first part in that it contains additional questions to gather information about the amount of times students experience the scenarios they have to imagine. The second part of the survey in this iteration is almost identical to the second part of the survey used in the first iteration. As was pointed out in the recommendations of the first iteration, see section 4.7, some scenarios were not familiar to students which might make it harder for them to imagine these scenarios. Consequently, in this iteration two small changes were made. The two sentences in the category 'Growth mindset' where students imagine the teacher saying '...you are not good in mathematics' are be replaced by '... you find mathematics difficult', which is less harsh from the teacher and therefore possibly more common. Apart from this, all scenarios are identical to the scenarios described in the first iteration, see section 4.3. The closure in this iteration and in the first iteration are identical.

**a) Growth mindset**

*You are not able to complete a simple exercise during a math lesson. The teacher sees this, walks up to you and 1) says 'It does not matter, because for some students mathematics remains difficult' 2) says 'Think again' 3) writes down the good answer in your exercise book.*

*During math lesson you receive your grade for a small exam. You failed the exam. The teacher hands out the exam and says: 'What a shame that you failed the exam'. After that the teacher says: 1) 'I expected this since you always have difficulties with math' 2) 'I did not expect this because normally you are so good in mathematics' and 3) 'You did not do this exam well'.*

**b) Performance goal and learning goal**

*The teacher hands out a form with a few exercises everyone in the classroom has to solve. Before you start with the form, the teacher tells the class what he/she will do with the form afterwards. The teacher says: 1) 'I will check the form and you will get a grade which will not be part of your final grade' 2) 'I will check the form and I will draw lines through the mistakes you made' and 3) 'I will check the form and write down hints next to certain exercises'.*

*The teacher is giving a trial exam during the lesson. You will not get a grade for the trial exam but the exam will be checked by the teacher. You ask the teacher why you have to participate in this trial exam. The teacher says: 1) 'I would like to know how well you understand everything' 2) 'Then you can see for yourself how well you understand everything' and 3) 'You can learn from it'.*

**c) Mathematics teaching anxiety**

*During math lesson the teacher explains a subject in front of the class and the subject is difficult for you. You 1) notice that the teacher herself finds the subject difficult 2) notice that the teacher herself finds the subject very easy and 3) do not know whether the teacher finds the subject difficult or easy.*

*The teacher makes a mistake on the board during math lesson. The teacher 1) pretends that she did not make a mistake 2) corrects her mistake and becomes nervous in front of the class and 3) corrects her mistake and continues in the same way she did before the mistake.*

**d) The concept of mistakes**

*During math lesson you are working on homework exercises. The teacher walks besides you and sees you made a few mistakes. She says: 1) 'Good that you made mistakes, because that means that you learned something' 2) 'Do not worry, there are a few questions you did well' and 3) 'I can see you have difficulties with math, since you make a lot of mistakes'.*

*During an explanation of the teacher in front of the class, the teacher asks a question in which you answer wrongly. The teacher says that the answer is wrong. Next, the teacher 1) asks another students who knows the right answer 2) tells the right answer and 3) gives an hint so that you can give the right answer yourself.*

## 5.4 Results

This section presents the analysis of the results obtained from the survey described in the previous chapter. All analyses were carried out using R.

### 5.4.1 First part: general feeling of math anxiety

The first set of questions aimed to measure the general feeling of stress students experience during math activities. The results must be approached with some caution because the list of questions asked in the first part is rather small and these results do not include all the potential stressful scenarios students can experience during math activities. Table 5.1 shows the average and standard deviation of the level of stress students indicated per question, which were calculated in the same way as in the first iteration, see section 4.5.1. Interestingly, the average level of stress students indicated for the scenario where the teacher asks a question publicly is much higher than when the teacher asks a question on a personal level. As expected, the average level of stress is high amongst all scenarios concerning an exam. The questionnaire was followed up by two open questions concerning the feelings and thoughts of students during moments of high levels of math anxiety. These answers are not analysed in detail but rather used to check whether students understood that the questions involved were meant for measuring stress, instead of other kinds of feelings like anger or sadness. A search through the answers of students revealed that only 4 students used the word angry, 0 students used the word irritated and 0 students used the word sad. Words which are more closely related to stress and math anxiety were more commonly found in the search. There were 115 students using the word afraid, 26 students using the word stress and 2 students using the word nervous. Interestingly for the second part of the survey, 44 students used the word grade and 79 students used the word 'Fout' which could be translated to mistake or wrong.

Table 5.1: Questionnaire ($n = 888$)

| **Questionnaire** | | |
|---|---|---|
| | Average ($\overline{x}$) | Standard deviation ($s$) |
| You hear the word mathematics | 1.87 | 1.26 |
| You read the word mathematics | 1.76 | 1.19 |
| You open your math book | 2.30 | 1.45 |
| You are doing your math homework alone at home | 2.63 | 1.57 |
| You are doing your math homework with friends at home | 2.00 | 1.31 |
| You are doing your math homework with family members at home | 2.67 | 1.78 |
| You are doing your math homework during a 'maatwerk' lesson [see subsection 3.2.3] | 1.98 | 1.23 |
| You are doing your math homework during a math lesson | 2.17 | 1.38 |
| The teacher explains a new subject in front of the class | 2.73 | 1.59 |
| The teacher asks you a question on personal level, such that others are not able to hear it | 2.40 | 1.46 |
| The teacher asks you a question in front of the class, such that everyone is able to hear it | 3.82 | 1.91 |
| You are thinking about an exam scheduled for next week | 3.82 | 1.77 |
| You are thinking about an exam scheduled for the next day | 4.64 | 1.86 |
| You are studying for an exam scheduled for the next day | 4.03 | 1.95 |
| You are writing an unexpected small exam | 5.33 | 1.76 |
| You are writing an expected small exam | 3.55 | 1.74 |
| You are writing an expected exam | 3.94 | 1.88 |

### 5.4.2 Second part: behaviour of the math teacher

Before proceeding to examine the results of this iteration, it is important to describe the reasons for choosing certain statistical tests and the details of these tests.

#### Data used for the statistical tests

As mentioned before, in the survey a scenario was described followed by three reactions from the teacher. Students had to imagine the scenario and indicate the level of stress they would feel after each of the three reactions. In this analysis we compare two reactions to get insight on the differences between the responses students give and eventually summarize all the comparisons together in tables. The data used in this experiment is ordinal since the students were asked to indicate their level of stress via a seven-item based Likert scale ranging from 'no stress' to 'a lot of stress'. In the additional questions, where students could indicate how often they experienced the scenarios they had to imagine, they could indicate 'never', 'sometimes', 'often' or 'very often'. In this analysis the responses to these additional questions, concerning the occurrence of the scenarios students had to imagine, were not used in the statistical analysis. In the previous iteration these responses were transferred into weights such that the weighted average and weighted standard deviations could be calculated. However, in this iteration statistical tests are performed and the use of these weights could be a source of uncertainty. Perhaps the most serious disadvantage for using this data is that the distance between the options 'never', 'sometimes', 'often' or 'very often' is quite unclear. A possible solution to this would be to use a statistical test which does not need the exact differences between responses, for example the sign test. However, the sign test uses less information than the responses provide since it only examines whether the differences between the responses are negative or positive and ignores the magnitude of the difference, see page 79 for further explanation. On the other hand, one advantage of using the weights in the analysis would be that the responses of students who have never experienced a certain scenario who might indicate less accurate levels of stress, would have less influence on the test. Nevertheless, these questions that presumably give additional information are not used in the statistical data. It is recommended in chapter 4.7 that further research needs to explore how this additional data could be included in the statistical test.

#### Statistical tests

The initial sample consisted of 888 students who answered all the questions in this second part of the survey. In this analysis the data is paired since the difference between two reactions is examined and every student responded to both reactions. It is important to bear in mind that the distribution of the ordinal data is unknown, so a non-parametric statistical test is chosen over a parametric statistical test. Furthermore, the aim of this iteration was to determine whether the hypothesis constructed in the first iteration, see section 4.8, should be accepted or rejected. The hypothesis states that the median of two reactions in the survey are equal.

$$H_0 : \text{The median of reaction 1 is equal to the median of reaction 2} \tag{5.1}$$

$$H_1 : \text{The median of reaction 1 is not equal to the median of reaction 2} \tag{5.2}$$

Therefore, in this iteration a statistical test is needed which can compare the median of two paired samples for which the distribution is unknown. Overall, two tests are in particular useful in this scenario, which are: the sign test and the Wilcoxon rank sum test. In the process of choosing a most reliable test and understanding that test in detail, the book [Mendenhall, 1975] is used.

### Sign test

In the sign test, for every student $i$, the paired difference $d_i$ is calculated between the level of stress indicated to the first reaction $x_i$, and the level of stress indicated to the second scenario $y_i$. The next step in this process is to count the positive differences $d_+$ and negative differences $d_-$. Let $n_0$ be the number of students indicating equal levels of stress to both scenarios and therefore creating a difference of zero. These responses are excluded from the data and therefore the sample size is reduced to $n - n_0$. Following the null hypothesis, it is expected that half of the responses are positive and half of them negative, so $d_+ = d_-$. Assuming that the null hypothesis is true, the median for both reaction will be the same and therefore the probability that one observation is positive will be 0.5, under the assumption that the ties $n_0$ are excluded. The distributions of $d_+$ and $d_-$ are therefore binomial and it can be easily calculated whether the observed $d_+$ lies within the rejection region of the binomial distribution.

### Paired Wilcoxon rank sum test

As mentioned before, the sign test ignores the magnitude of the difference between the paired observations. In contrast, the paired Wilcoxon rank sum test assigns ranks to the paired differences and therefore uses the magnitude of these differences. Similarly to the sign test, for every student $i$ the paired difference $d_i$ between the to responses to the reactions is calculated and the paired differences that equal to zero, are removed from the data. In the next step, the absolute values of the differences $d_i$ are ordered and ranked from smallest to largest, where ties in the responses are fixed by averaging the rank $r_i$ between the tied responses and assigning this average to each of the tied responses. Finally, the ranks that the paired differences were assigned to, are multiplied by $-1$ in the case that the paired difference was negative. In this way, the paired Wilcoxon rank sum test uses the sign of the difference between pairs and the magnitude of that difference. Assuming that the null hypothesis is true and the two medians of the reactions are equal, it is expected that the rank sum of the positive differences is equal to the rank sum of the negative differences. In contrast with the sum of positive observations in the sign test ($d_i$), the probability of the rank sum of the positive differences ($r_+$) in the paired Wilcoxon rank sum test, is less straightforward to calculate. The sample size in this study equals $(888 - n_0)$, which is considered to be large enough to use the law of large numbers, which states that the probability of $r_+$ is approximately normally distributed. Because of that, it is accurate to use a sample $z$ test [Mendenhall, 1975] to approximate the probability of $r_+$. [Mendenhall, 1975, pg.379] describes that

$$E(r_+) = \frac{n(n+1)}{4} \text{ and } V(r_+) = \frac{n(n+1)(2n+1)}{24} \tag{5.3}$$

and that we can construct that test statistic $z \sim \mathcal{N}(0,1)$ in the following way

$$z = \frac{r_+ - E(r_+)}{\sqrt{V(r_+)}}. \tag{5.4}$$

Consequently, it can be easily calculated whether the test statistic $z$ lies within the rejection region of the standard normal distribution. The use of the $z$-statistic must be approached with some caution because the sample size might be large, but there are only 12 possible different values in the list of ranks since the paired differences are integers between $-6$ and 6.

### Effect size

It is almost certain that when the hypothesis is tested for equal medians that the null hypothesis is rejected for an extremely small $p$-value. However, because of the large sample size a note of caution is due since differences can be significant but are not always relevant. It is important to pay attention to the effect size of the test but it is rather difficult to define the effect size in this context, since the effect size is more commonly used to check the effect of a certain treatment or medicine. Looking at the hypothesis described previously, see equation 5.1, the effect size in this scenario would be the effect of the teacher reacting in the way reaction 2 describes, in comparison with the basis of reacting in the way reaction 1 describes. In this iteration there are two ways to get insight on the effect size: via the effect size used for the Wilcoxon rank test, which is described by [Cohen, 1988] and [C. O. Fritz, P. E. Morris, and Richler, 2012], or via the difference between the estimated value of positive differences and the observed value positive differences calculated in the sign test. The effect size $r$ for the Wilcoxon rank test is the following:

$$r = \frac{z}{\sqrt{n}}, \tag{5.5}$$

where $z$ is the $z$-value calculated in the Wilcoxon rank sum test and $n$ the sample size. In this report, an effect size is considered small when $0.1 < r < 0.3$, moderate when $0.3 < r < 0.5$ and large when $r > 0.5$, which is recommended by [Cohen, 1988].

### Conclusion

An overview of the hypothesis, data and assumptions made for the two tests, is set out in figure 5.1. Considering the major advantage of the Wilcoxon rank sum test in that it takes the magnitude of the differences into account, it is decided to use the Wilcoxon rank sum test for a paired experiment. However, considering the importance of the effect size, the sign test will also be presented so that a comparison can be made. Finally, the sample will be divided into subgroups concerning grade, gender and level of education. Statistical tests will be performed on these subgroups, but the details about these test will be presented in the appendix, see chapter 7.

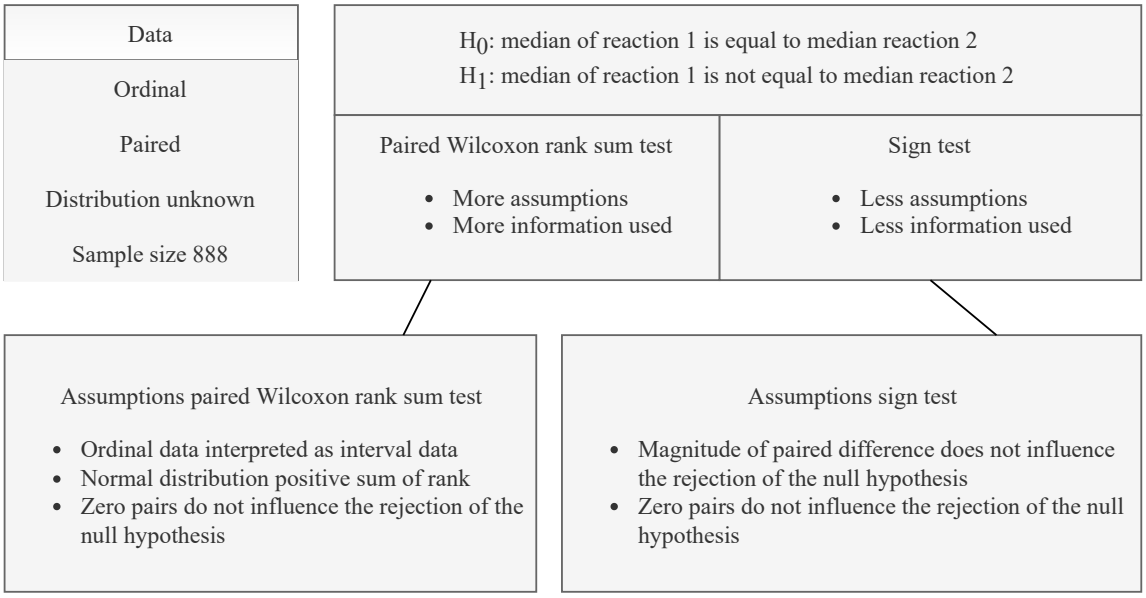


Figure 5.1: Overview of the discussions about the hypothesis, the data used and the assumptions made while using the sign test or the paired Wilcoxon test.

**a) Growth mindset**

The first set of questions aimed to gather information on the impact of math teachers showing their belief in the growth mindset or the fixed mindset on high school students' feelings of stress they experience during math activities.

*Scenario 1*
*You are not able to complete a simple exercise during a math lesson. The teacher sees this, walks up to you and*
*1) says 'It does not matter, because for some students mathematics remains difficult' (fixed mindset)*
*2) says 'Think again' (growth mindset)*
*3) writes down the good answer in your exercise book (mindset unclear)*

What stands out in the upper half of figure 5.2 is that almost half of the students ($\sim 49.4\%$) indicated their level of stress with a 1 to the third reaction of the teacher, in which the teacher does not reveal whether she has a growth mindset or a fixed mindset. To this reaction only 12 ($\sim 1.4\%$) students indicated the two highest level of stress. Furthermore, there is a clear trend of decreasing visible in all three reactions, where the most chosen option in the second reaction is an anxiety level of 2 and in the first and third reaction an anxiety level of 1. From the bottom half of figure 5.2 it is clear that a majority of students have experienced the second and third reaction at least once. However, for the first reaction this proportion is only 37.8%. Interestingly, the average concerning the second reaction where the teacher shows her belief in the growth mindset in a way that the student has to try an exercise again, is the highest.

*Scenario 2*
*During math lesson you receive your grade for a small exam. You failed the exam. The teacher hands out the exam and says: 'What a shame that you failed the exam'. After that the teacher says:*
*1) 'I expected this since you always have difficulties with math' (low expectations and criticism on ability)*
*2) 'I did not expect this because normally you are so good in mathematics' (high expectations and praises on ability)*
*3) 'You did not do this exam well'(no expectations, criticism or praises)*

What is most striking about the bottom half of figure 5.3 is the widespread responses of the students to all three reactions. Since the amount of students indicating higher levels of stress, is high for every reaction, the question arises whether this scenario causes feelings of stress in general, unrelated to the specific reactions of the teacher. However, the average of the third reaction, where the teacher specifically only states that the student did not do the exam well, is the highest amongst the three. Finally, it is important to bear in mind that a large majority of students never experienced the first reaction and it is unclear whether the students can imagine that scenario well enough to give an estimate on the level of stress they would experience.

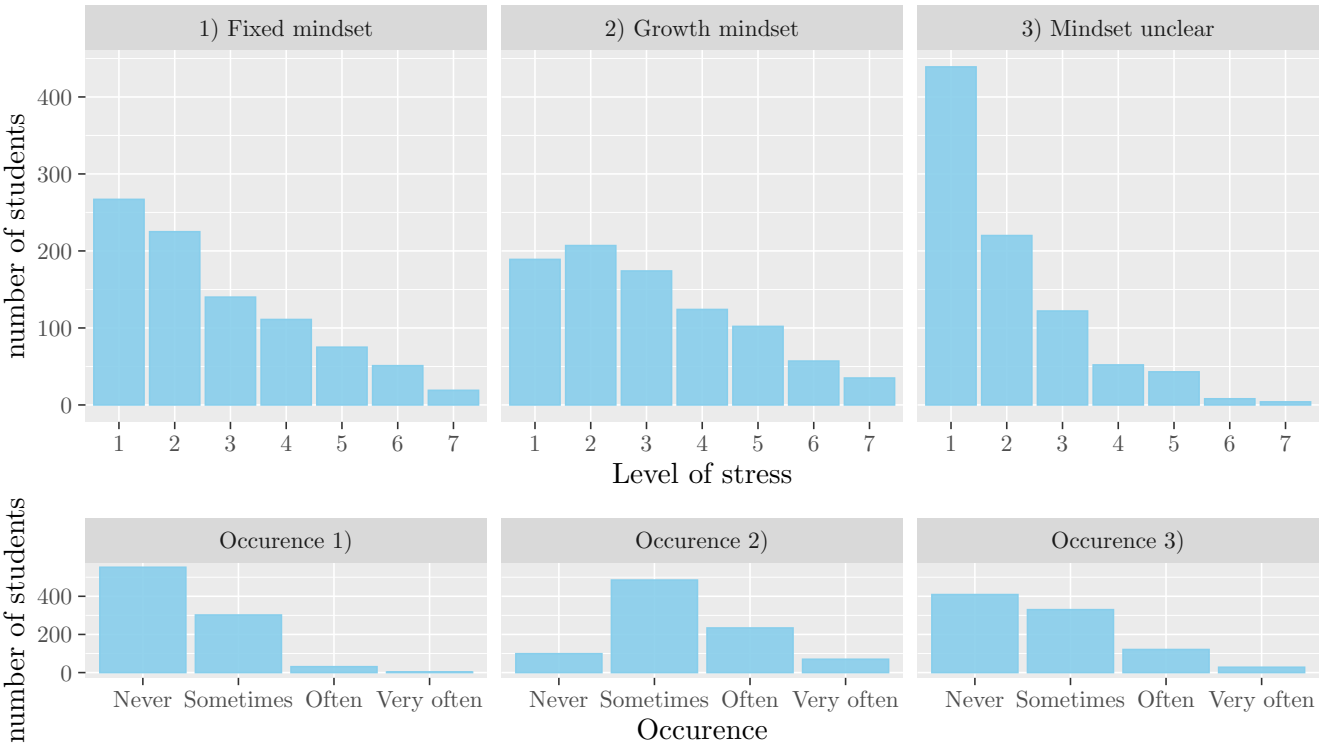


Figure 5.2: Growth mindset histogram scenario 1 ($n = 888$). The averages of the first, second and third reaction are respectively 2.70, 3.06 and 1.96.

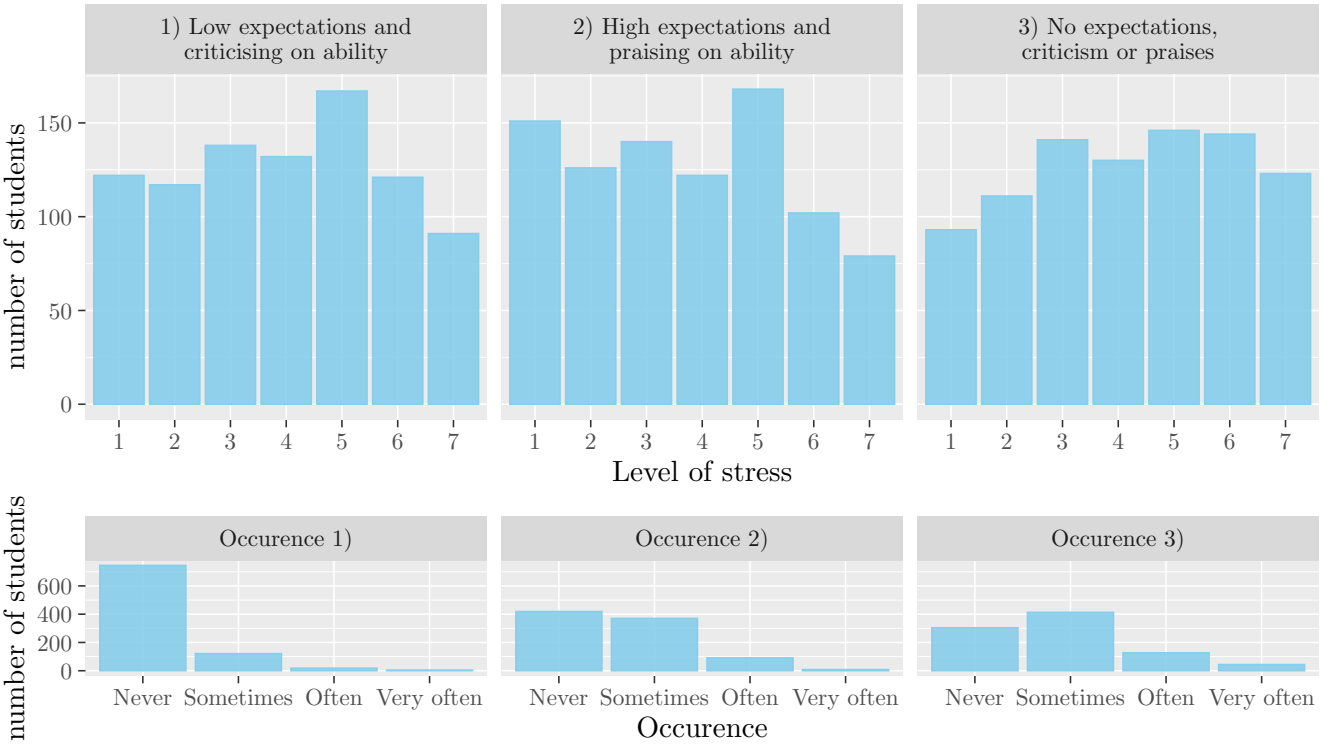


Figure 5.3: Growth mindset histogram scenario 2 ($n = 888$). The averages of the first second and third reaction are respectively 3.94, 3.73 and 4.18.

From the left side of figure 5.4 it is clear that the median of the second reaction, where the teacher shows her belief in the growth mindset, is higher than for the reactions where the teacher shows her belief in the fixed mindset or does not show whether she believes in the fixed mindset or the growth mindset. A Wilcoxon rank test indicated that the median of the second scenario is significantly higher than the median of the first scenario with a $z$-value of approximately $-8.010$, see table 5.2. In addition, the median of the second scenario is also significantly higher than the median of the first scenario with a $z$-value of approximately $-18.475$. The effect scores of the tests are considered low in comparison with the first reaction and moderate in comparison with the third reaction. In addition to the effect score concerning the Wilxocon rank sum test, a sign test was performed in order to get better insight on this effect size. It is clear from table 5.2 that the difference between the expected value of positive differences is smaller when the first and the second reaction are compared (100). For the comparison between the second reaction and the third reaction, this difference was higher (247.5). Taken into account that the sample size of this test is 888, these differences are considerably large.
The right side of figure 5.4 shows the boxplot concerning the second scenario of this category. No difference between the medians of the three reactions can be seen. However, the proportion of students indicating high levels of stress, above a level of 6, is higher for the last reaction, where the teacher does not reveal any expectations, criticism or praises. The sign test reveals that the difference between the median from the first reaction, where the teacher shows low expectations and criticises on the ability of the student, and the second reaction, where the teacher shows high expectations and praises on the ability of the student, is small, see table 5.2.

Table 5.3 compares the medians within several subgroups. The data in this table reveals that the median of students from the first grade differs to all of the three reactions of the first scenario. Table 7.4 shows that these medians differ significantly ($z \approx -6.844, z \approx -9.405$ and $z \approx -4.565$) with moderate to large effect sizes for the Wilcoxon rank sum test. The highest median found on the left side of table 5.3 considering the first scenario, is within the subgroup female. It is clear from this table that the median of the level of stress female students indicated for the scenario where the teacher shows her belief in the growth mindset (4), is higher than for the male students (2). In this female subgroup, the median of the level of stress is lower for the first reaction where the teacher shows her belief in the fixed mindset, and the lowest for the scenario where the teacher does not show whether she believes in the fixed or growth mindset. In table 7.4 it is shown that these medians differ significantly ($z \approx -6.382, z \approx -13.318$ and $z \approx -10.105$) with moderate and high effect sizes.
In the comparison of the three reactions from the second scenario, table 5.3 reveals an interesting aspect of the comparison between subgroups. The median for every reaction is one level of stress higher for the female students in comparison with the male students. Another subgroup that differs from the overall data is the subgroup havo. The median they indicate for the first two reactions are lower than the median of the last reaction. In table 5.3 it is concluded that the median of the third reaction differs significantly from the first and the second reaction with $p$-values of 0.001 and 0.029 and very close to moderate effect sizes $r \approx -0.299$.

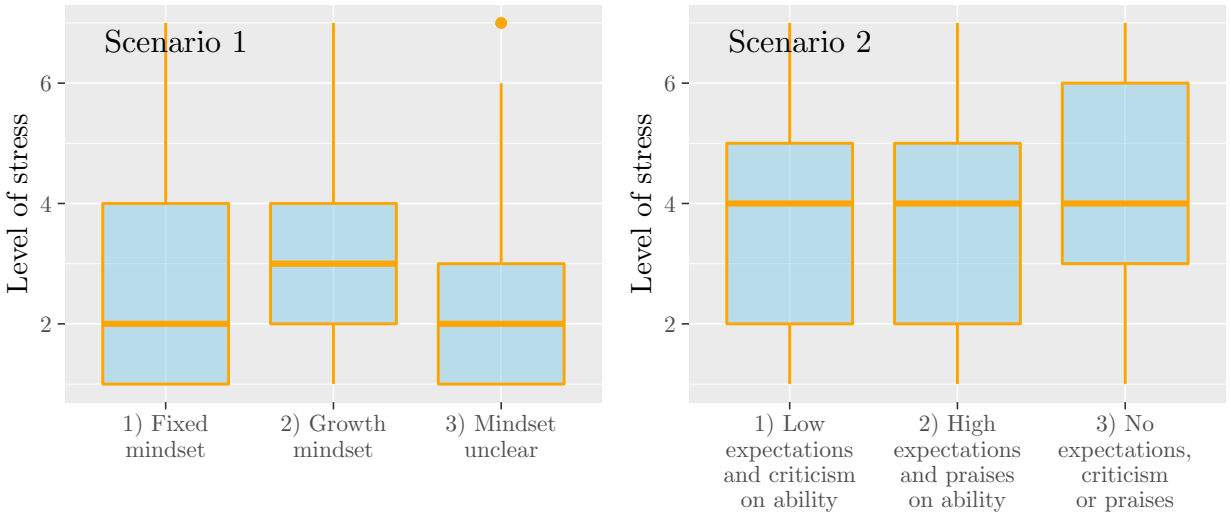


Figure 5.4: Growth mindset boxplot ($n = 888$). The outliers of a boxplot are drawn as dots. Outliers are, by default in R, defined as observations outside the interval $q_1 - 1.5 \cdot IQR; q_3 + 1.5 \cdot IQR$ where $q_1, q_3$ and $IQR$ are the first quartile, the third quartile and the difference between the first and the third quartile respectively.

Table 5.2: Results Wilcoxon rank sum test ($n = 888$) and sign test. Effect size for Wilcoxon rank sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade.

| Null hypothesis | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|
| $H_0$ : median 1.1 equals median 1.2 | $-8.010$ | $< 0.001$ | $-0.269$ | 173 | 273 |
| $H_0$ : median 1.2 equals median 1.3 | $-18.475$ | $< 0.001$ | $-0.620$ | 551 | 303.5 |
| $H_0$ : median 1.1 equals median 1.3 | $-13.507$ | $< 0.001$ | $-0.453$ | 425 | 262 |
| $H_0$ : median 2.1 equals median 2.2 | $-3.078$ | 0.002 | $-0.103$ | 316 | 305.5 |
| $H_0$ : median 2.2 equals median 2.3 | $-7.711$ | $< 0.001$ | $-0.259$ | 192 | 288.5 |
| $H_0$ : median 2.1 equals median 2.3 | $-4.447$ | $< 0.001$ | $-0.149$ | 244 | 299.5 |

Table 5.3: Median per class, gender and level and overall of the six reactions regarding the category growth mindset. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade.

| Group | $n$ | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 |
|---|---|---|---|---|---|---|---|
| 1st grade | 251 | 2 | 3 | 1 | 4 | 4 | 5 |
| 2nd grade | 177 | 2 | 2 | 1 | 4 | 3 | 4 |
| 3rd grade | 187 | 3 | 3 | 2 | 4 | 3 | 4 |
| 4th grade | 172 | 3 | 3 | 2 | 4 | 4 | 4 |
| 5th grade | 100 | 3 | 3 | 1 | 4 | 3 | 4 |
| 6th grade | 1 | 3 | 3 | 3 | 3 | 3 | 4 |
| Female | 384 | 3 | 4 | 2 | 5 | 5 | 5 |
| Male | 455 | 2 | 2 | 1 | 3 | 3 | 4 |
| Other | 24 | 2 | 3.5 | 1.5 | 5 | 3 | 4.5 |
| Rather not tell | 25 | 3 | 3 | 2 | 3 | 5 | 5 |
| Vwo | 618 | 2 | 3 | 2 | 4 | 4 | 4 |
| Havovwo | 143 | 2 | 3 | 1 | 4 | 4 | 5 |
| Havo | 127 | 2 | 2 | 1 | 3 | 3 | 4 |
| Overall | 888 | 2 | 3 | 2 | 4 | 4 | 4 |

**b) Performance goal and learning goal**

The second set of questions aimed to compare scenarios in which teachers mention their performance goal or learning goal towards a student prior to a mathematical exercise.

*Scenario 1*
*The teacher hands out a form with a few exercises everyone in the classroom has to solve. Before you start with the form, the teacher tells the class what he/she will do with the form afterwards. The teacher says:*
*1) 'I will check the form and you will get a grade which will not be part of your final grade' (performance goal with grade)*
*2) 'I will check the form and I will draw lines through the mistakes you made' (performance goal with red lines)*
*3) 'I will check the form and write down hints next to certain exercises' (learning goal with hints)*

The responses to the three reactions are quite similar, see figure 5.5. Overall, the lowest level of anxiety is most commonly chosen by the students, with proportions of approximately 46.1%, 41.7% and 56.0% for the first, second and third reaction, respectively. Closer inspection of the figure shows that the number of students indicating a level of stress higher than a four, is lower in the last reaction ($\sim 8.6\%$) where the teacher puts the emphasis on the learning goal by writing down hints next to exercises. In addition, the average of this third reaction is the lowest amongst the three. It is shown in the bottom of the figure that the proportions of students never experiencing the scenario is approximately 48.4%, 41.7% and 61.9% for the first, second and third reaction, respectively.

*Scenario 2*
*The teacher is giving a trial exam during the lesson. You will not get a grade for the trial exam but the exam will be checked by the teacher. You ask the teacher why you have to participate in this trial exam. The teacher says:*
*1) 'I would like to know how well you understand everything' (performance goal towards teacher)*
*2) 'Then you can see for yourself how well you understand everything' (performance goal towards student)*
*3) 'You can learn from it' (learning goal)*

The responses to the next scenario are comparable to the first scenario, where the lowest level of stress is also most apparent, see figure 5.6. The reaction with the highest number of students indicating the lowest level of stress is the second reaction where the teacher emphasises the performance goal in a way that students can check themselves how well they understand everything. The average of this reaction is also slightly lower than the other two averages. Comparison between the first and the second reaction shows that the number of students indicating a 6 is equal for both reactions, as well as for the number of students indicating a 7 for the level of stress. From the bottom half of figure 5.6 it is clear that the reactions on this scenario are quite common for the students.

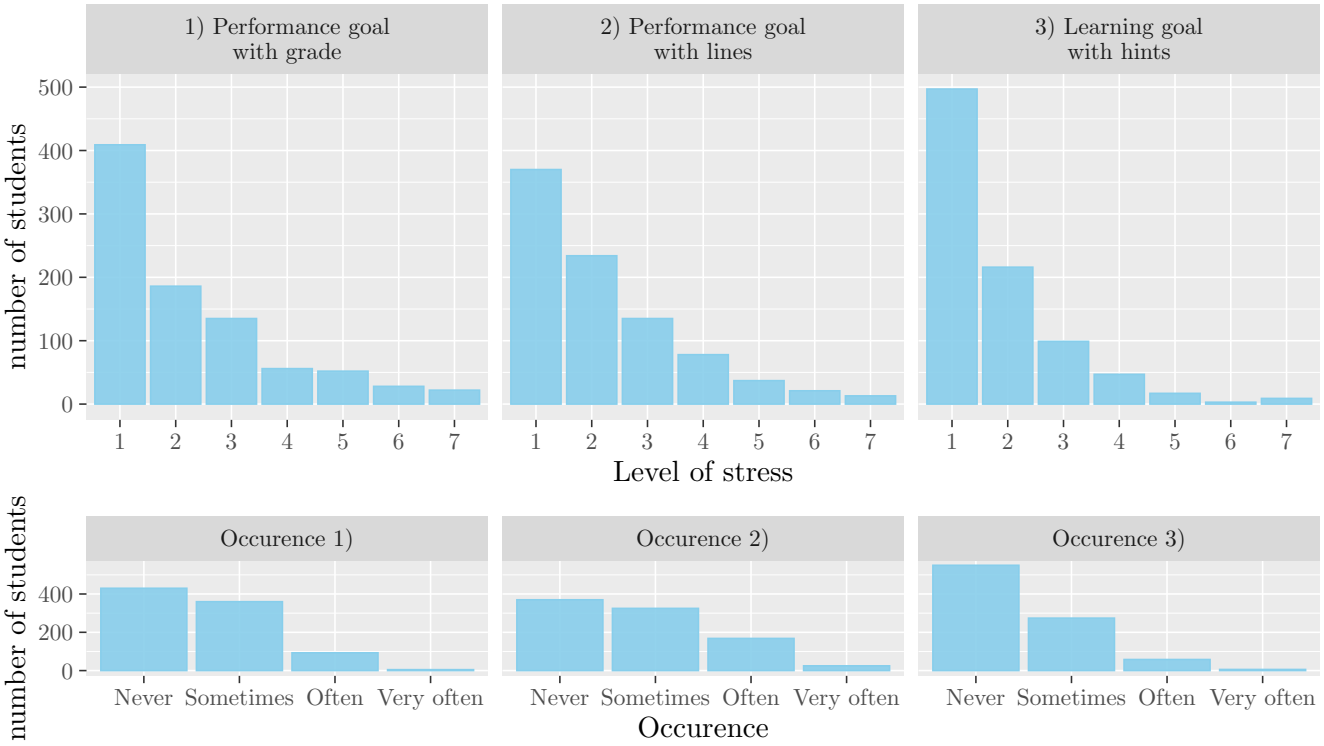


Figure 5.5: Performance goal and learning goal histogram scenario 1 ($n = 888$). The averages of the first second and third reaction are respectively 2.24, 2.20 and 1.78.

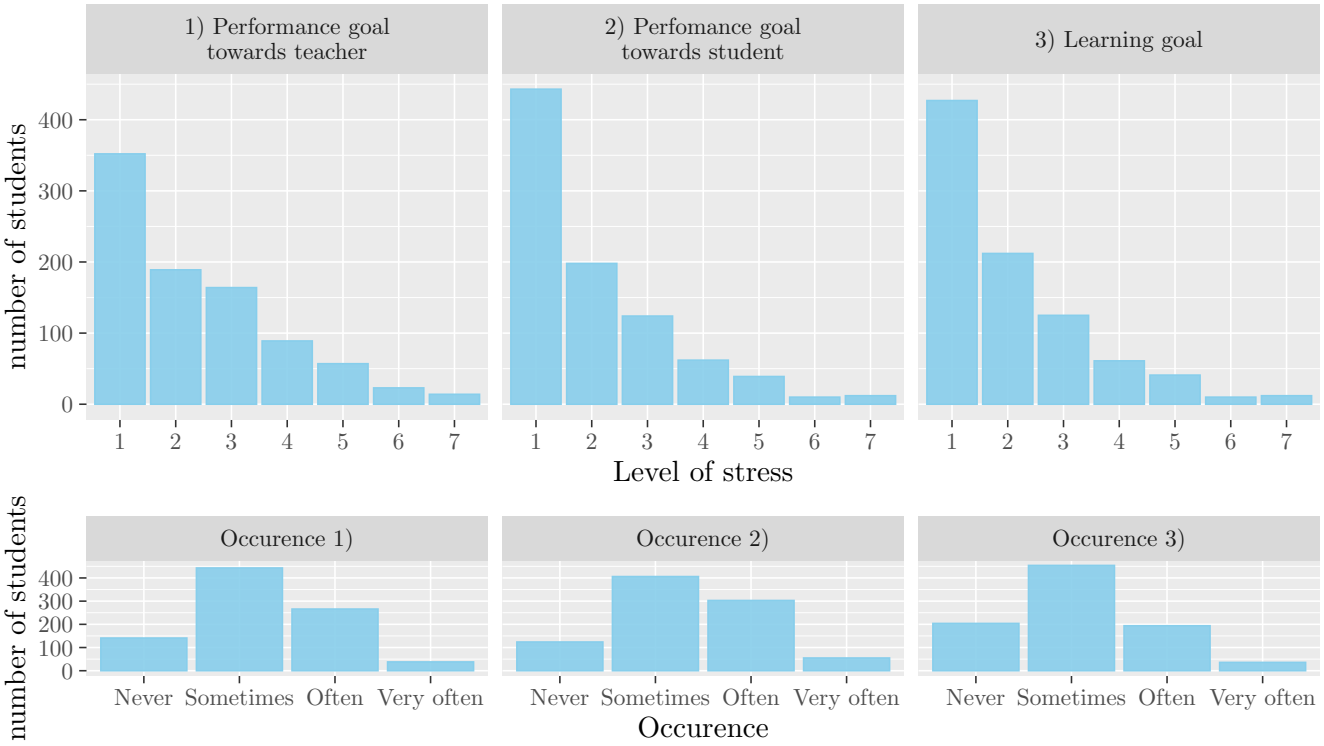


Figure 5.6: Performance goal and learning goal histogram scenario 2 ($n = 888$). The averages of the first second and third reaction are respectively 2.36, 2.02 and 2.05.

The two boxplots concerning the first and second reaction, where the teacher checks exercises with a formative grade or by drawing lines through mistakes, are equal, see figure 5.7. By the Wilcoxon rank sum test with a $p$-value of approximately 0.376 these medians are not significantly different under standard confidence intervals. The sign test supports this view with a relatively small difference between the estimated amount of positive signs (208.5) and observed positive signs (216). The third reaction however, where the teacher explains the learning goal of an exercise, shows a median of 1 instead of 2. Table 5.4 shows that the median of the third reaction differs significantly from the median of the first reaction with a $z$-value of approximately $-10.745$ and is also significantly different from the median of the second scenario with a $z$-value of approximately $-13.200$. Both differences show moderate effect sizes, which are supported by the sign test, which shows relatively large differences between the estimated and observed positive differences.
As the right side of figure 5.7 reveals, the boxplots of the three reactions concerning the second scenario are identical. However, the Wilcoxon rank sum test shows that the medians of the first and second reactions are significantly different with a $z$-value of approximately $-9.954$ as well as the median of the first and the third reaction with a $z$-value of approximately $-8.166$. The first comparison shows a moderate effect size and the last comparison a small effect size. The sign test confirms these effect sizes in such way that it shows a larger gap between the estimation and the observation of the positive differences in the first comparison. Furthermore, the sign test shows that in both cases the observed value of positive differences is bigger than the estimated value, which means that the median of the first reaction is significantly higher than the median found in the second and third reactions.

Table 5.3 highlights the differences of medians within subgroups. Considering all the grades, only students from the first grade show a median of 1 instead of 2 for the first reaction, where the teacher grades an exercise in a formative matter. However, table 5.5 reveals that they do not differ significantly from the second scenario under a confidence interval with $\alpha = 0.05$. The sign test supports this view with only a small difference between the expected value and the observed value of positive differences. Another interesting aspect of table 5.5 is the low median levels of the subgroup male. They show a median of 1 for every scenario but the statistical test still show significant differences ($z \approx -8.606$ and $z \approx -5.701$) between the second and the third reaction and the first and the second reaction with moderate and small effect sizes respectively.
Similar to the boxplots from figure 5.7, table 5.5 gives only little insight because of the similarity between the three reactions. What stands out in this part of the table are the medians corresponding the subgroups first graders, the second graders and male students. These subgroups show a higher median when the teacher says that she will check whether the students understand the subject, in comparison with the teacher putting the emphasis on the students checking if they understand it themselves or putting the emphasis on the learning goal only. These differences between the medians of the first reaction and the other two reactions are significant in all three reactions, see table 7.7 for the corresponding $z$-values. The effect sizes where small in comparison to the median of the first and third reactions for the first graders and the male students, but the Wilcoxon rank test together with the sign test showed that the other two comparisons had large effect sizes.

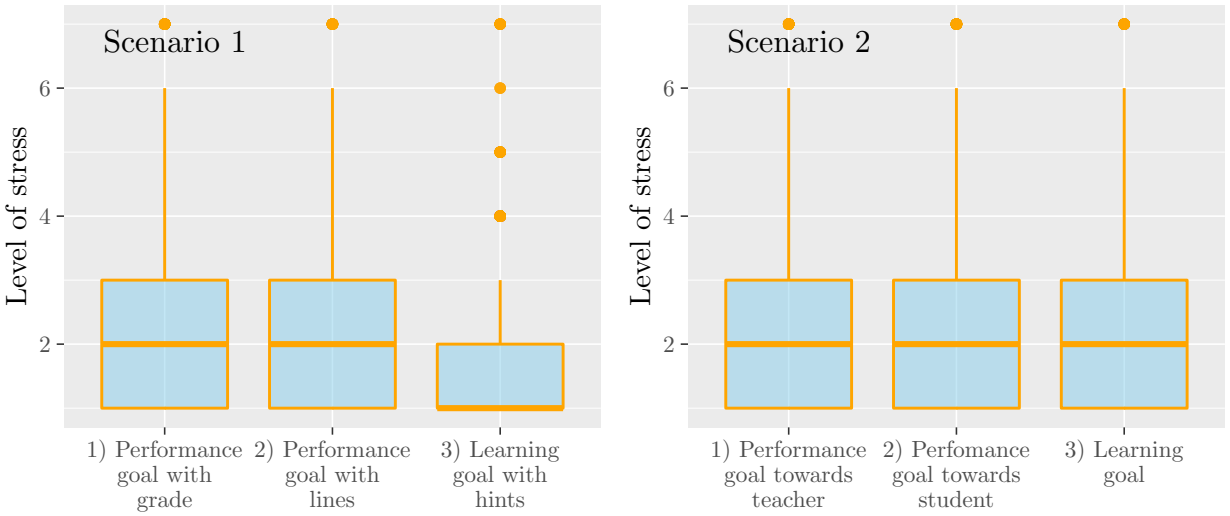


Figure 5.7: Performance goal and learning goal boxplot ($n = 888$). The outliers of a boxplot are drawn as dots. Outliers are, by default in R, defined as observations outside the interval $q_1 - 1.5 \cdot IQR; q_3 + 1.5 \cdot IQR$ where $q_1, q_3$ and $IQR$ are the first quartile, the third quartile and the difference between the first and the third quartile respectively.

Table 5.4: Results Wilcoxon rank sum test ($n = 888$) and sign test. Effect size for Wilcoxon rank sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade.

| Null hypothesis | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|
| $H_0$ : median 1.1 equals median 1.2 | $-0.885$ | 0.376 | $-0.030$ | 216 | 208.5 |
| $H_0$ : median 1.2 equals median 1.3 | $-13.200$ | $< 0.001$ | $-0.443$ | 320 | 185.0 |
| $H_0$ : median 1.1 equals median 1.3 | $-10.745$ | $< 0.001$ | $-0.361$ | 320 | 210.0 |
| $H_0$ : median 2.1 equals median 2.2 | $-9.954$ | $< 0.001$ | $-0.334$ | 300 | 193.5 |
| $H_0$ : median 2.2 equals median 2.3 | $-0.955$ | 0.340 | $-0.032$ | 144 | 154.5 |
| $H_0$ : median 2.1 equals median 2.3 | $-8.166$ | $< 0.001$ | $-0.274$ | 300 | 210.5 |

Table 5.5: Median per class, gender and level and overall of the six reactions regarding the category performance goal and learning goal. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade.

| Group | $n$ | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 |
|---|---|---|---|---|---|---|---|
| 1st grade | 251 | 1 | 2 | 1 | 2 | 1 | 1 |
| 2nd grade | 177 | 2 | 2 | 1 | 2 | 1 | 1 |
| 3rd grade | 187 | 2 | 2 | 1 | 2 | 2 | 2 |
| 4th grade | 172 | 2 | 2 | 1 | 2 | 2 | 2 |
| 5th grade | 100 | 2 | 2 | 1.5 | 2 | 2 | 2 |
| 6th grade | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| Female | 384 | 2 | 2 | 2 | 2 | 2 | 2 |
| Male | 455 | 1 | 1 | 1 | 2 | 1 | 1 |
| Other | 24 | 1 | 2 | 1 | 1 | 1 | 1 |
| Rather not tell | 25 | 2 | 2 | 1 | 2 | 2 | 1 |
| Vwo | 618 | 2 | 2 | 1 | 2 | 2 | 2 |
| Havovwo | 143 | 1 | 2 | 1 | 2 | 1 | 2 |
| Havo | 127 | 2 | 2 | 1 | 2 | 1 | 2 |
| Overall | 888 | 2 | 2 | 1 | 2 | 2 | 2 |

**c) Mathematics teaching anxiety**

The following part of the survey measured the impact of teachers showing signs of mathematics teaching anxiety on the level of stress students experience during math activities. The first set of questions aimed to illustrate a scenario which helps distinguish the level of mathematics teaching anxiety a teacher can suffer from.

*Scenario 1*
*During math lesson the teacher explains a subject in front of the class and the subject is difficult for you. You*
*1) notice that the teacher herself finds the subject difficult (insecure)*
*2) notice that the teacher herself finds the subject very easy (confident)*
*3) do not know whether the teacher finds the subject difficult or easy (unclear)*

It is apparent from the top half of figure 5.8 that almost half ($\sim 43.9\%$) of the students indicated to feel no stress at all when the teacher seems confident. However, when a teacher seems insecure it is clear from the upper left side of figure 5.8 that this proportion is lower, namely 25.1%. Additionally, the average of this first reaction is the highest amongst the three. While the responses to the first iteration are widespread, the responses to the second reaction are mostly between the anxiety levels 1 and 3 ($\sim 79.5\%$). From the bottom half of figure 5.8 it can be seen that the first reaction is less common for the students than the other two reactions. A majority of students ($\sim 68.1\%$) indicated that they have never experienced a scenario where the teacher seems insecure while explaining a difficult subject. The students experienced the second and third reactions more often, with proportions of approximately 9.0% and 37.8%.

*Scenario 2*
*The teacher makes a mistake on the board during math lesson. The teacher*
*1) pretends that she did not make a mistake (hiding mistakes)*
*2) corrects her mistake and becomes nervous in front of the class (insecure showing mistakes)*
*3) corrects her mistake and continues in the same way she did before the mistake (confident showing mistakes)*

The responses to the three reactions of this scenario are very similar in that they all show a large proportion of students, $\sim 45.6\%$, $\sim 46.4\%$ and 71.4% respectively, indicating that they feel no stress at all. Interestingly, students seem to indicate similar levels of stress when a teacher is hiding a mistake or seems insecure after making a mistake. The levels of stress students indicate for the scenario in which the teacher confidently continues after making mistakes seems to be slightly lower since the proportion of students indicating levels of stress higher than a 3 is approximately 6.0%, while this proportion is 22.7% and 21.1% for the second and third reactions, respectively. Also the average of this third reaction appears to be the lowest amongst the three. Finally, it is important to bear in mind that the first two reactions are indicated to be not common for a majority of the students. Approximately 80.3% of the students indicated that they have never experienced a teacher hiding mistakes and that proportion was approximately 77.7% for the second reaction. The third reaction however, shows that students indicate that it is less uncommon when a teacher continues with her lesson confidently after she made a mistake.

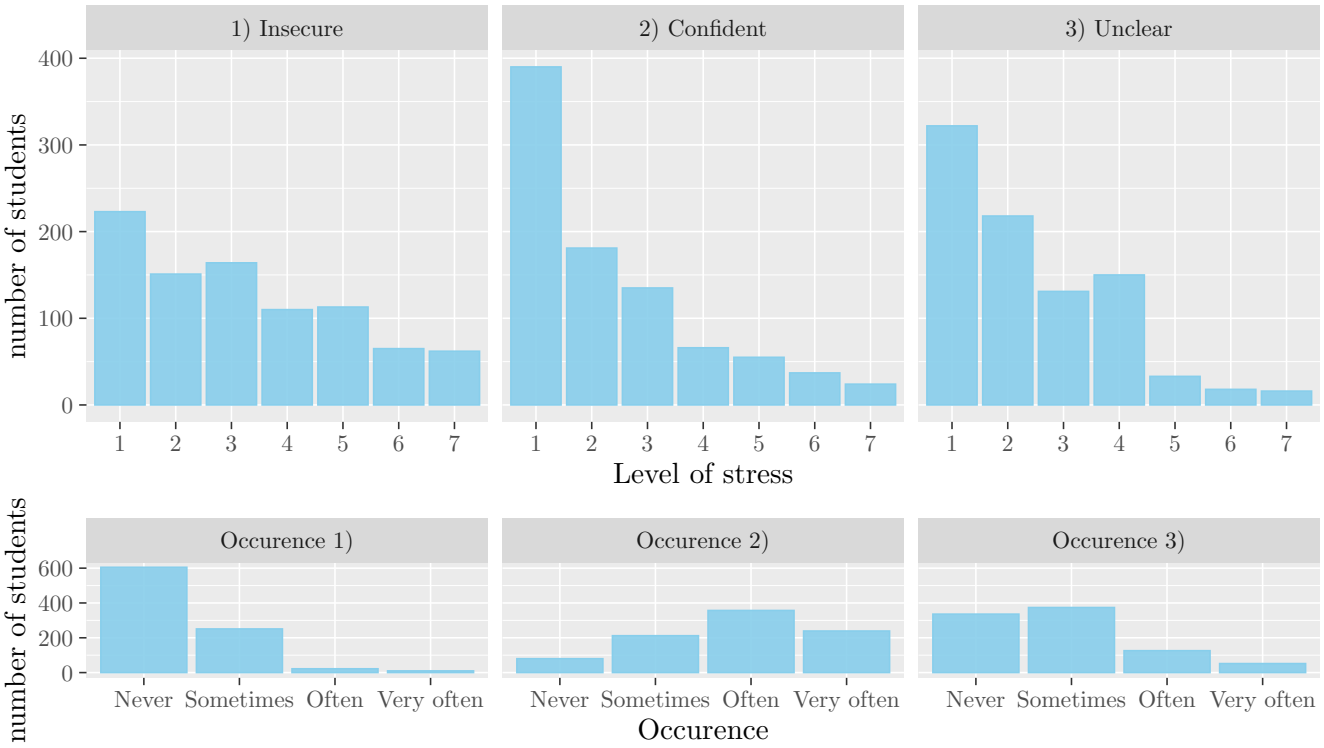


Figure 5.8: Mathematics teaching anxiety histogram scenario 1 ($n = 888$). The averages of the first second and third reaction are respectively 3.20, 2.35 and 2.41.

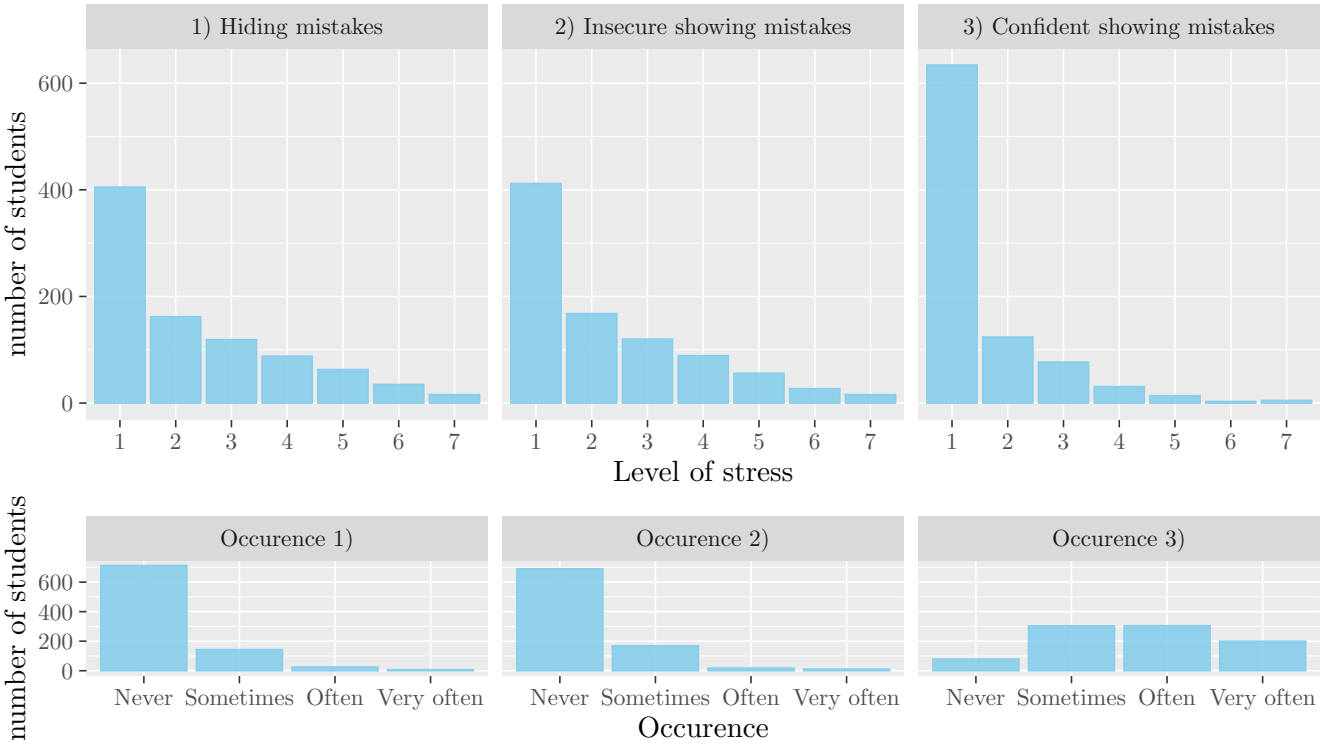


Figure 5.9: Mathematics teaching anxiety histogram scenario 2 ($n = 888$). The averages of the first second and third reaction are respectively 2.34, 2.27 and 1.53.

The results of the first scenario can be compared in the boxplots on the left side of figure 5.10. It is clear from these boxplots that the median of the first reaction is the highest, which represents the students experiencing a difficult lesson while the teacher seems insecure. In the boxplot it is also apparent that the standard deviation is bigger than shown in the other two reactions concerning this scenario. In line with the boxplot, table 5.6 shows that the median of the first reaction differs significantly from the median of the second scenario ($z \approx -11.576$), where the teacher seems confident, and differs significantly from the third scenario ($z \approx -14.335$), both with moderate effect sizes. The sign tests confirm the moderate effect sizes in that there is a considerable gap between the estimated and observed value of the positive differences. In addition to these significant differences, the table shows that the medians of the second and third reactions are not significantly different under a confidence interval with $\alpha = 0.05$.
The two boxplots on the right side of figure 5.10 concerning the first and second reactions, where the teacher hides her mistake or seems insecure after making the mistake, are identical. By the Wilcoxon rank sum test with a $p$-value of 0.085 these medians are not significantly different under a confidence interval with $\alpha = 0.05$. The sign test supports this view with a relatively small difference between the estimated amount of positive signs (188.5) and the observed positive signs (199). The third reaction however, where the teacher continues her lesson confidently after making a mistake, shows a median of 1 instead of 2 with outliers on every level above 3. Table 5.4 shows that the median of the third reaction differs significantly from the median of the first reaction with a $z$-value of approximately $-15.227$ and differs significantly from the median from the second scenario with a $z$-value of approximately $-15.415$. Both differences show large effect sizes, which are supported by the sign test and show relatively large differences between the estimated and observed positive differences.

The division in subgroups is set out in table 5.7 and surprisingly, there is almost no variation in medians between the subgroups considering the first reaction of the first scenario in which the teacher seems insecure. In the second and third reactions however, when the teacher seems confident or when it is unclear whether the teacher is insecure or confident, there are some differences between the subgroups in their medians. If the teacher shows confidence, the first graders, the male students and the havo students indicated their levels of stress in such a way that their median ended up to be only a 1, instead of a 2 which is more common amongst the other groups. Interestingly, table 7.8 shows that none of the subgroups are significantly different in the comparison between the median of the second reaction and the third reactions under a confidence interval of $\alpha = 0.05$, except for the subgroup havo which shows a very small significant difference between the two medians with a $z$-value of approximately $-3.273$ and a small effect size. On the other hand, the comparison of the first and the second reactions shows significant differences within all the subgroups, see table 7.8 for all the $z$-values and effect sizes.
Table 7.9 reveals that the differences between the subgroups in their medians concerning the second scenarios, are quite small. The two subgroups standing out in the table are the second graders and the male students in the way that they show low medians in the first and second scenario where the teacher hides mistakes or seems insecure after making a mistake. However, closer inspection of table 7.9 reveals that the medians of the second and third reactions differ significantly for the second graders ($z \approx -6.596$) and the male students ($z \approx -10.954$) as well as the median of the first and third reactions ($z \approx -6.520$ and $z \approx -10.849$) with moderate and large effect sizes.

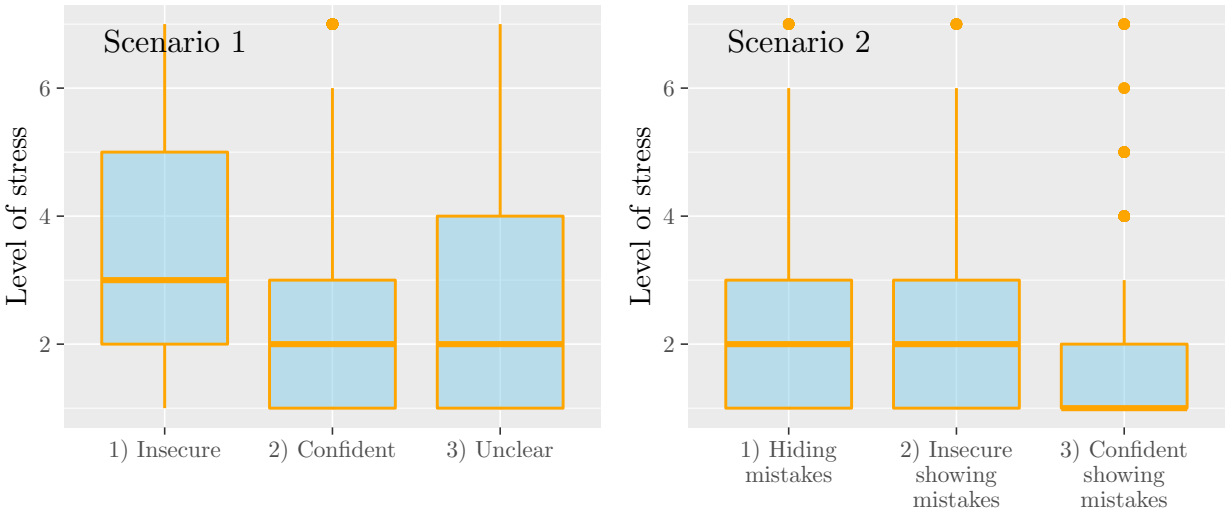


Figure 5.10: Mathematics teaching anxiety boxplot ($n = 888$). The outliers of a boxplot are drawn as dots. Outliers are, by default in R, defined as observations outside the interval $q_1 - 1.5 \cdot IQR; q_3 + 1.5 \cdot IQR$ where $q_1, q_3$ and $IQR$ are the first quartile, the third quartile and the difference between the first and the third quartile respectively.

Table 5.6: Results Wilcoxon rank sum test ($n = 888$) and sign test. Effect size for Wilcoxon rank sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade.

| Null hypothesis | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|
| $H_0$ : median 1.1 equals median 1.2 | $-11.576$ | $< 0.001$ | $-0.388$ | 492 | 333.0 |
| $H_0$ : median 1.2 equals median 1.3 | $-1.362$ | 0.173 | $-0.046$ | 204 | 234.5 |
| $H_0$ : median 1.1 equals median 1.3 | $-14.335$ | $< 0.001$ | $-0.481$ | 483 | 305.0 |
| $H_0$ : median 2.1 equals median 2.2 | $-1.725$ | 0.085 | $-0.058$ | 199 | 188.5 |
| $H_0$ : median 2.2 equals median 2.3 | $-15.227$ | $< 0.001$ | $-0.511$ | 376 | 202.0 |
| $H_0$ : median 2.1 equals median 2.3 | $-15.415$ | $< 0.001$ | $-0.517$ | 379 | 207.0 |

Table 5.7: Median per class, gender and level and overall of the six reactions regarding the category math teaching anxiety. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade.

| Group | $n$ | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 |
|---|---|---|---|---|---|---|---|
| 1st grade | 251 | 3 | 1 | 2 | 2 | 1 | 1 |
| 2nd grade | 177 | 3 | 2 | 2 | 1 | 1 | 1 |
| 3rd grade | 187 | 3 | 2 | 2 | 2 | 2 | 1 |
| 4th grade | 172 | 3 | 2 | 2 | 2 | 2 | 1 |
| 5th grade | 100 | 3.5 | 2 | 2.5 | 2 | 2 | 1 |
| 6th grade | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| Female | 384 | 3 | 2 | 2 | 2 | 2 | 1 |
| Male | 455 | 3 | 1 | 2 | 1 | 1 | 1 |
| Other | 24 | 3 | 1.5 | 2 | 2 | 2 | 1 |
| Rather not tell | 25 | 3 | 2 | 3 | 2 | 3 | 1 |
| Vwo | 618 | 3 | 2 | 2 | 2 | 2 | 1 |
| Havovwo | 143 | 3 | 2 | 2 | 2 | 1 | 1 |
| Havo | 127 | 3 | 1 | 2 | 2 | 2 | 1 |
| Overall | 888 | 3 | 2 | 2 | 2 | 2 | 1 |

**d) Concept of mistakes**

In the final part of the survey, students were asked to imagine scenarios which involve mistakes they made personally while doing their mathematical exercises or publicly in front of the class.

*Scenario 1*
*During math lesson you are working on homework exercises. The teacher walks besides you and sees you made a few mistakes. She says:*
*1) 'Good that you made mistakes, because that means that you learned something' (focus on learning)*
*2) 'Do not worry, there are a few questions you did well' (positive focus on mistakes)*
*3) 'I can see you have difficulties with math, since you make a lot of mistakes' (negative focus on mistakes)*

Figure 5.11 shows that students responded to the first and the second reactions in a similar way. Both reactions show a clear decline in students indicating higher levels of stress. When the teacher focuses on the learning aspect of a mistake, approximately 33.7% of the students indicated to feel no stress at all. This proportion was approximately 28.9% in the second reaction, where the teacher focuses on the mistake but does that in a positive way. The third reaction however, shows a large deviation in responses, where almost every level of stress is quite apparent and from which the average is clearly higher. The occurrence of the reactions according to the students is quite similar for the three reactions, where the proportion of students not experiencing the reaction was approximately 61.4%, 55.6% and 59.7% for the first, second and third reaction respectively.

*Scenario 2*
*During an explanation of the teacher in front of the class, the teacher asks a question in which you answer wrongly. The teacher says that the answer is wrong. Next, the teacher*
*1) asks another students who knows the right answer (redirecting question)*
*2) tells the right answer (correction by teacher)*
*3) gives an hint so that you can give the right answer yourself (correction by student)*

As can be seen in figure 5.12, the responses to the three reactions all show a clear decline in students indicating higher levels of stress. The highest proportion of students indicating that they feel no stress at all (37.2%), is shown in the middle of the figure for the second reaction, when the teacher corrects their mistake publicly. This proportion is approximately 29.3% and 34.1% for the first and third reactions, respectively. The highest proportion of students indicating levels of stress higher than a 3 is approximately 31.4% for the first reaction where the teacher redirects the wrongly answered question to another student, whereas this proportion is approximately 20.6% and 35.1% for the second and third reactions, respectively. Furthermore, it is apparent from the bottom half of the figure that the reactions are not that uncommon for students.

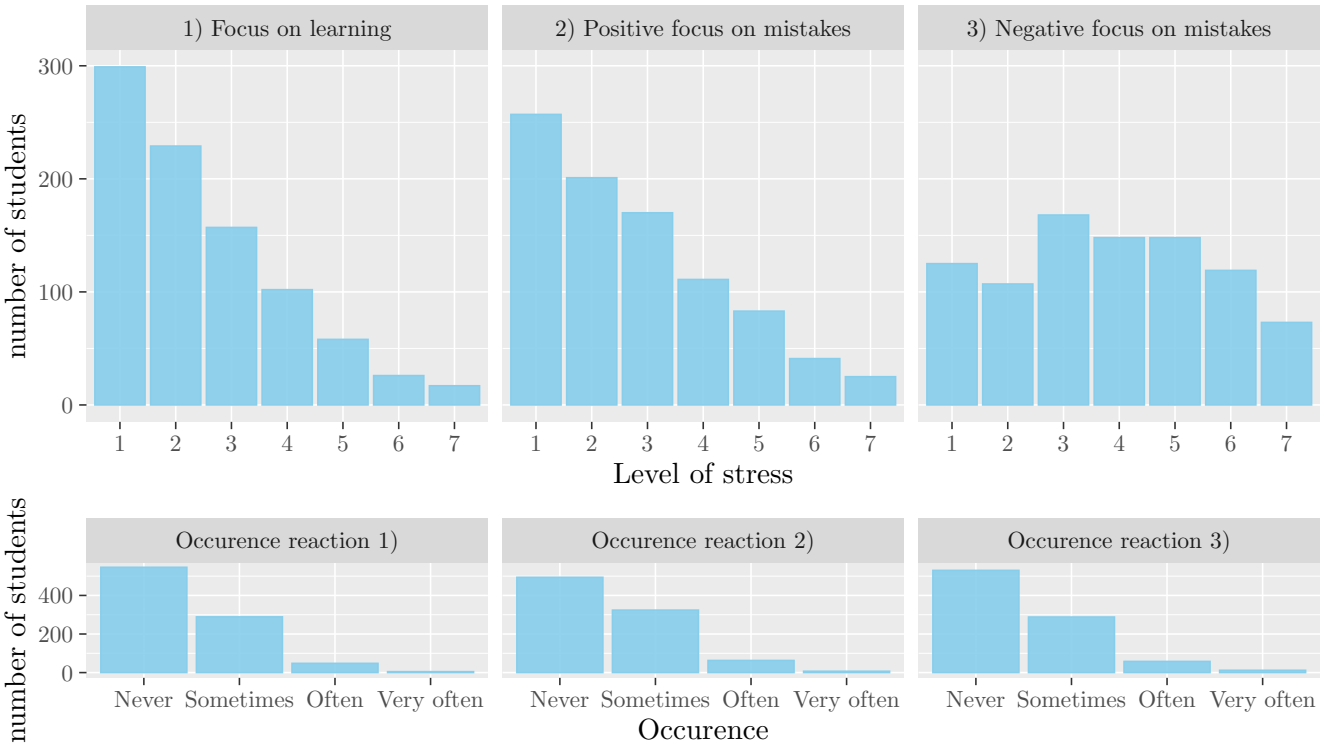


Figure 5.11: Concept of mistakes histogram scenario 1 ($n = 888$). The averages of the first second and third reaction are respectively 2.48, 2.76 and 3.83.

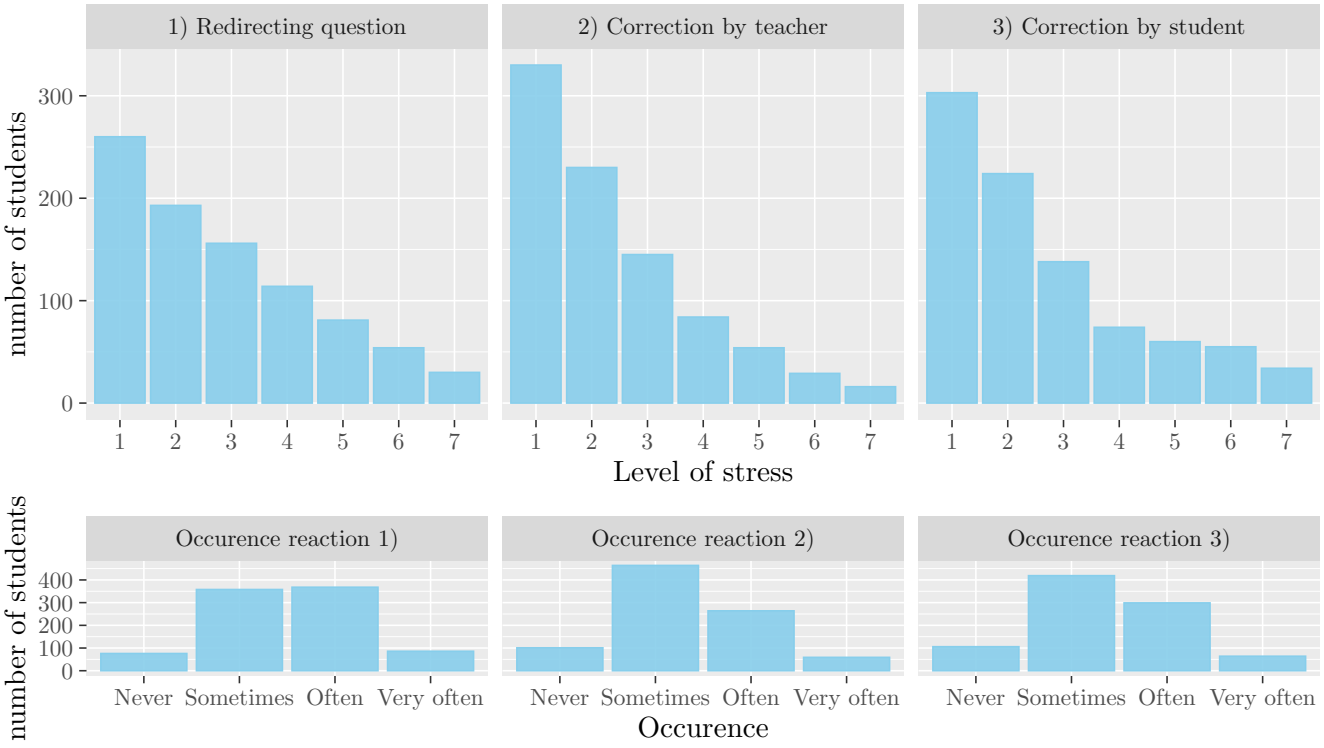


Figure 5.12: Concept of mistakes histogram scenario 2 ($n = 888$). The averages of the first second and third reaction are respectively 2.83, 2.38 and 2.62.

From the boxplots on the left side of figure 5.13 it can be seen that by far the highest median measured in this scenario belongs to the third reaction, where the teacher focuses in a negative way on the mistake a student made. This is clearly supported by table 5.8 where it is shown that the median of the first reaction differs significantly ($z \approx -20.511$) from the third reaction as well as the second scenario ($z \approx -18.316$), both with large effect sizes. The difference between the two medians equals two levels, which is considered to be large on a scale of 1 to 7 and is not shown in any other scenario in this study. The first and second reactions where the teacher puts the focus on the learning aspect of a mistake or focuses positively on the mistake in emphasizing the correct exercises, are not different in the boxplot but table 5.8 shows a small significant difference ($z \approx -6.284$) with a small effect size.
On the right side of figure 4.16 it can be seen that the last two reactions show a median of 2 and the first reaction a median of 3. Table 5.8 shows that the first two reactions are significantly different with a $z$-value of approximately $-13.549$ and a moderate effect size, which is supported by the sign test where the gap between the estimated and observed value of the positive differences is small. The difference between the median of the first and third reaction is significant with a small effect size, which questions the relevance of this finding.

Table 5.9 shows the separation in subgroups in order to compare the medians each subgroup indicated. The most striking result in this table is the difference between the female subgroup and the male subgroup in the third reaction of the first scenario, where the teacher focuses negatively on a mistake. The female students indicated their levels of stress in such way that the median is 5, whereas this median is 3 in the male subgroup. In addition, table 7.11 shows that the difference in median between the responses on the teacher focusing positively on the mistakes and focusing negatively on the mistake in the female subgroup is significant with a $z$-value of approximately $-14.043$ and a very large effect size. The sign test reveals that there is a large gap between the expected positive differences (147) and the observed positive differences (20). Furthermore, the male subgroup is, apart from the one student in the 6th grade, the only subgroup with a median level of 3 in the third reaction instead of 4. However, the difference between the second and third reactions is still significant ($z \approx -11.270$) as well as the difference between the first and the third reactions ($z \approx -13.818$).
Table 5.9 also shows that the medians in the lower grades are all equal to each other within the three reactions. In contrast, the upper grades show higher medians for the first reaction in which the teacher redirects the question to another student. These differences between the median of the first and third reactions however, are not significant for neither grades on a significance level of $\alpha = 0.05$. There is a significant difference between the median of the first and second reactions in the fourth grade ($z \approx -6.515$) with a moderate effect size, which is partly supported by the sign test, where the gap between the estimated (43) and observed value (78) of positive differences is relatively small. The Wilcoxon rank sum test could not be performed on the subgroup of the fifth graders because of the large amount of ties for this scenario. The sign test however shows for this subgroup a small gap as well (24 estimated and 44 observed).

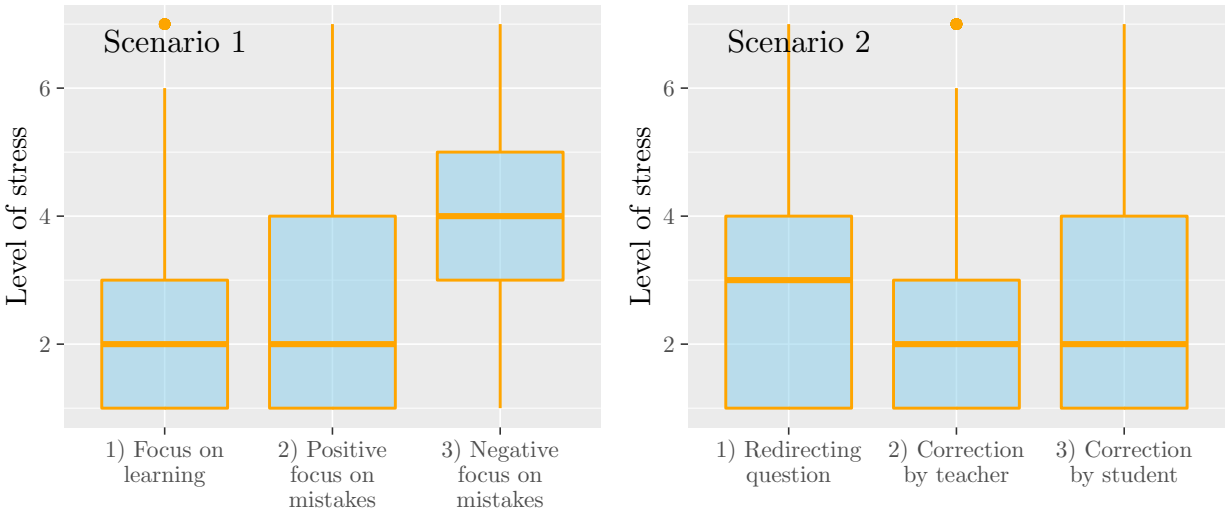


Figure 5.13: Concept of mistakes boxplot ($n = 888$). The outliers of a boxplot are drawn as dots. Outliers are, by default in R, defined as observations outside the interval $q_1 - 1.5 \cdot IQR; q_3 + 1.5 \cdot IQR$ where $q_1, q_3$ and $IQR$ are the first quartile, the third quartile and the difference between the first and the third quartile respectively.

Table 5.8: Results Wilcoxon rank sum test ($n = 888$) and sign test. Effect size for Wilcoxon rank sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade.

| Null hypothesis | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|
| $H_0$ : median 1.1 equals median 1.2 | $-6.284$ | $< 0.001$ | $-0.211$ | 177 | 242.5 |
| $H_0$ : median 1.2 equals median 1.3 | $-18.316$ | $< 0.001$ | $-0.615$ | 67 | 315.5 |
| $H_0$ : median 1.1 equals median 1.3 | $-20.511$ | $< 0.001$ | $-0.688$ | 33 | 320.5 |
| $H_0$ : median 2.1 equals median 2.2 | $-13.549$ | $< 0.001$ | $-0.455$ | 355 | 206.5 |
| $H_0$ : median 2.2 equals median 2.3 | $-4.724$ | $< 0.001$ | $-0.159$ | 232 | 265.5 |
| $H_0$ : median 2.1 equals median 2.3 | $-4.196$ | $< 0.001$ | $-0.141$ | 340 | 286.5 |

Table 5.9: Median per class, gender and level and overall of the six reactions regarding the category concept of mistakes. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade.

| Group | $n$ | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 |
|---|---|---|---|---|---|---|---|
| 1st grade | 251 | 2 | 2 | 4 | 2 | 2 | 2 |
| 2nd grade | 177 | 2 | 2 | 4 | 2 | 2 | 2 |
| 3rd grade | 187 | 2 | 2 | 4 | 2 | 2 | 2 |
| 4th grade | 172 | 2 | 3 | 4 | 3 | 2 | 2 |
| 5th grade | 100 | 2 | 3 | 4 | 3 | 2 | 2 |
| 6th grade | 1 | 3 | 3 | 3 | 1 | 1 | 2 |
| Female | 384 | 2 | 3 | 5 | 3 | 2 | 2.5 |
| Male | 455 | 2 | 2 | 3 | 2 | 2 | 2 |
| Other | 24 | 3 | 3 | 4 | 2 | 1.5 | 2 |
| Rather not tell | 25 | 3 | 3 | 4 | 3 | 2 | 3 |
| Vwo | 618 | 2 | 2 | 4 | 3 | 2 | 2 |
| Havovwo | 143 | 2 | 3 | 4 | 2 | 2 | 2 |
| Havo | 127 | 2 | 2 | 4 | 2 | 2 | 2 |
| Overall | 888 | 2 | 2 | 4 | 3 | 2 | 2 |

### 5.4.3 Comparison first part and second part

In the last part of this section, a comparison is presented between the first part of the survey, where the general feeling of stress during math activities is measured, and the second part of the survey, where the role of certain behaviour of the teacher towards the students is measured. In this comparison the differences between age groups is included in an attempt to gather insight on the way math anxiety develops through the years of high school. Similarly to the first iteration, the average of part 1 and the weighted average of part 2 were compared in order to get an insight on the relative impact of the scenarios described in the second part. $\overline{x}_i^1$ equals the average level of stress student $i$ indicated to the first part of the survey and $\overline{x}_i^2$ equals the average level of stress this student indicated to the second part of the survey. The differences between these two were calculated ($d_i = \overline{x}_i^1 - \overline{x}_i^2$) and analysed. A positive $d_i$ means that the average student $i$ indicated in the first part of the survey was higher than the average the student indicated in the second part of the survey. This means that the student indicates to feel more stress in the described general scenarios than in the scenarios where there is certain interaction between the teacher and the student. Calculations reveal that approximately 73.1% students indicated higher levels of stress to the first part of the survey and the average level of $d_i$ was approximately 0.48. The averages of the two parts of the survey are shown in figure 5.14 while the students are divided into age groups. There seems to be small differences between the groups, but further statistical tests should be performed to gather information on the significance of these differences. In the following analysis, the results of the age groups 11, 18 and 19 are not taken into account since they all have small sample sizes. In this figure, the highest average level of stress students indicated in the first part of the survey is apparent at the age of 17 and the smallest at the age of 12. With the exception of the age of 14, the average level of stress increases through the years. The largest average level of stress in the second part of the survey is apparent at the age of 13 and 16 years old. The smallest average is found in the group of student of 14 years old.

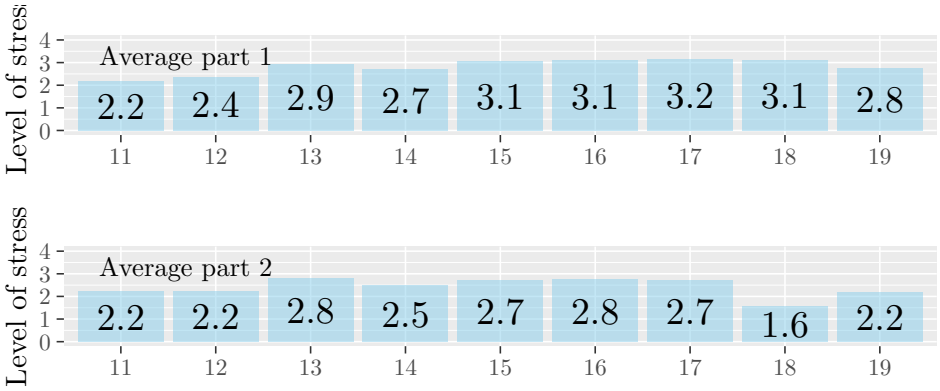


Figure 5.14: Comparison between the average students indicated for part 1 and part 2 of the survey ($n = 888$). The students are classified into age, where the sample size per group equals $n_{11} = 6$, $n_{12} = 121$, $n_{13} = 204$, $n_{14} = 184$, $n_{15} = 162$, $n_{16} = 144$, $n_{17} = 58$, $n_{18} = 6$, $n_{19} = 4$

## 5.5 Conclusion and discussion second iteration

This thesis was designed to determine which factors in the behaviour of math teachers in their contact with high school students, contribute to the developing, worsening or alleviating math anxiety during math activities. The aim of the present iteration was to investigate the main research question together with sub-questions stated in section 3.8 and the hypothesis stated in section 4.8. Per category, two scenarios have been examined together with three reactions of the teacher regarding this scenario. It has been hypothesised that the medians of the level of stress student indicate to these three reactions, are equal. The following part of this section moves on to analyse this hypothesis, starting with the first question concerning the category 'Growth mindset'.

*What is the impact of math teachers showing their belief in the fixed mindset on high school students' feelings of stress they experience during math activities?*

The most interesting finding in this category is the high levels of stress students indicated for the scenario where the teacher shows her belief in the growth mindset in comparison with the teacher showing her belief in the fixed mindset or when the teacher does not reveal her belief in this matter. The median level of stress was a 3 on a scale from 1 to 7 when students tried to imagine the scenario where the teacher shows her belief in the growth mindset in a way that she convinces the student to try to solve an exercise again, when the student failed once. This median level of stress was a 2 for the other two reactions, while the students additionally indicated that they experienced it more often that a teacher shows her belief in that growth mindset. In this iteration it was found that the difference between the median was significant for both comparisons. However, the comparison between the fixed mindset and the growth mindset showed a rather low effect size, so the question arises whether this difference is relevant. These findings support the findings from the first iteration, where an important suggestion was made about this category, see section 4.6. The assumption was made in this iteration that the teacher shows her belief in the growth mindset when she forces a student to try to solve an exercise again. However, students might lack experience in handling the exercise themselves. Therefore, it may be the case that students in the scenario focus on the fact that they have to try the exercise without help instead of focusing on the fact that the teacher seems to believe that the student can solve it without their help. The high number of students indicating to feel no stress at all in the third reaction, where the teacher immediately writes down the answer in the book, supports this view. These findings are unexpected because of the way the first reaction could be interpreted as a harsh way of talking to students because of the words '...for some students mathematics remains difficult', whereas the second reaction only states 'Think again'. Interestingly, the median found in the subgroup of female students, was two levels higher (4) than the median found in the male subgroup (2). Apparently, female students indicated their level of stress in such a way that their median for the scenario in which the teacher emphasizes her belief in the growth mindset in trying to convince the student to try again, is relatively high, whereas the male students indicated in such a way that their median was relatively low in this scenario.

Another unexpected outcome was found in the second part of this category. The goal of this part of the survey was to compare the level of stress students indicate after they failed an exam and when the teacher expresses that she has low expectations of the student and criticises on their ability, that she has high expectations and praises on ability or when the teacher expresses no expectations, criticism or praises. Surprisingly, the average is the highest in the last scenario, where the teacher only states the fact that is already known by the student, without any assumptions about their abilities by stating 'You did not do this exam well'. Even though the medians concerning these three reactions are the same, it is shown by the Wilcoxon rank sum test that the median of the reaction where the teacher does not show any expectations differs significantly from the other reactions. However, these differences show small effect sizes and it is questionable whether these differences are relevant. A possible explanation for this finding might be that the teacher says directly to the student that the exam was not made well by her/him with the words 'You did not do this exam well', whereas the first two reactions only imply this in an indirect way with the use of the words 'I expected this..' or 'I did not expect this...'.

Regarding the category 'Performance goal and learning goal', the following research question was examined.

*What is the impact of math teachers mentioning the performance goal prior to a mathematical exercise on high school students' feelings of stress they experience?*

The main findings in this category is the significantly lower median level of stress students indicated when a teacher announces that she will check exercises by writing down hints in comparison with the teacher announcing that she will give a formative grade or draws lines through the mistakes. In the first reaction of the teacher she emphasizes the learning goal instead of the performance goal and on top of that indirectly emphasizes her belief in the growth mindset of the student because she thinks that the student can correct the mistake with some help from the teacher. This observation supports the view made in the first category, because it was suggested there that students feel more stress in a scenario where they have to solve an exercise themselves, without the help of a teacher, regardless of the way the teacher puts the emphasis on the growth mindset. To be more precise, the median level of stress students indicated for the reaction from the teacher 'Think again' is a 3, whereas the median level of stress when the teacher writes down hints next to exercises, is a 1. In this study, both of these reactions were considered to emphasize the growth mindset of the teacher, but the students experience these two reactions very differently. A rather unexpected result of this category is the similar levels of stress students indicated when the teacher announces that she will check the exercises with a formative grade and when she will check it by drawing lines through the mistakes. It was found in the first part of the survey, where the general feeling of stress was measured through short scenarios involving math activities, that the average level of stress in scenarios involving an exam were higher than in scenarios that not include any involvement of exams. Therefore, it is rather surprising that the median level of stress of the first reaction, in which a formative grade will be given, equals the median level of stress when only lines are drawn through mistakes. This result is supported by the Wilcoxon rank sum test where it was found that these two reactions do not differ significantly from each other.

In the second part of this category, the performance goal was compared against the learning goal in a different way. The teacher describes, prior to a trial exam, that she herself likes to know how well the students understand the material and that she wants the students to check themselves how well they understand material or she very clearly emphasizes the learning goal by saying 'You can learn from it'. Data from this study suggest that there is only little difference in feelings of stress students indicate to these reactions. However, the Wilcoxon rank sum test together with the sign test show that the median level of stress is significantly higher when the teacher wants to know how well the student understands the material than when the teacher wants the students to check themselves how well they understand something.

The next research question is analysed within the category 'Mathematics teaching anxiety'.

*What is the impact of teachers showing signs of mathematics teaching anxiety on high school students' feelings of stress they experience during math activities?*

This study confirms that signs of math anxiety amongst teachers are associated with higher levels of stress amongst students. The highest median level of stress was indicated in the scenario where the teacher explains a difficult subject and seems insecure. In section 2.4 it is described that this is one of the signs of math teaching anxiety and math anxiety. In comparison with the teacher seeming confident or when the confidence of the teacher is unclear to the students, Wilcoxon rank sum test confirms with moderate effect sizes that the median level of the reaction where the teacher is insecure differs significantly from the other two. In addition, the second scenario described in this category, supports this view since it shows the lowest median level of stress for the teacher seeming to be confident after making a mistake on the board in comparison to the teacher hiding the mistake, or to the teacher seeming to be insecure after making the mistake. The Wilcoxon rank sum test reveals that the median level of stress indicated for the confident reaction on a mistake is significantly different from the other two reactions, with a large effect size.
Finally, the findings of this category must be approached with caution since the number of students indicating that they have never experienced scenarios they had to imagine was high, and therefore it might be difficult for them to decide on the level of stress they would feel in a scenario like that.

Turning now to the last two research questions regarding the category 'Concept of mistakes', where the first question focuses on students publicly giving the wrong answer to a question.

*What is the impact of teachers forcing students to publicly answer questions involving math on the feelings of stress students experience in upcoming math activities?*

Regarding this research question it was found in the first part of the survey that publicly answering questions of the teacher causes a higher average level of stress in comparison with questions on a personal level. In contrast with this finding, results of the second part of the survey show that the scneario involving a public question showed lower medians in general in comparison with the scenario involving a personal question. Different reactions of the teacher were compared concerning a public question and the median of these reactions were all identical and equal to a level of 2, whereas the median level of stress regarding a scenario where the teacher asks a personal question, the median levels of stress students indicated where levels of 2,2 and 4. However, it is important to bear in mind that the students had to imagine the reactions on the scenarios and give an estimate level of stress specifically on these reactions, so it might be the case that the reaction for which they indicated a 4 was on its own stressful for the students, regardless of the scenario.
In addition, this study did not only give insight on the difference between asking a question in person or in public to a student, but also to the way teachers react after a wrong answer to a public question. Three different reactions of the teacher were compared, which were: redirecting the question, correction by the teacher and correction by the student. The median levels of stress were the same for all three reactions, however the Wilcoxon rank sum test revealed that the median level of stress when the question is redirected to another student is significantly higher than when the teacher corrects the mistake herself, where the effect size is moderate. This finding is rather interesting because it was shown in the first part of the survey that students indicate to feel a higher average level of stress when they have to answer a question publicly in comparison with answering a question privately. This finding might suggest that the reason is mainly connected with the comparison students make with other students instead of feeling stressed about wrongly answering the question and the everyone noticing that they are not able to answer.

The last research question gives insight on the way teachers handle students' mistakes.

*What is the impact of math teachers focusing on mistakes high school students make during their math activities on their feelings of stress they experience?*

Interestingly, the largest difference between median levels of stress through reactions is shown in this category. Comparing the median levels, students indicated higher levels of stress when a teacher focuses negatively on a mistake in the following way: 'I can see you have difficulties with math, since you make a lot of mistakes', than when the teacher focuses on the learning aspect of mistakes or focuses in a positive way on the mistake by saying 'Do not worry, there are a few questions you did well.' The median level of stress found for the negative reaction was a 4, which is considered to be high on a scale from 1 to 7. The differences between the median level of stress indicated for the negative reaction and with the other two reactions, are significant with large effect sizes. Next to this comparison, it is important to keep in mind that in the reaction which is considered to be the most stressful for students, the teacher does not only focus negatively on the mistake but also shows her belief in the fixed mindset. By looking at the amount of mistakes, she draws conclusions on the mathematical ability of the student in general. Another interesting finding is that the female subgroup showed the largest median level of stress throughout the survey for this negative reaction, which was a median level of 5, whereas it was a 3 in the male subgroup.

The main research question aimed to combine the previous questions.

*Which factors in the behaviour of math teachers in their contact with high school students, contribute to the developing, worsening or alleviating of math anxiety during math activities?*

In summary, the most obvious finding to emerge from this study is that the participating students in this study indicated to feel higher levels of stress when they imagined a scenario in which they are forced to try an exercise again, even though the teacher indirectly implies that she believes in the growth mindset. Comparing the medians, this reaction is indicated to be even more stressful for students than when the teacher shows her belief in the fixed mindset by stating that the student will remain to have difficulties with math, where the effect size of this difference is rather small so the question arises whether this difference is relevant. However, these findings suggest that for students it is stressful to solve problematic mathematical issues without a helping hand of the teacher. This view is supported in the last part of the survey where it was found that students indicated to feel the least stress when the teacher checks their exercises by writing down hints next to the mistakes made, instead of drawing lines trough the mistakes or grade the exercises in a formative matter. An outcome considering the mindset of the teacher was found which was more expected. When the teacher concludes after a few mistakes a student makes that the student finds mathematics difficult in general, the highest level of stress throughout the whole study was found. In this reaction, the teacher shows her belief in the fixed mindset of the student, which is considered to be stressful. Another more expected outcome of this study was that students indicate to feel more stress when a teacher seems insecure in front of the class.

# Chapter 6

# Conclusion and discussion

The aim of this thesis was to examine the role of the behaviour of math teachers in the developing, worsening or alleviating math anxiety. Both quantitative and qualitative data was gathered via surveys and interviews. The following chapter summarizes the main findings, the limitations of the study and gives recommendations for future research. For a more detailed description of the findings concerning the research questions and hypothesis, see section 5.5.

## 6.1 Main findings

This study confirms that students indicate to feel significantly higher levels of stress when they notice signs of math teaching anxiety amongst their teachers, such as insecurities. This result supports evidence from previous research on this topic, as indicated by [Olson and Stoehr, 2019] and [Peker, 2009], furthermore see section 2.4.

Additionally, this study has found that high school students indicate to feel significantly higher levels of stress when they imagine a scenario in which the teacher seems to believe in the growth mindset by forcing the student to try an exercise again in comparison with a scenario in which the teacher seems to believe in the fixed mindset by stating that some students will remain to have difficulties with math. The effect size of this significant difference is rather small, so the question arises whether this result is relevant. However, the fact that the students did not indicate significantly higher levels of stress to the situation in which the teacher seems to believe in the fixed mindset, is already a result on it's own. Suggestions are made about the reasons for this unexpected result, which seems to be in contrast with earlier research on this topic, as indicated by [Gunderson et al., 2018] and [Bostwick et al., 2020], furthermore see section 2.2. A possible explanation for these results may be the lack of experience students have in handling the exercises themselves. Therefore, it may be the case that students in this scenario focus on the fact that they have to try the exercise without help, instead of focusing on the fact that the teacher seems to believe that the student can solve it without their intervention.

This reasoning is supported by three findings elsewhere in the study. Firstly, a significant difference was found, with moderate effect sizes, between the level of stress students indicate for the teacher showing her growth mindset in this matter and the teacher not showing her mindset in a way that she immediately writes down the answer in the book of the student. The second finding which supports this view origins in a scenario in which the teacher announces to evaluate formative assessment with a formative grade, with lines through mistakes or with hints next to mistakes. It was found that students indicated low levels of anxiety in the last situation. Since the hints could be seen as help from the teacher, this supports the view that students might feel higher levels of stress when they have to solve exercises themselves without help of the teacher. Finally, the last finding supporting this explanation comes from the part of the study focusing on the way a teacher handles mistakes. Apparently, when a teacher focuses negatively on a mistake by concluding, after a few mistakes a student makes, that the student finds mathematics difficult in general, shows the highest level of stress throughout the whole study. This way of handling mistakes shows that the teacher believes in the fixed mindset, since she draws conclusions on the mathematical ability of the student in general. This result is found to be significantly higher with large effect sizes, in comparison with scenarios in which the teacher either focuses in a positive way on the mistake or focuses on the learning goal of the mistake. An implication of this might be that students do feel lower levels of stress when the teacher seems to believe in the growth mindset, but the amount of help the teacher offers to the student is a crucial factor in the ability of the student to experience these lower levels of stress.

## 6.2 Limitations of the study

Some of the results and conclusions made in this thesis need to be interpreted with caution because of certain assumptions that are made.

First of all, conclusions are made about factors in the behaviour of math teachers influencing math anxiety. Even though the theoretical framework contains detailed descriptions of these factors, see chapter 2, it is not proven that the scenarios constructed to test these factors, are a complete representation.

Another note of caution is due considering the qualitative research conducted in the first iteration. This part of the research involved interviews with two students for whom the researcher is also their math teacher. Therefore, it is important to bear in mind that the students might react to the question in a way that they remain loyal to their math teacher. On the other hand, their connection could help them feel comfortable enough to give detailed answers.

As described previously, throughout the thesis, surveys were set out for students to measure their level of stress through certain scenarios. In addition, the last two iterations included questions measuring the occurrence of these scenarios. It was found that some scenarios were uncommon for most of the students and it is therefore unclear whether the students could make a precise indication of the level of stress they would feel in that scenario.

Turning to the most restrictive assumption of this study, which is related to the statistical analysis of the results. The first of these assumption was made concerning the Wilcoxon rank sum test together with the sign test, in that the ties between positive and negative differences do not influence the decision on rejecting the hypothesis. It is apparent from the results of the sign tests shown in the appendix, see section 7, that most comparisons between reactions involve a large amount of ties.
Another assumption was made in the Wilcoxon rank sum test, which is related to the distribution of the rank that was considered to be approximately normally distributed. However, this is a rather strong assumption considering the fact that the ranks only consist of a maximum of 12 different numbers. The last assumption was made with respect to the data used for the statistical tests. The data was ordinal since the students could indicate their level of stress via a seven-item based Likert scale ranging from 'no stress' to 'a lot of stress'. However, in the Wilcoxon rank sum test, this data was interpreted as interval data, assuming that the length between the seven options was equal.

## 6.3 Recommendations

The main question raised by this study was whether it is preferable for teachers to express their growth mindset if students experience higher levels of stress because of the lack of experience they might have in trying to solve exercises by themselves. This would be a fruitful area for further work since math anxiety has large consequences on, for example the math achievement in high school, but also the future career choices, see section 2.1. A natural progression of this work would be to analyse scenarios in which students' experience in handling exercises alone could be compared with their level of stress when a teacher shows her belief in the growth mindset in a way that she forces the students to try to solve exercises themselves. Furthermore, a greater focus on the growth mindset in classrooms could help students to improve their skills in working on exercises themselves, without experiencing math anxiety. Therefore, interventions concerning the growth mindset could be usefully explored in further research.

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# Chapter 7

# Appendix

## 7.1 Open questions first iteration

Table 7.1: First open questions first iteration

| **Look at the situation(s) where you filled in a seven. What are your thoughts in these moment(s)? For example: I can not do it, I am afraid that I will make a mistake, etc.** |
|---|
| ik ben bang dat ik het verpest ookal heb ik goed geleerd ik ga het niet halen, ik ga een 1 halen, ik snap het niet |
| Ik denk dan dat ik het niet kan en ben bang dat het een onvoldoende wordt. |
| Op zulke momenten denk ik van dat dit zeker een onvoldoende wordt. |
| ik denk ik dan dat ik het niet ga kunnen en dat ik een onvoldoende ga halen. |
| Ik kan het niet |
| Ik ben bang dat ik niet weet wat ik moet doen |
| Ik denk dan vooral aan het falen van de toets |
| Ik denk dan gelijk dat ik te weinig weet |
| Ik wil het graag snappen en goed doen. En omdat dan bijv. mijn vader er bij is krijg ik stress want als ik het fout doe wordt hij soort boos. En dan lukken niet eens simpele keersommen mij terwijl ik het antwoord wel weet in mn hoofd maar ik durf het niet te zeggen. |
| Ik ben bang dat ik het verkeerde antwoord geef ik weet niet of ik het goed ga doen |
| Dat ik vergeten ben hoe het moet en dat het niet gaat lukken. |
| Dat ik het niet kan, en dan ben ik ineens alles wat ik heb geleerd vergeten. |
| Ik ben dan bang dat ik verkeerd maak, dus als mn vader ziet dat het niet lukt, als ik in de klas een openbare vraag moet beantwoorden en dat verkeerd zeg, of als ik een onverwacht SO moet maken en niet weet of ik goed genoeg ben voorbereid. |
| Ik ben bij een klassikale vraag bang dat ik een verkeerd antwoord geef en bij een onverwacht S.O. ben ik bang dat ik de stof toch niet snap omdat ik het dan niet nog een keer heb kunnen oefenen en doornemen. |
| Ik denk dan dat ik nog niet goed genoeg heb voorbereid en het dus niet kan. |
| Dit is zo moeilijk hoe ga ik dit ooit morgen goed doen dat ik het niet goed genoeg weet |
| Ik hoop dat ik een voldoende haal |
| Ik ben bang dat ik het fout doe waardoor ik slechter presteer |
| dat ik een goed cijfer voor het onderwerp wil halen en denk dat ik niet genoeg heb geleerd of het onderwerp vaak niet goed begrijp |
| Heb ik wel goed geleerd? |
| ik moet opschieten met leren |
| ik kan het niet, ik ga falen |
| ik denk dat ik het niet kan omdat ik niet goed genoeg heb geleerd |
| Ik wilde even zeggen dat ik een beetje last heb van sociale angst, dus dat zou de uitslag van mijn resultaten misschien beïnvloeden |
| ik ben bang dat ik het ga verpesten, het is toch een kernvak en moet er een goed cijfer voor halen anders worden mn ouders misschien boos |
| Op dat soort momenten ben ik inderdaad bang dat ik het niet kan en dat ik alles fout zal doen. Ik ben bang dat ik alles vergeet. |
| "Wat als ik de opdrachten op de toets niet begrijp..... straks doe ik het fout.....ik ga het nooit halen...." |
| ik ga een 1 halen |
| Waarschijnlijk ik kan het niet |

Table 7.2: First open questions first iteration

| **Look at the situation(s) where you filled in a seven. What do you feel in your body in these moment(s)? For example: a high heart rate, sweaty hands etc.** |
|---|
| nerveus |
| ik voel me dan een beetje misselijk, ik kan niet nadenken, zweethanden |
| Hoge hartslag |
| Ik krijg kortsluiting in mijn hoofd en ik ben begin me te stressen. |
| ik heb het dan vaak heel warm, maar ik zweet niet. |
| het gevoel dat je benen van rubber zijn |
| Een hoge hartslag |
| zweethanden en mn benen trillen |
| Ik denk alleen dan veel na in mijn hoofd |
| zweethanden, hoofdpijn |
| Ik word rood en krijg een snelle hartslag |
| spanning |
| nee |
| Nou dat niet per se, maar in mn hoofd word het 1 grote chaos en ja |
| Hoge hartslag, zweten, twijfelen aan wat ik kan. (Soms ook hoofdpijn en helaas ook wel eens een blackout.) |
| Mijn hart gaat sneller kloppen door de zenuwen |
| hoge hartslag,buikpijn |
| Niet perse iets wat ik merk aan me lichaam ik heb dan gewoon veel stress |
| zweet handen en steen in mijn maag |
| zweethanden |
| Zweet handen, paniek |
| hoger hartslag plus hoofdpijn rond mijn ogen en voorkant bvan mijn hoofd |
| hoge hartslag |
| stress, beetje woede |
| hoge hartslag, tranen in mijn ogen, brok in mijn keel |
| hoofdpijn blackout zweten etc |
| zweet handen, veel hoesten, niet nadenken, tril been maar dat heb ik wel vaker, snel afgeleid |
| Spanning, ik voel het in mijn buik, een hogere hartslag. |
| zweethanden |
| ”hoge hartslag buikpijn ” |
| Zware hartslag, zweethanden, niet helder kunnen nadenken |

## 7.2 Interview with students

Table 7.3: Interview students with English translation (n=2)

| You are not able to complete a difficult exercise during a math lesson. The teacher sees this, walks up to you and | |
|---|---|
| Student M. | Student I. |
| 1) says 'It does not matter, not everyone is good at math' | |
| 'Your confidence does not get better from that.' | 'I can really not do it and that gives stress. I always want to do it right and if people tell that it is not good, I get stressed. I prefer to try with the teacher and that the teacher then says: "See, you can do it". It should not have something to do with the fact whether I am good in mathematics.' |
| 'Je zelfvertrouwen gaat daar niet van omhoog.' | 'Ik kan het dus echt niet, en dat geeft stress. Ik wil het altijd goed doen en als mensen dan aangeven dat het niet goed is, raak ik in de stress. Liever heb ik dat ik samen met een docent het ga proberen en dat de docent dan zegt: zie je wel het lukt wel. Het moet niet iets te maken hebben met of ik goed ben in wiskunde.' |
| 2) says 'Think again' | |
| 'I already looked into the exercise well and thought about it for a second time. I would be frustrated, but I would not become insecure since I know that I would understand it well in the end' | 'If somebody says: think well about it for another time, than the only thing I think is that I have to think very well about it and then I don't think about the exercise itself anymore. I forget what I have to do (I actually forget everything). even if my dad is asking what 6 divided by 3 is, I would respond with 3 because I can do nothing anymore. I cannot think clearly then.' |
| 'Ik heb al goed naar de som gekeken en een tweede keer na gedacht. Ik zou dan gefrustreerd zijn, ik word daar niet onzeker van want ik weet dat ik het uiteindelijk wel goed kan snappen.' | 'Als iemand zegt: denk nog zelf een keer goed na, dan denk ik alleen maar: ik moet nu heel goed nadenken en dan denk ik niet meer aan de som zelf. Dan vergeet ik wat ik moet doen (eigenlijk vergeet is alles). Zelfs als mijn vader dan vraagt wat 6/3 is, zou ik dan met 3 reageren omdat dan eigenlijk niks meer lukt. Ik kan niet meer helder nadenken.' |

| You are not able to complete a difficult exercise during a math lesson.<br>The teacher sees this, walks up to you and | |
|---|---|
| Student M. | Student I. |
| 3) writes down the good answer in your exercise book. | |
| 'I would think about the exam that I would not know it by myself then.' | 'This is only nice if I get the explanation afterwards and know what I did 'wrong'. Than I know what steps I have to take. I like it when I have the steps in my head, because if I get stuck in an exam because I have stress for example, than I can still fall back to the steps. Sometimes I also forget the steps. If I start and I am not able to do it, I get stress and than nothing works out anymore and I give up.' |
| 'Ik zou dan denken aan de toets dat ik het dan zelf niet zou weten.' | 'Alleen fijn als ik achteraf wel uitleg krijg en weet wat ik 'verkeerd' heb gedaan. Dat ik dan weet welke stappen ik moet zetten. Ik vind het fijn als ik stappen in mijn hoofd heb, want als ik dan bijvoorbeeld bij een toets vastloopt omdat ik stress heb, kan ik proberen terug te vallen op de stappen. Soms vergeet ik dan ook de stappen zelf. Als ik begin en het lukt niet, dan krijg ik stress en dan lukt het niet meer en geef ik uiteindelijk op.' |
| During math lesson you receive your grade for a small exam. You failed the exam.<br>The teacher hands out the exam and says: 'What a shame that you failed the exam'.<br>After that the teacher says: | |
| 1) 'I expected this since you are not so good in mathematics' | |
| 'This is mean. It is not nice because it does not motivate the student.' | 'I would find this very painful. Even though I am not able to do it, I did do my best. If a teacher says that he/she expected this, then he/she says that before he/she knows whether I did my best or not. If they realise I can do it, but that it just did not work out, then it would be less of a disappointment. It is really annoying that in an exam I am not able to show what I can do. |
| Dit is gemeen. Het is niet aardig want het motiveert niet echt voor de leerling. | Heel pijnlijk zou ik dat vinden. Ook al kan ik het niet, ik heb wel mijn best gedaan. Als een docent zegt: ik had dat verwacht, dan zegt hij/zij dat voordat ze weet of ik wel mijn best heb gedaan. Als ze wel realiseren dat ik het kan, maar dat het dan niet lukte, dan is het minder een soort van teleurstelling. Het is echt vervelend dat ik precies bij een toets niet kan laten zien wat ik kan. |

| | |
|---|---|
| During math lesson you receive your grade for a small exam. You failed the exam.<br>The teacher hands out the exam and says: 'What a shame that you failed the exam'.<br>After that the teacher says: | |
| Student M. | Student I. |
| 2) 'I did not expect this because normally you are so good in mathematics' | |
| 'Then I would think that there is an expectation and you have to show that of again. Therefore this would give me a little stress.' | 'It is a shame, but this is less frustrating because it does not go well in one try and in the previous reaction it happens more often.' |
| 'Dan zou ik denken dat er een verwachting is en dat moet je dan weer laten zien. Het zou daarom wel een beetje stress geven.' | 'Het is jammer, maar dit is minder frustrerend want nu gaat het maar één keer niet goed en bij de bovenstaande gebeurt het vaker.' |
| 3) 'You did not do this exam well' | |
| 'I already know that I failed the exam so the teacher does not have to repeat that. It is the reality so you don't have to say that again.' | 'It is the way it is, but still I don't like it and I don't want to accept it. That is why I still chose a 6. In this moment I still find it stupid and annoying so if you get a reaction from the teacher, it is difficult to deal with that.' |
| 'Ik weet al dat ik het slecht heb gemaakt dus dat hoeft de docent dan niet nog te zeggen. Dat is de realiteit dus dat hoef je niet nog een keer te zeggen.' | 'Het is gewoon zo, maar alsnog vind ik het niet leuk en het niet wil accepteren. Daarom heb ik een 6 ingevuld. Ik vind het op dit moment nog heel stom en vervelend dus als je dan een reactie krijgt van de docent, is het nog moeilijk om daarmee om te gaan.' |
| The teacher hands out a form with a few exercises everyone in the classroom has to solve.<br>Before you start with the form, the teacher tells the class what he/she will do with the form afterwards.<br>The teacher says: | |
| 1) 'I will check the form and you will get a grade which will not be part of your final grade' | |
| 'It will give extra stress if the teacher gives a grade which is connected to the exercise form. Then I think about what my parents think about my grade. If the teacher does not put it on Magister, I might less because then I can check how well I understand everything and then my parents will not get disappointed.' | 'The grade will not be part of my final grade so it does not matter and I can see what mistakes I made.' |
| 'Als de docent een cijfer vastzet aan het werkblad dan geeft dat wel extra stress. Dan denk ik aan wat mijn ouders daarvan vinden. Als de docent het cijfer niet op magister zet, vind ik het minder erg want dan kan ik zien hoe goed ik het al begrijp en dan raken mijn ouders niet teleurgesteld.' | 'Het telt niet mee dus het maakt niet uit dat ik een fout maak en ik kan zien wat voor een fout ik heb gemaakt.' |

| | |
|---|---|
| The teacher hands out a form with a few exercises everyone in the classroom has to solve.<br>Before you start with the form, the teacher tells the class what he/she will do with the form afterwards.<br>The teacher says: | |
| Student M. | Student I. |
| 2) 'I will check the form and I will draw lines through the mistakes you made' | |
| 'Hier is geen cijfer aan vastgebonden en dat is fijner. Dan kan ik beter kijken wat ik fout heb gedaan.' | 'Als ze het onderstreept of uitlegt waarom het fout is, dan is dat beter. Dan is het niet fout en er wordt niks aan gedaan. Nu kan je het nog anders doen. En dan weet ik dat als ik een andere som tegenkom wat ik moet doen.' |
| 'There is no grade connected to this so that is more pleasant. Then I can better check what I did wrongly.' | 'If she draws lines or explains why it is wrong, than that is better. Then it is not wrong and nothing will be done. Now I can still do it differently. And then I know that when I come across another exercise I know what to do.' |
| 3) 'I will check the form and write down hints next to certain exercises' | |
| 'I think that is good, because you get feedback on the mistakes you made. I would find it irritating if I would still do not understand it.' | 'With hints you still don't know precisely if it helps because after hints you are sometimes still not able to do it or you think to much about it. Hints can be pleasant if you really end up with the good answer in the and or that you understand it after extra explanation. If that does not happen, I would get irritated that I still do not understand it.' |
| 'Dat vind ik alleen maar goed, want dan krijg je feedback over wat je fout hebt gedaan. Ik zou het wel irritant vinden als ik het dan nog steeds niet snap.' | 'Bij hints weet je nog steeds niet precies of het helpt want de hints kunnen ervoor zorgen dat het nog steeds niet lukt of dat ik juist te ver ga nadenken. Hints kunnen fijn zijn als je daarna ook wel op het antwoord komt of dat het nog in de uitleg komt. Als dat niet gebeurt, zou ik geirriteerd raken dat ik het nog steeds niet snap.' |
| The teacher is giving a trial exam during the lesson.<br>You will not get a grade for the trial exam but the exam will be checked by the teacher.<br>You ask the teacher why you have to participate in this trial exam. The teacher says: | |
| 1) 'I would like to know how well you understand everything' | |
| 'During some courses I don't pay a lot of attention and then the teacher knows that I still don't know it well enough. During some courses it is also difficult to pay attention, but with mathematics I don't have that, because I chose that course. I also have a feeling the teacher then has a opinion about me.' | Then I would think whether I understand it well or not. Then I want to do it right. For myself I would like to understand it, because I have motivation for school. After the trial exam this feeling will still be in the background a bit but then in the end I can still let it go. I don't stay with that feeling. But sometimes it comes back a little bit. |
| 'Bij sommige vakken let ik niet zo goed op en dan weet de docent dat ik het nog niet echt doorheb. Bij sommige vakken is het ook lastig om op te letten, maar bij wiskunde heb ik dat niet, want dat vak heb ik ook gekozen. Ik heb dan ook het gevoel dat de docent een mening over mij heeft.' | 'Dan ga ik nadenken of ik het wel begrijp of niet. Dan wil ik het goed doen. Voor mezelf wil ik het ook snappen, doordat ik voor school wel motivatie heb. Na de oefentoets zit dit gevoel nog een beetje op de achtergrond maar dan kan ik het ook wel een beetje laten gaan. Ik blijf niet in het gevoel zitten. Maar het komt soms wel een beetje terug.' |

| | |
|---|---|
| The teacher is giving a trial exam during the lesson.<br>You will not get a grade for the trial exam but the exam will be checked by the teacher.<br>You ask the teacher why you have to participate in this trial exam. The teacher says: | |
| Student M. | Student I. |
| 2) 'Then you can see for yourself how well you understand everything' | |
| 'In that case you can still see well where your attention should go to. The amount of stress this gives me, depends on how well I did the trial exam. If I did not do it well, then I still have to do a lot.' | 'I already make it easier for myself then. What I did well and didn't do well stays less in my head. The teacher knows better what is wrong and I know that less, so I actually don't know what I do understand and what I don't. It is less stressful but that is not in particular better because I know less about how well I understand it.' |
| 'Dan kan je nog goed zien waar je aandacht aan moet besteden. Hoeveel stress ik daarvan krijg, hangt ervan af hoe goed ik het heb gemaakt. Als ik het niet goed heb gemaakt, dan moet ik nog heel veel doen.' | 'Ik maak het voor mezelf dan al weer makkelijker. Het blijf minder in mijn hoofd hangen wat ik wel en niet goed doe. De docent weet beter wat fout is en ik weet dat minder, dus ik weet eigenlijk niet zo goed wat ik nou wel en wat nou niet begrijp. Het is daarom minder stressvol, maar dat is niet perse beter want dan weet ik minder over hoeveel ik begrijp.' |
| 3) 'You can learn from it' | |
| 'There is not much difference in comparison to the previous, because also in this situation you can find out whether you understand something well and if you still have to do a lot.' | 'I am not sure what so that gives me a bit stress.' |
| 'Niet zo veel verschil met de vorige, want ook hier komt je erachter of je iets goed begrijpt en of je nog veel moet doen.' | 'Ik weet niet zo goed wat dus dat geeft me dan een klein beetje stress.' |
| During math lesson the teacher explains a subject in front of the class and the subject is difficult for you.<br>You: | |
| 1) notice that the teacher herself finds the subject difficult | |
| 'I get stress because that is then apparently a difficult subject and I do not know whether I will understand it at well.' | 'It gives me stress to see that the teacher also does not know exactly what to do. Then it is more difficult to see what I have to do since it probably will become more chaotic. Then I still not know what to do.' |
| 'Ik krijg stress want dat is dan blijkbaar een lastig onderwerp en dan weet ik niet of ik het ook ga begrijpen.' | 'Het geeft mij stress om te zien dat de docent ook niet precies weet wat hij moet doen. Dan is het moeilijker om te zien wat ik moet doen omdat het dan waarschijnlijk wat chaotischer is. Dan weet ik nog steeds niet wat ik moet doen.' |

| During math lesson the teacher explains a subject in front of the class and the subject is difficult for you. You: | |
|---|---|
| Student M. | Student I. |
| 2) notice that the teacher herself finds the subject very easy | |
| 'Then I feel the pressure because then I have the feeling that I might also find it easy and then the teacher also goes through the material faster.' | 'That gives a good feeling, they understand it and they can give explanations. I still have a little stress, because I still find it difficult myself.' |
| 'Dan voel ik druk want dan heb ik het gevoel dat ik het ook makkelijk moet vinden en dan gaat de docent ook vaak snel door de stof heen.' | 'Dat geeft een fijn gevoel, dan snappen ze het en kunnen ze uitleg geven. Ik heb dan nog steeds een beetje stress, want ik vind het zelf alsnog wel moeilijk.' |
| 3) do not know whether the teacher finds the subject difficult or easy. | |
| 'Dat is niet erg, dan is het neutraal en kan je zelf je mening erover vormen.' | 'Vergelijkbaar met hierboven. Daarnaast is ook niet elke les hetzelfde, sommige onderwerpen of uitleg kan ik wel goed volgen en dan gaat het huiswerk ook soepel.' |
| 'That is not that bad, because than it is neutral and you can form your own opinion.' | 'Comparable with the previous one. Furthermore, it is not every lesson the same, some subjects or explanations I can follow and then the homework goes easier as well.' |
| The teacher makes a mistake on the board during math lesson. The teacher | |
| 1) pretends that she did not make a mistake | |
| 'If kids do not find out, they will learn it in a wrong way. Then I think: why do you do this, now everyone is learning the wrong way. I get extra stress from that.' | 'That is irritating. It is very weird, because everyone makes mistakes. Sometimes it gives a good feeling if I understand something and I find out that there is a mistake made. Stress is not so much, I just find it weird.' |
| 'Als leerlingen het niet doorhebben, leren leerlingen het ook fout. Ik denk dan: waarom doet u dat zo, nu leert u het ons verkeerd aan. Ik krijg er geen extra stress van.' | 'Dat is irritant. Het is heel apart, want iedereen maakt fouten. Het geeft soms juist een goed gevoel als ik het snap en ik ontdek dat er een fout wordt gemaakt. Stress valt mee, ik vind het vooral een beetje gek.' |
| 2) corrects her mistake and becomes nervous in front of the class | |
| 'Students become nervous of that and then they wonder if they do it well themselves.' | 'I do understand that teachers find that difficult but I don't get extra stress from that. The mistake has been recovered. Therefore it is clear now.' |
| 'Leerlingen worden daar ook zenuwachtig worden en dan vragen ze zich ook af of ze het goed doen.' | 'Ik snap wel dat de docent dat moeilijk vinden, maar ik krijg daar niet extra stress van. De fout is verbetert. Daardoor is het wel duidelijk.' |
| 3) corrects her mistake and continues in the same way she did before the mistake. | |
| 'No stress here because everyone makes mistakes sometimes.' | 'The mistake is recovered and after that is it good again. So not really stress.' |
| 'Hier totaal geen stress want iedereen maakt wel foutjes.' | 'Fout is verbeterd en daarna is het wel weer fijn. Dus niet echt stress.' |

| During math lesson you are working on homework exercises.<br>The teacher walks besides you and sees you made a few mistakes. She says: | |
|---|---|
| Student M. | Student I. |
| 1) 'Good that you made mistakes, because that means that you learned something' (focus on learning) | |
| 'I don't mind, because this is meant positively.' | 'Nice because that is a positive way to say it. In general in other stuff in my life when I feel stress and other people are calming me down, which is nice.' |
| 'Niet heel erg, want dit is positief gezien.' | 'Fijn dat is een positieve manier om het te zeggen. In het algemeen in andere dingen in mijn leven als ik stress heb en andere stellen mij gerust dan is dat fijn.' |
| 2)'Do not worry, there are a few questions you did well' (positive focus on mistakes) | |
| 'This one is negative, while it should be positive. The teacher thinks I only have a few good answers so not a lot. Then I still have not mastered it.' | 'It depends on how they formulate it. A few questions means that I did a lot of other questions wrongly and then I will think about that and that gives a little bit more stress. I want to do it well for myself and the teacher thinks that there is a lot which I did not do good. The opinion of people around me plays a small role but mostly my own opinion.' |
| 'Deze is negatief, terwijl het positief moet zijn. Ik heb er maar een paar goed volgens de docent dus een heleboel ook niet. Dan heb ik het nog niet onder de knie.' | 'Het ligt eraan hoe ze het formuleren. Een paar vragen betekent dat ik veel vragen niet goed heb gedaan en dan ga ik daarover nadenken en dat geeft iets meer stress. Ik wil het voor mezelf goed doen en volgens de docent heb ik dan veel niet goed gedaan. De mening van mensen om me heen speelt een beetje mee maar vooral ikzelf.' |
| 3) 'I can see you have difficulties with math, since you make a lot of mistakes'. (negative focus on mistakes) | |
| 'Not really, positive because then your teacher would help you with that. The teacher sees that you have difficulties with it.' | 'Then they base that on my mistakes while that does not have to be that way always. The difficulties are mostly due to thinking to much and then not understanding the material. I can always ask classmates or family, it is not always caused by me not understanding it.' |
| 'Niet heel erg, positief want dan zou je docent je daar wel mee helpen. De docent ziet dat je er moeite mee hebt.' | 'Dan baseren ze dat op mijn fouten terwijl dat hoeft niet altijd zo te zijn. De moeite ligt vooral bij het teveel nadenken dan dat ik de stof niet snap. Ik kan het altijd vragen aan klasgenoten of aan familie, het ligt er niet altijd aan dat ik het niet snap.' |

| During an explanation of the teacher in front of the class the teacher asks a question which you answer wrongly. The teacher says that the answer is wrong. Next, the teacher | |
|---|---|
| Student M. | Student I. |
| 1) asks another students who knows the right answer | |
| 'In general I am startled if I am chosen to answer the question. All of a sudden I don't remember anything we where discussing. I get stress (shortly) when I am chosen. After that I do remember it. Also when another student gets the turn, I think: this I knew. In an exam I actually have that too but than it is more spread out over the exam. So a little longer and not much in a short period.' | 'Now another student knows it and than I get the feeling that I should have known it as well. Than I think: this is pretty stupid of me because afterwards I think I should/could have known it.' |
| 'In het algemeen schrik ik als ik de beurt krijg. Ineens heb ik dan geen idee meer waar we het over hadden. Ik krijg ineens stress (kort) als ik de beurt krijg. Daarna wist ik het eigenlijk wel gewoon. Ook als een andere leerling dan soms de beurt krijgt, denk ik: dat wist ik gewoon. In een toets heb ik dat eigenlijk ook maar dan is het meer verpreid over de toets. Dus iets langer en niet heel veel in korte tijd.' | 'Nu weet een andere klasgenoot het wel en dan heb ik het gevoel dat ik dat eigenlijk ook had moeten weten. Dan denk ik: best wel een beetje dom van mij want achteraf denk ik dat had ik kunnen/moeten weten.' |
| 2) tells the right answer | |
| | 'Not really bad because here I don't feel as stupid.' |
| | 'Niet heel erg want ik voel me hier niet zo dom' |
| 3) gives an hint so that you can give the right answer yourself. | |
| | 'Not really bad, since I did it myself and I have learned something new.' |
| | 'Niet heel erg, want ik heb het dan alsnog zelf gedaan en ik heb weer iets nieuws geleerd.' |

## 7.3 Statistical tests second iteration

In this section the statistical results of the second iteration are shown.

Table 7.4: Category growth mindset situation 1 results Wilcoxon rang sum test ($n = 888$) and sign test. Effect size for Wilcoxon rang sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade. Some comparisons are left out because of their large amount of ties.

| Group | $n$ | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|---|
| $H_0$ : median 1.1 equals median 1.2 | | | | | | |
| 1st grade | 251 | −6.844 | < 0.001 | −0.432 | 31 | 74.5 |
| 2nd grade | 177 | −4.643 | < 0.001 | −0.348 | 30 | 53 |
| 3th grade | 187 | −1.893 | 0.058 | −0.138 | 46 | 60.5 |
| 4th grade | 172 | −1.871 | 0.016 | −0.143 | 43 | 55.5 |
| 5th grade | 100 | −1.828 | 0.068 | −0.183 | 22 | 29.5 |
| Female | 384 | −6.382 | < 0.001 | −0.326 | 76 | 134 |
| Male | 455 | −4.536 | < 0.001 | −0.212 | 86 | 124.5 |
| Other | 24 | – | – | – | 3 | 6 |
| Rather not tell | 25 | – | – | – | 7 | 8.5 |
| Vwo | 618 | −5.511 | < 0.001 | −0.222 | 136 | 194.5 |
| Havovwo | 143 | −5.533 | < 0.001 | −0.463 | 12 | 40.5 |
| Havo 11 | 127 | −3.182 | 0.001 | −0.282 | 24 | 38 |
| Overall | 888 | −8.010 | < 0.001 | −0.269 | 173 | 273 |
| $H_0$ : median 1.2 equals median 1.3 | | | | | | |
| 1st grade | 251 | −9.405 | < 0.001 | −0.594 | 156 | 89 |
| 2nd grade | 177 | −7.673 | < 0.001 | −0.577 | 97 | 53.5 |
| 3th grade | 187 | −9.405 | < 0.001 | −0.625 | 114 | 61.5 |
| 4th grade | 172 | −8.550 | < 0.001 | −0.658 | 116 | 62.5 |
| 5th grade | 100 | −6.877 | < 0.001 | −0.688 | 68 | 37 |
| Female | 384 | −13.318 | < 0.001 | −0.516 | 215 | 129 |
| Male | 455 | −12.001 | < 0.001 | −0.379 | 186 | 1195 |
| Other | 24 | – | – | – | 10 | 6 |
| Rather not tell | 25 | – | – | – | 14 | 8 |
| Vwo | 618 | −15.111 | < 0.001 | −0.452 | 308 | 191.5 |
| Havovwo | 143 | −7.592 | < 0.001 | −0.385 | 58 | 37 |
| Havo | 127 | −7.632 | < 0.001 | −0.550 | 59 | 33.5 |
| Overall | 888 | −18.475 | < 0.001 | −0.620 | 551 | 303.5 |
| $H_0$ : median 1.1 equals median 1.3 | | | | | | |
| 1st grade | 251 | −4.565 | < 0.001 | −0.288 | 103 | 72 |
| 2nd grade | 177 | −4.283 | < 0.001 | −0.322 | 68 | 44.5 |
| 3th grade | 187 | −7.612 | < 0.001 | −0.557 | 96 | 56.5 |
| 4th grade | 172 | −7.964 | < 0.001 | −0.607 | 102 | 57 |
| 5th grade | 100 | −5.615 | < 0.001 | −0.561 | 56 | 32 |
| Female | 384 | −10.105 | < 0.001 | −0.680 | 280 | 152.5 |
| Male | 455 | −8.086 | < 0.001 | −0.563 | 243 | 135.5 |
| Other | 24 | – | – | – | 15 | 8 |
| Rather not tell | 25 | – | – | – | 13 | 7.5 |
| Vwo | 618 | −11.237 | < 0.001 | −0.608 | 385 | 214.5 |
| Havovwo | 143 | −4.603 | < 0.001 | −0.635 | 90 | 50 |
| Havo | 127 | −6.198 | < 0.001 | −0.677 | 76 | 39 |
| Overall | 888 | −13.507 | < 0.001 | −0.453 | 425 | 262 |

Table 7.5: Category growth mindset situation 2 results Wilcoxon rang sum test ($n = 888$) and sign test. Effect size for Wilcoxon rang sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade. Some comparisons are left out because of their large amount of ties.

| Group | $n$ | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|---|
| $H_0$ : median 2.1 equals median 2.2 | | | | | | |
| 1st grade | 251 | −0.236 | 0.814 | −0.015 | 81 | 88 |
| 2nd grade | 177 | −3.053 | 0.002 | −0.229 | 72 | 61.5 |
| 3th grade | 187 | −2.567 | 0.010 | −0.188 | 66 | 56.5 |
| 4th grade | 172 | −0.645 | 0.519 | −0.049 | 55 | 62.5 |
| 5th grade | 100 | −1.940 | 0.052 | −0.194 | 42 | 37 |
| Female | 384 | −1.929 | 0.054 | −0.098 | 134 | 131.5 |
| Male | 455 | −2.542 | 0.011 | −0.119 | 165 | 155.5 |
| Other | 24 | – | – | – | 10 | 8.5 |
| Rather not tell | 25 | – | – | – | 7 | 10 |
| Vwo | 618 | −2.477 | 0.013 | −0.100 | 221 | 217.5 |
| Havovwo | 143 | −0.955 | 0.339 | −0.080 | 45 | 44.5 |
| Havo | 127 | −1.561 | 0.119 | −0.138 | 50 | 43.5 |
| Overall | 888 | −3.078 | 0.002 | −0.103 | 316 | 305.5 |
| $H_0$ : median 2.2 equals median 2.3 | | | | | | |
| 1st grade | 251 | −5.147 | $< 0.001$ | −0.325 | 49 | 82 |
| 2nd grade | 177 | −4.619 | $< 0.001$ | −0.347 | 27 | 56 |
| 3th grade | 187 | −3.366 | 0.001 | −0.246 | 38 | 58 |
| 4th grade | 172 | −0.313 | 0.754 | −0.024 | 58 | 57.5 |
| 5th grade | 100 | −3.386 | 0.001 | −0.339 | 20 | 34.5 |
| Female | 384 | −3.889 | $< 0.001$ | −0.198 | 92 | 124.5 |
| Male | 455 | −6.902 | $< 0.001$ | −0.324 | 87 | 146.5 |
| Other | 24 | – | – | – | 6 | 9 |
| Rather not tell | 25 | – | – | – | 7 | 8.5 |
| Vwo | 618 | −5.337 | $< 0.001$ | −0.215 | 143 | 199 |
| Havovwo | 143 | −4.854 | $< 0.001$ | −0.406 | 22 | 45.5 |
| Havo | 127 | −3.369 | 0.001 | −0.299 | 27 | 44 |
| Overall | 888 | −7.711 | $< 0.001$ | −0.259 | 192 | 288.5 |
| $H_0$ : median 2.1 equals median 2.3 | | | | | | |
| 1st grade | 251 | −4.260 | $< 0.001$ | −0.269 | 59 | 87 |
| 2nd grade | 177 | −1.760 | 0.078 | −0.132 | 50 | 61 |
| 3th grade | 187 | −0.501 | 0.616 | −0.037 | 51 | 57 |
| 4th grade | 172 | −0.871 | 0.384 | −0.066 | 58 | 58.5 |
| 5th grade | 100 | −1.664 | 0.096 | −0.166 | 26 | 35.5 |
| Female | 384 | −1.689 | 0.091 | −0.198 | 111 | 131.5 |
| Male | 455 | −4.147 | $< 0.001$ | −0.324 | 119 | 151.5 |
| Other | 24 | – | – | – | 9 | 7.5 |
| Rather not tell | 25 | – | – | – | 5 | 9 |
| Vwo | 618 | −2.401 | 0.016 | −0.215 | 182 | 208.5 |
| Havovwo | 143 | −3.895 | $< 0.001$ | −0.406 | 31 | 49 |
| Havo | 127 | −2.184 | 0.029 | −0.299 | 31 | 42 |
| Overall | 888 | −4.447 | $< 0.001$ | −0.149 | 244 | 299.5 |

Table 7.6: Performance goal and learning goal situation 1 results Wilcoxon rang sum test ($n = 888$) and sign test. Effect size for Wilcoxon rang sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade. Some comparisons are left out because of their large amount of ties.

| Group | $n$ | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|---|
| $H_0$ : median 1.1 equals median 1.2 | | | | | | |
| 1st grade | 251 | $-1.753$ | 0.080 | $-0.111$ | 52 | 62.5 |
| 2nd grade | 177 | $-0.284$ | 0.776 | $-0.021$ | 40 | 39.0 |
| 3th grade | 187 | $-2.865$ | 0.004 | $-0.210$ | 58 | 45.0 |
| 4th grade | 172 | $-0.964$ | 0.335 | $-0.074$ | 43 | 40.0 |
| 5th grade | 100 | – | – | – | 23 | 22.0 |
| Female | 384 | $-2.250$ | 0.024 | $-0.115$ | 119 | 103.5 |
| Male | 455 | $-1.051$ | 0.293 | $-0.049$ | 85 | 91.0 |
| Other | 24 | – | – | – | 5 | 6.5 |
| Rather not tell | 25 | – | – | – | 7 | 7.5 |
| Vwo | 618 | $-2.051$ | 0.040 | $-0.082$ | 158 | 142.5 |
| Havovwo | 143 | $-2.175$ | 0.030 | $-0.182$ | 27 | 38.0 |
| Havo 11 | 127 | $-0.571$ | 0.568 | $-0.051$ | 31 | 28.0 |
| Overall | 888 | $-0.885$ | 0.376 | $-0.030$ | 216 | 208.5 |
| $H_0$ : median 1.2 equals median 1.3 | | | | | | |
| 1st grade | 251 | $-6.133$ | $< 0.001$ | $-0.387$ | 80 | 49.0 |
| 2nd grade | 177 | $-7.189$ | $< 0.001$ | $-0.540$ | 71 | 38.0 |
| 3th grade | 187 | $-5.751$ | $< 0.001$ | $-0.421$ | 60 | 35.5 |
| 4th grade | 172 | $-6.563$ | $< 0.001$ | $-0.500$ | 73 | 41.0 |
| 5th grade | 100 | – | – | – | 36 | 21.5 |
| Female | 384 | $-9.399$ | $< 0.001$ | $-0.480$ | 169 | 98.5 |
| Male | 455 | $-8.606$ | $< 0.001$ | $-0.403$ | 131 | 75.0 |
| Other | 24 | – | – | – | 9 | 5.0 |
| Rather not tell | 25 | – | – | – | 11 | 6.5 |
| Vwo | 618 | $-11.589$ | $< 0.001$ | $-0.466$ | 231 | 130.5 |
| Havovwo | 143 | $-4.560$ | $< 0.001$ | $-0.381$ | 48 | 29.5 |
| Havo | 127 | $-4.451$ | $< 0.001$ | $-0.395$ | 41 | 25.0 |
| Overall | 888 | $-13.200$ | $< 0.001$ | $-0.443$ | 320 | 185.0 |
| $H_0$ : median 1.1 equals median 1.3 | | | | | | |
| 1st grade | 251 | $-3.292$ | 0.001 | $-0.208$ | 74 | 56.5 |
| 2nd grade | 177 | $-5.688$ | $< 0.001$ | $-0.428$ | 66 | 41.0 |
| 3th grade | 187 | $-6.241$ | $< 0.001$ | $-0.456$ | 77 | 47.0 |
| 4th grade | 172 | $-5.928$ | $< 0.001$ | $-0.452$ | 69 | 41.0 |
| 5th grade | 100 | – | – | – | 34 | 24.5 |
| Female | 384 | $-8.951$ | $< 0.001$ | $-0.457$ | 182 | 111.0 |
| Male | 455 | $-5.701$ | $< 0.001$ | $-0.267$ | 121 | 87.0 |
| Other | 24 | – | – | – | 8 | 6.0 |
| Rather not tell | 25 | – | – | – | 9 | 6.0 |
| Vwo | 618 | $-10.536$ | $< 0.001$ | $-0.424$ | 236 | 145.0 |
| Havovwo | 143 | $-1.342$ | 0.180 | $-0.112$ | 42 | 36.5 |
| Havo | 127 | $-3.792$ | $< 0.001$ | $-0.336$ | 42 | 28.5 |
| Overall | 888 | $-10.745$ | $< 0.001$ | $-0.361$ | 320 | 210.0 |

Table 7.7: Category performance goal and learning goal situation 2 results Wilcoxon rang sum test ($n = 888$) and sign test. Effect size for Wilcoxon rang sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade. Some comparisons are left out because of their large amount of ties.

| Group | $n$ | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|---|
| $H_0$ : median 2.1 equals median 2.2 | | | | | | |
| 1st grade | 251 | −6.033 | $< 0.001$ | −0.381 | 88 | 55.0 |
| 2nd grade | 177 | −4.482 | $< 0.001$ | −0.337 | 50 | 30.0 |
| 3th grade | 187 | −4.850 | $< 0.001$ | −0.355 | 66 | 40.5 |
| 4th grade | 172 | −2.772 | 0.006 | −0.211 | 53 | 41.0 |
| 5th grade | 100 | −3.798 | $< 0.001$ | −0.380 | 43 | 27.0 |
| Female | 384 | −7.740 | $< 0.001$ | −0.395 | 158 | 98.5 |
| Male | 455 | −6.408 | $< 0.001$ | −0.300 | 129 | 84.5 |
| Other | 24 | – | – | – | 4 | 4.0 |
| Rather not tell | 25 | – | – | – | 9 | 6.5 |
| Vwo | 618 | −8.543 | $< 0.001$ | −0.344 | 212 | 135.5 |
| Havovwo | 143 | −3.850 | $< 0.001$ | −0.322 | 50 | 34.5 |
| Havo | 127 | – | – | – | 38 | 23.5 |
| Overall | 888 | −9.954 | $< 0.001$ | −0.334 | 300 | 193.5 |
| $H_0$ : median 2.2 equals median 2.3 | | | | | | |
| 1st grade | 251 | −2.403 | 0.016 | −0.152 | 33 | 45.5 |
| 2nd grade | 177 | −0.107 | 0.915 | −0.008 | 32 | 33.0 |
| 3th grade | 187 | −0.725 | 0.468 | −0.053 | 29 | 30.0 |
| 4th grade | 172 | −1.814 | 0.070 | −0.138 | 37 | 31.0 |
| 5th grade | 100 | – | – | – | 13 | 15.0 |
| Female | 384 | −1.049 | 0.294 | −0.054 | 72 | 80.0 |
| Male | 455 | −0.657 | 0.511 | −0.031 | 60 | 62.5 |
| Other | 24 | – | – | – | 4 | 4.5 |
| Rather not tell | 25 | – | – | – | 8 | 7.5 |
| Vwo | 618 | −0.210 | 0.834 | −0.008 | 107 | 108.5 |
| Havovwo | 143 | −0.967 | 0.333 | −0.081 | 23 | 27.5 |
| Havo | 127 | – | – | – | 14 | 18.5 |
| Overall | 888 | −0.955 | 0.340 | −0.032 | 144 | 154.5 |
| $H_0$ : median 2.1 equals median 2.3 | | | | | | |
| 1st grade | 251 | −3.030 | 0.002 | −0.191 | 81 | 62.0 |
| 2nd grade | 177 | −4.025 | $< 0.001$ | −0.303 | 57 | 38.0 |
| 3th grade | 187 | −3.988 | $< 0.001$ | −0.292 | 64 | 45.0 |
| 4th grade | 172 | −4.132 | $< 0.001$ | −0.315 | 55 | 38.0 |
| 5th grade | 100 | −3.509 | $< 0.001$ | −0.351 | 43 | 27.5 |
| Female | 384 | −6.382 | $< 0.001$ | −0.326 | 157 | 106.5 |
| Male | 455 | −4.987 | $< 0.001$ | −0.234 | 128 | 92.0 |
| Other | 24 | – | – | – | 6 | 5.5 |
| Rather not tell | 25 | – | – | – | 9 | 6.5 |
| Vwo | 618 | −7.738 | $< 0.001$ | −0.311 | 215 | 145.0 |
| Havovwo | 143 | −2.371 | 0.018 | −0.198 | 51 | 40.0 |
| Havo | 127 | −2.339 | 0.019 | −0.208 | 34 | 25.5 |
| Overall | 888 | −8.166 | $< 0.001$ | −0.274 | 300 | 210.5 |

Table 7.8: Mathematics teaching anxiety situation 1 results Wilcoxon rang sum test ($n = 888$) and sign test. Effect size for Wilcoxon rang sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade. Some comparisons are left out because of their large amount of ties.

| Group | $n$ | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|---|
| $H_0$ : median 1.1 equals median 1.2 | | | | | | |
| 1st grade | 251 | −4.580 | < 0.001 | −0.289 | 127 | 92.5 |
| 2nd grade | 177 | −5.576 | < 0.001 | −0.419 | 92 | 60.0 |
| 3th grade | 187 | −4.822 | < 0.001 | −0.353 | 105 | 72.0 |
| 4th grade | 172 | −5.850 | < 0.001 | −0.446 | 101 | 65.5 |
| 5th grade | 100 | −5.285 | < 0.001 | −0.528 | 67 | 43.0 |
| Female | 384 | −6.517 | < 0.001 | −0.333 | 220 | 155.5 |
| Male | 455 | −9.453 | < 0.001 | −0.443 | 246 | 159.5 |
| Other | 24 | – | – | – | 12 | 8.0 |
| Rather not tell | 25 | – | – | – | 14 | 10.0 |
| Vwo | 618 | −9.676 | < 0.001 | −0.389 | 353 | 239.0 |
| Havovwo | 143 | −3.361 | 0.001 | −0.281 | 67 | 47.5 |
| Havo | 127 | −5.590 | < 0.001 | −0.496 | 72 | 46.5 |
| Overall | 888 | −11.576 | < 0.001 | −0.388 | 492 | 333.0 |
| $H_0$ : median 1.2 equals median 1.3 | | | | | | |
| 1st grade | 251 | −0.379 | 0.705 | −0.024 | 63 | 64.0 |
| 2nd grade | 177 | −1.389 | 0.165 | −0.104 | 32 | 42.0 |
| 3th grade | 187 | −0.342 | 0.733 | −0.025 | 46 | 48.5 |
| 4th grade | 172 | −1.537 | 0.124 | −0.117 | 43 | 50.0 |
| 5th grade | 100 | −1.127 | 0.260 | −0.113 | 20 | 30.0 |
| Female | 384 | −0.286 | 0.775 | −0.015 | 110 | 115.0 |
| Male | 455 | −2.224 | 0.026 | −0.104 | 82 | 105.0 |
| Other | 24 | – | – | – | 6 | 7.0 |
| Rather not tell | 25 | – | – | – | 6 | 7.5 |
| Vwo | 618 | −0.040 | 0.968 | −0.002 | 152 | 165.0 |
| Havovwo | 143 | −0.158 | 0.874 | −0.013 | 32 | 32.5 |
| Havo | 127 | −3.273 | 0.001 | −0.290 | 20 | 37.0 |
| Overall | 888 | −1.362 | 0.173 | −0.046 | 204 | 234.5 |
| $H_0$ : median 1.1 equals median 1.3 | | | | | | |
| 1st grade | 251 | −6.777 | < 0.001 | −0.428 | 131 | 88.5 |
| 2nd grade | 177 | −6.564 | < 0.001 | −0.493 | 91 | 55.0 |
| 3th grade | 187 | −6.671 | < 0.001 | −0.488 | 101 | 62.5 |
| 4th grade | 172 | −6.399 | < 0.001 | −0.488 | 90 | 56.0 |
| 5th grade | 100 | −5.683 | < 0.001 | −0.568 | 70 | 43.0 |
| Female | 384 | −8.983 | < 0.001 | −0.458 | 216 | 140.5 |
| Male | 455 | −10.924 | < 0.001 | −0.512 | 241 | 146.0 |
| Other | 24 | – | – | – | 12 | 8.0 |
| Rather not tell | 25 | – | – | – | 14 | 10.5 |
| Vwo | 618 | −12.697 | < 0.001 | −0.511 | 347 | 215.5 |
| Havovwo | 143 | −4.516 | < 0.001 | −0.378 | 69 | 47.5 |
| Havo | 127 | −5.051 | < 0.001 | −0.448 | 67 | 42.0 |
| Overall | 888 | −14.335 | < 0.001 | −0.481 | 483 | 305.0 |

Table 7.9: Mathematics anxiety situation 2 results Wilcoxon rang sum test ($n = 888$) and sign test. Effect size for Wilcoxon rang sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade. Some comparisons are left out because of their large amount of ties.

| Group | $n$ | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|---|
| $H_0$ : median 2.1 equals median 2.2 | | | | | | |
| 1st grade | 251 | −0.616 | 0.538 | −0.039 | 56 | 53.0 |
| 2nd grade | 177 | −0.686 | 0.492 | −0.052 | 37 | 36.0 |
| 3th grade | 187 | −0.082 | 0.934 | −0.006 | 35 | 36.5 |
| 4th grade | 172 | −2.367 | 0.018 | −0.181 | 45 | 37.5 |
| 5th grade | 100 | −0.338 | 0.735 | −0.034 | 26 | 25.5 |
| Female | 384 | −1.259 | 0.208 | −0.064 | 92 | 86.5 |
| Male | 455 | −1.456 | 0.145 | −0.068 | 97 | 91.5 |
| Other | 24 | – | – | – | 5 | 4.5 |
| Rather not tell | 25 | – | – | – | 5 | 6.0 |
| Vwo | 618 | −1.480 | 0.139 | −0.060 | 143 | 134.0 |
| Havovwo | 143 | −0.013 | 0.990 | −0.001 | 27 | 27.5 |
| Havo | 127 | −1.293 | 0.196 | −0.115 | 29 | 27.0 |
| Overall | 888 | −1.725 | 0.085 | −0.058 | 199 | 188.5 |
| $H_0$ : median 2.2 equals median 2.3 | | | | | | |
| 1st grade | 251 | −6.713 | $< 0.001$ | −0.424 | 93 | 53.0 |
| 2nd grade | 177 | −6.596 | $< 0.001$ | −0.496 | 63 | 33.0 |
| 3th grade | 187 | −7.143 | $< 0.001$ | −0.522 | 84 | 45.0 |
| 4th grade | 172 | −7.771 | $< 0.001$ | −0.593 | 83 | 43.0 |
| 5th grade | 100 | −5.940 | $< 0.001$ | −0.594 | 53 | 28.0 |
| Female | 384 | −9.961 | $< 0.001$ | −0.508 | 179 | 98.0 |
| Male | 455 | −10.954 | $< 0.001$ | −0.514 | 173 | 90.5 |
| Other | 24 | – | – | – | 13 | 7.0 |
| Rather not tell | 25 | – | – | – | 11 | 6.5 |
| Vwo | 618 | −13.924 | $< 0.001$ | −0.560 | 276 | 145.0 |
| Havovwo | 143 | −4.345 | $< 0.001$ | −0.363 | 48 | 28.5 |
| Havo | 127 | −5.097 | $< 0.001$ | −0.452 | 52 | 28.5 |
| Overall | 888 | −15.227 | $< 0.001$ | −0.511 | 376 | 202.0 |
| $H_0$ : median 2.1 equals median 2.3 | | | | | | |
| 1st grade | 251 | −6.771 | $< 0.001$ | −0.427 | 96 | 55.0 |
| 2nd grade | 177 | −6.520 | $< 0.001$ | −0.490 | 70 | 39.5 |
| 3th grade | 187 | −6.847 | $< 0.001$ | −0.501 | 70 | 37.5 |
| 4th grade | 172 | −8.260 | $< 0.001$ | −0.630 | 93 | 48.0 |
| 5th grade | 100 | −5.953 | $< 0.001$ | −0.595 | 50 | 27.0 |
| Female | 384 | −10.496 | $< 0.001$ | −0.536 | 180 | 99.0 |
| Male | 455 | −10.849 | $< 0.001$ | −0.509 | 176 | 94.0 |
| Other | 24 | – | – | – | 12 | 7.0 |
| Rather not tell | 25 | – | – | – | 11 | 7.0 |
| Vwo | 618 | −14.005 | $< 0.001$ | −0.563 | 275 | 144.0 |
| Havovwo | 143 | −4.040 | $< 0.001$ | −0.338 | 52 | 32.5 |
| Havo | 127 | −5.469 | $< 0.001$ | −0.485 | 52 | 30.5 |
| Overall | 888 | −15.415 | $< 0.001$ | −0.517 | 379 | 207.0 |

Table 7.10: Concept of mistakes situation 1 results Wilcoxon rang sum test ($n = 888$) and sign test. Effect size for Wilcoxon rang sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade. Some comparisons are left out because of their large amount of ties.

| Group | $n$ | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|---|
| $H_0$ : median 1.1 equals median 1.2 | | | | | | |
| 1st grade | 251 | −3.977 | < 0.001 | −0.251 | 50 | 73.0 |
| 2nd grade | 177 | −0.705 | 0.481 | −0.053 | 44 | 47.5 |
| 3th grade | 187 | −2.228 | 0.026 | −0.163 | 42 | 52.5 |
| 4th grade | 172 | −4.362 | < 0.001 | −0.333 | 27 | 45.5 |
| 5th grade | 100 | – | – | – | 14 | 24.0 |
| Female | 384 | −3.661 | < 0.001 | −0.187 | 91 | 115.5 |
| Male | 455 | −5.265 | < 0.001 | −0.247 | 74 | 113.5 |
| Other | 24 | – | – | – | 4 | 6.5 |
| Rather not tell | 25 | – | – | – | 8 | 7.0 |
| Vwo | 618 | −5.150 | < 0.001 | −0.207 | 133 | 177.5 |
| Havovwo | 143 | −4.243 | < 0.001 | −0.355 | 18 | 36.0 |
| Havo | 127 | −0.592 | 0.554 | −0.052 | 26 | 29.0 |
| Overall | 888 | −6.284 | < 0.001 | −0.211 | 177 | 242.5 |
| $H_0$ : median 1.2 equals median 1.3 | | | | | | |
| 1st grade | 251 | −9.270 | < 0.001 | −0.585 | 22 | 91.0 |
| 2nd grade | 177 | −8.255 | < 0.001 | −0.620 | 14 | 62.0 |
| 3th grade | 187 | −8.047 | < 0.001 | −0.588 | 15 | 64.0 |
| 4th grade | 172 | −8.678 | < 0.001 | −0.662 | 10 | 61.0 |
| 5th grade | 100 | −6.581 | < 0.001 | −0.658 | 6 | 37.5 |
| Female | 384 | −14.043 | < 0.001 | −0.717 | 20 | 147.0 |
| Male | 455 | −11.270 | < 0.001 | −0.528 | 42 | 151.5 |
| Other | 24 | – | – | – | 2 | 7.0 |
| Rather not tell | 25 | – | – | – | 3 | 10.0 |
| Vwo | 618 | −15.804 | < 0.001 | −0.636 | 49 | 227.5 |
| Havovwo | 143 | −5.942 | < 0.001 | −0.497 | 11 | 44.0 |
| Havo | 127 | −7.182 | < 0.001 | −0.637 | 7 | 44.0 |
| Overall | 888 | −18.316 | < 0.001 | −0.615 | 67 | 315.5 |
| $H_0$ : median 1.1 equals median 1.3 | | | | | | |
| 1st grade | 251 | −10.766 | < 0.001 | −0.680 | 12 | 90.5 |
| 2nd grade | 177 | −9.079 | < 0.001 | −0.682 | 4 | 61.0 |
| 3th grade | 187 | −9.103 | < 0.001 | −0.666 | 11 | 67.0 |
| 4th grade | 172 | −9.767 | < 0.001 | −0.745 | 2 | 63.5 |
| 5th grade | 100 | −6.851 | < 0.001 | −0.685 | 4 | 38.5 |
| Female | 384 | −14.451 | < 0.001 | −0.737 | 15 | 152.0 |
| Male | 455 | −13.818 | < 0.001 | −0.648 | 17 | 152.5 |
| Other | 24 | – | – | – | 0 | 8.0 |
| Rather not tell | 25 | – | – | – | 1 | 8.0 |
| Vwo | 618 | −17.351 | < 0.001 | −0.698 | 23 | 230.5 |
| Havovwo | 143 | −8.015 | < 0.001 | −0.670 | 5 | 46.0 |
| Havo | 127 | −7.467 | < 0.001 | −0.663 | 5 | 44.0 |
| Overall | 888 | −20.511 | < 0.001 | −0.688 | 33 | 320.5 |

Table 7.11: Concept of mistakes 2 results Wilcoxon rang sum test ($n = 888$) and sign test. Effect size for Wilcoxon rang sum test calculated per grade and overall. Grade 6 is not included in the table since there was only one student indicating to be in the 6th grade. Some comparisons are left out because of their large amount of ties.

| Group | $n$ | $z$ | $p$ | $r$ | $d_+$ | $0.5 \cdot (n - n_0)$ |
|---|---|---|---|---|---|---|
| $H_0$ : median 2.1 equals median 2.2 | | | | | | |
| 1st grade | 251 | $-7.073$ | $< 0.001$ | $-0.446$ | 95 | 55.0 |
| 2nd grade | 177 | $-5.731$ | $< 0.001$ | $-0.431$ | 70 | 41.5 |
| 3th grade | 187 | $-5.255$ | $< 0.001$ | $-0.384$ | 68 | 43.0 |
| 4th grade | 172 | $-6.515$ | $< 0.001$ | $-0.497$ | 78 | 43.0 |
| 5th grade | 100 | – | – | – | 44 | 24.0 |
| Female | 384 | $-10.460$ | $< 0.001$ | $-0.534$ | 182 | 102.0 |
| Male | 455 | $-8.599$ | $< 0.001$ | $-0.403$ | 155 | 92.5 |
| Other | 24 | – | – | – | 8 | 5.5 |
| Rather not tell | 25 | – | – | – | 10 | 6.5 |
| Vwo | 618 | $-11.807$ | $< 0.001$ | $-0.475$ | 256 | 147.0 |
| Havovwo | 143 | $-4.337$ | $< 0.001$ | $-0.363$ | 48 | 29.0 |
| Havo | 127 | $-5.106$ | $< 0.001$ | $-0.453$ | 51 | 30.5 |
| Overall | 888 | $-13.549$ | $< 0.001$ | $-0.455$ | 355 | 206.5 |
| $H_0$ : median 2.2 equals median 2.3 | | | | | | |
| 1st grade | 251 | $-1.800$ | 0.072 | $-0.114$ | 65 | 72.0 |
| 2nd grade | 177 | $-0.423$ | 0.672 | $-0.032$ | 50 | 47.0 |
| 3th grade | 187 | $-2.904$ | 0.004 | $-0.212$ | 45 | 58.5 |
| 4th grade | 172 | $-2.691$ | 0.007 | $-0.205$ | 44 | 55.0 |
| 5th grade | 100 | $-2.411$ | 0.016 | $-0.241$ | 28 | 32.5 |
| Female | 384 | $-2.838$ | 0.005 | $-0.145$ | 113 | 124.5 |
| Male | 455 | $-3.816$ | $< 0.001$ | $-0.179$ | 109 | 128.0 |
| Other | 24 | – | – | – | 3 | 5.5 |
| Rather not tell | 25 | – | – | – | 7 | 7.5 |
| Vwo | 618 | $-4.604$ | $< 0.001$ | $-0.185$ | 169 | 194.5 |
| Havovwo | 143 | $-0.852$ | 0.394 | $-0.071$ | 35 | 38.0 |
| Havo | 127 | $-1.263$ | 0.207 | $-0.112$ | 28 | 33.0 |
| Overall | 888 | $-4.724$ | $< 0.001$ | $-0.159$ | 232 | 265.5 |
| $H_0$ : median 2.1 equals median 2.3 | | | | | | |
| 1st grade | 251 | $-2.558$ | 0.011 | $-0.161$ | 100 | 81.5 |
| 2nd grade | 177 | $-3.311$ | 0.001 | $-0.249$ | 77 | 55.0 |
| 3th grade | 187 | $-0.288$ | 0.773 | $-0.021$ | 61 | 60.5 |
| 4th grade | 172 | $-2.065$ | 0.039 | $-0.157$ | 65 | 57.5 |
| 5th grade | 100 | $-1.233$ | 0.217 | $-0.123$ | 37 | 31.5 |
| Female | 384 | $-3.603$ | $< 0.001$ | $-0.184$ | 166 | 134.5 |
| Male | 455 | $-2.419$ | 0.016 | $-0.113$ | 160 | 137.5 |
| Other | 24 | – | – | – | 4 | 6.0 |
| Rather not tell | 25 | – | – | – | 10 | 8.5 |
| Vwo | 618 | $-3.161$ | 0.002 | $-0.127$ | 243 | 208.5 |
| Havovwo | 143 | $-2.060$ | 0.039 | $-0.172$ | 51 | 42.5 |
| Havo | 127 | $-2.034$ | 0.042 | $-0.181$ | 46 | 35.5 |
| Overall | 888 | $-4.196$ | $< 0.001$ | $-0.141$ | 340 | 286.5 |